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The Octopus at Play: novelty-seeking analysis and play behavior in *O. bimaculoides*

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Abstract

What constitutes a behavior as play, and do octopuses experience it? Octopuses are often colloquially regarded as a “smart” species, yet their cognition is not fully understood. In learning behavioral trends many species exhibit, we can begin to discern certain actions as play. However, due to the lack of research in generalized octopus behavior, play and tactile exploration have not yet been fully explored in *Octopus bimaculoides*. This study examines whether these octopuses exhibit criteria for play behavior, if they are reactive to photoperiods (daytime and nighttime), and if their working memory is sensitive to novel object recognition tasks. Prior research argues that octopuses prefer certain shapes, textures, and novel objects. While a prior study suggests octopuses may be nocturnal, this study yielded significant results for diurnal, tactile play behavior, as well as tentative individual preferences in textures and shapes. This study cannot significantly argue that octopuses prefer novel objects, but future research with a larger sample size may be able to assess these findings further.

Introduction

Cephalopods are considered an anomaly in the world of invertebrates, as they exhibit cognitively-rich actions–such as hunting, hiding, and decision-making behavior–that converges with those of mammals or birds (Cook et al., 2009). However, octopus cognition and behavior are concepts that have yet to be explored thoroughly–identifying such behavior in the wild poses many challenges, as they hide from predators and stimuli are not easily manipulated. Thus, researchers have turned to addressing octopus cognition in a lab setting. One cognitively rich behavior is play; in this research, we asked if octopuses do play, and if so, how they might engage in this behavior.

Burghardt (2005) listed five widely accepted requirements in order to classify an animal's behavior as play:

1. Play behavior is incompletely functional in the context in which it is expressed.

2. Play behavior is spontaneous and voluntary (done for its own sake).

3. Play has to differ from other behavior in being exaggerated, being modified, or occurring precociously.

4. Play behavior occurs repeatedly but is not stereotypic.

5. Play has to be observed in healthy subjects and initiated in stress-free conditions.

There are some toils capturing and quantifying play behavior in octopuses. Some behaviors, such as hiding in their jars, actively eating, resting (visibly), exploring, and swimming (without touching the floor) are observed in lab octopuses (Hamlett, 2024). These actions *may* include play behavior, but this is clearly difficult to disentangle. A recent study that has not yet been peer reviewed (via bioRxiv) examined if certain behaviors stimulate an octopus enough to be considered play behavior. The researchers attempted to observe octopuses at play via placement of a test tube containing shrimp, followed by the placement of a second empty tube (Jarmoluk & Pelled, 2024). This assumed that the desire to catch and eat shrimp likely motivated the octopus to figure out how to open the translucent test tube; it was assumed that any behavior toward the second empty test tube constitutes play. This study is largely confounded, and it is not necessarily an accurate display of the species at play as they only learned how to open the tube after the exposure to shrimp, regardless of the fact that they continued to open it even after the researchers placed a tube without shrimp. This directly violates requirement 1 of Burghardt's list; this behavior was conducted in search of food (shrimp), and was therefore not incompletely functional.

In studying an octopus at play, current research primarily focuses on the California two-spot, but *Octopus vulgaris* and *Octopus maya* behaviors have also been studied. The gross brain anatomy of the species is largely the same (Stoskopf & Oppenheim, 1996; Shigeno & Ragsdale, 2015), allowing for conclusions regarding another species to be applied in current research. The octopus central nervous system consists of a circumesophageal brain, axial nerve cords in each arm, and two paired optic lobes (Albertin et al., 2015; Young, 1971) and undergoes a maturation stage similar to rats (Vergara-Ovalle et al., 2022; Anderson et al., 2004). Physiologically, in *O. vulgaris*, the vertical lobe (VL), containing about half of the central nervous system's neurons (Young, 1963), is considered the epicenter of memory and specifically, visual-association learning (Bidel et al., 2023; Boycott & Young, 1955; Shigeno et al., 2018). Octopuses do exhibit the cognitive processes required to engage in play–they experience working memory habits and learning (Wells, 1978), and lesions to their VL have led to behavioral deficiencies when they are faced with learning a new task (Hochner et al., 2006).

Octopus memory has been explored in the capacity of spatial recognition (Mather, 1995), but their short-term working memory has seldom been studied in the context of novel object recognition (Vergara-Ovalle, 2023). It is assumed that octopuses across species are likely motivated by hunting instincts and have a nature to hunt prey, such as shrimp and crabs (Kuba et al., 2006b); thus, natural behavior versus conditioned behavior in captivity may be difficult to gauge and has arguably not been done yet. Octopuses also may exhibit their own unique, personal behaviors–it is unknown whether certain behaviors can be deemed natural or instinctual across a species based on an experiment with a single animal. Furthermore, as octopuses grow older, their likelihood to engage in potential play behaviors may be increased as their fear of predators decreases (Forsythe et al., 1991). While previous research has laid a preliminary foundation for understanding the octopus at play, a true demonstration of that remains to be seen. Octopus working memory and novel recognition may play a part in understanding their overall behavior and preference for certain items while exhibiting alleged play behavior. By identifying if the octopus does experience play as a natural behavior, another piece can be added to the puzzle of understanding cephalopod cognition.

The Current Study

The goal of this study is to examine whether the California two-spot octopus (*O. bimaculoides*) experiences natural play in captivity as a natural, untriggered, and unconditioned behavior. There is evidence to suggest that octopuses are drawn to a variety of textures and shapes (Cooke et al., 2019), implying that octopuses may exhibit criteria that align with those detailed for play behavior and likely have textural preferences even on an individual basis. Furthermore, octopus working memory is examined through novelty recognition. Throughout analyses of novel object recognition and play behavior in captive, wild-caught octopuses, habituation may also be considered. Octopuses have exhibited that they tend to become more "outgoing" as they grow older, are more comfortable in their environment, and are less fearful of predators (Forsythe et al., 1991), therefore, older octopuses who have been in a stable environment for longer may exhibit more play-like behaviors than younger octopuses who have only recently been caught. Analysis of their short-term memory and interest in novel objects may better elucidate the nature of their play. A study on *O. maya* suggests that octopuses may be novel-object seeking (Vergara-Ovalle et al., 2023), although adult octopuses move at a slower pace than many mammals (Antunes & Biala, 2012), so the study design must be adjusted accordingly (e.g., longer trial periods for octopuses than mammals).

Thus far, novel object recognition in *O. bimaculoides* has yet to be explored, and in understanding this better, we can examine potential play behavior in a more dynamic sense. Small toys of textural variety, such as fidget toys, are used to further assess the claims that octopuses may experience play behavior through preference for different textures and shapes will be examined, and we hypothesize that individual preferences for toy shape and texture will be observed. Additional evidence suggests that juvenile octopuses tend to exhibit nocturnal behavior (Sinn, 2008), leading to a reasonable hypothesis that adult octopuses may interact with a stimulus in the tank in accordance with lighting changes (which correlate with photoperiods). To test this, this study divides photoperiods into 2 groups: "AM," where the lights are on and people are moving freely about the lab and "PM," where the lights are off and there is no one in the lab. Given the prior research, it is likely that the octopus will experience tactile behavior during a "PM" photoperiod. Supplementary behavioral analyses will explore the nature of this play: considerations such as toy interaction time, the nature of the interaction, the type of toy, and the time of day and external stimuli (photoperiods).

This study will investigate novel object recognition in octopuses that have been exposed to toys (conditioned) and octopuses that have only experienced a deprived environment since captivity (naïve). Due to the possibility that octopuses (specifically, *O. maya*) may experience novelty seeking behavior, it is possible that *O. bimaculoides* does as well. We hypothesize that naïve animals will spend less time interacting with familiar objects versus novel objects than conditioned animals in the novel object recognition task; the significance of a novel object may not be as great to a conditioned animal, as it has been exposed to all of these toys before. However, a naïve animal only knows the toys it has been shown, thus novelty may be more significant. If *O. bimaculoides* is seen to be drawn to novel objects, their preference for certain items can be better analyzed in future studies. Finally, we propose that the inquisitive nature of octopuses may lead to toy interaction behavior in the form of short, repeated contacts with the object in the tank.

Methods

Four adult specimens of *O. bimaculoides* were obtained commercially from the wild in November 2024 and shipped to Chicago, Illinois where they were maintained in 20-gallon tanks (salinity 33 ppt) with a carbon filter, bubbler, and ultraviolet sterilizer. They were fed three fiddler crabs and/or frozen shrimp daily prior to and through experimentation. Each tank contained one clay pot for shelter in the same location in each tank and rocks along the bottom of the tank. Various toys were ordered via Amazon in a "fidget pack," and were equilibrated in deionized salinated water prior to being placed in a tank.

Toy Selection

Fifty-four toys were separated based on texture and shape and were noted as floating or sinking. A high variance of toy shapes were included in this sample to thoroughly assess possible preference for shape and/or texture, and each toy was scored on a continuum: toys at the beginning of the continuum were deemed to be the most spherical (e.g., golf ball) and the toys at the end were deemed to be the most linear (e.g., foam arm), and each toy was numbered (Appendix A). All other toys were placed accordingly in the continuum and reviewed by other lab members and the principal investigator prior to experimentation. A large sample of textures and shapes were included, as octopuses have demonstrated a discrimination between shapes (Buresch et al., 2024), but whether they have a preference for certain non-prey textures or shapes is unknown.

Toy Exploration

Two initial octopuses were arbitrarily selected from the sample of four octopuses (C1 and C2). These two animals were sexed as male and female, respectively, and were both estimated to be 6-9 months old. Their tanks were “deprived” environments; other lab animals typically had plastic fronds, shells, and toy figures of various sizes and textures in their tanks. However, these octopuses only had substrates and one jar for shelter in addition to their UV sterilizer, bubbler, and carbon filter. Video footage was recorded with two Wyze Cam Pan 3 motion-sensor cameras, two Wyze V4 cameras, and supplementary video was obtained on an iPhone 13; the behavior of each of the two octopuses was monitored over a 24-hour period to assess for photoperiods and lighting changes, sensitivity to movement in the room, feeding times, and where toys were moved around the tank relative to the octopus.

A number generator selected 10 toys at random (Appendix B; some toys overlapped between octopuses); each toy was individually tested such that an individual toy was added to the tank of one octopus for an initial observation period of 5 minutes. The toy was placed approximately one inch in front of the octopus. The criterion for labeling a toy as “preferred” states that an octopus must deliberately engage with the toy for double the amount of time as it did during the initial five-minute period. For instance, if the octopus engaged with a toy once for 30 seconds over five minutes, it must engage with the toy for a combined total of 60 seconds over 10 minutes (including the five-minute period) to ensure deliberate interest in the toy. After this observation, the toy was removed from the tank, and the next toy in the sequence was placed in the tank approximately one inch from the animal. This process was repeated for the remaining toys. To explore the full set of toys, this testing process was then repeated with 10 new toys randomly selected and introduced in a different randomized order twice more over a three-week period, with one week between each round of testing. While each octopus was not exposed to all 30 of the same toys, similar toys of size and texture were selected for both octopuses. All toys were removed between rounds of testing.

After the final round of testing, all toys were then removed for a 48-hour period as a "reset" period. After this 48-hour period, one preferred toy was selected at random and placed approximately one inch in front of the octopus. The octopus was then left with the toy for a 24-hour period where it was monitored via Wyze Cam Pan 3 motion sensor cameras. After the 24-hour period, the toy was removed, and the octopus experienced a 24-hour period with no toy in the tank. Another "preferred" toy was selected at random and placed in the tank for 24 hours, and the same processes were followed until all preferred toys had been individually left in the tank for a 24-hour period. Leaving the toy in the tank for 24 hours allowed the octopus to explore the toy, manipulate the toy, and experience the toy in its tank during both "AM" and "PM" photoperiods.

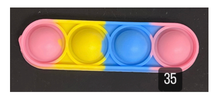
Toy Exploration Analysis

Variables of interest included total time spent interacting with each toy (Figure 2), number of individual interactions with the toy (how many times the octopus returned to the toy; Figure 3), and the nature of the interaction (resting, holding, moving). Resting is noted as the animal having 1+ limb(s) touching the toy (typically on top of or on the lateral aspects of the toy), but they are not actively moving the toy. Holding, specifically for toys that are not suctioned to the bottom, constitutes the octopus grabbing onto the toy, usually with the intermediate or distal part(s) of their arm(s). The texture and shape of each toy was also considered, as well as the time of day.

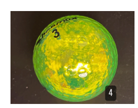
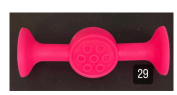
Novel Object Recognition Tasks

Two of the same toys were selected from the 24-hour set, and six different sets of matching toys were selected in total. The matching toys were duplicates of the initially preferred toys. Each of the six pairs were then paired together, forming three sets of pairs (Table 1). These groups were constructed such that the different toys were dissimilar in shape but were still considered "preferred" by at least one of the conditioned octopuses. One of the two different toys in each group was included that was specifically interacted with frequently by the original two octopuses during their 24-hour testing period.

Group 1

Small pop-it (x2)	
Suction ball (x2)	

Group 2

Golf ball (x2)	
Pink multi-suction (x2)	

Group 3

Purple multi-suction (x2)	
Marble netted tube (x2)	

Table 1: Novel object toy sets

Two naïve, new octopuses were selected (N1 and N2), both of which had not encountered toys while in captivity. Using a novel object recognition task paradigm (Vergara-Ovalle et al., 2023) conducted during the "AM" photoperiod, the two identical toys were placed on opposite sides of both the octopus and the tank. Since adult octopuses move slower than many mammals during these tasks (Vergara-Ovalle et al., 2023; Antunes & Biala, 2012), the toys were left in the tank for 30 minutes to give the animals adequate time to explore both items. All stimuli were then removed from the tank for 30 minutes. One initial toy was then placed in the tank along with the novel toy from the same group, and both toys were left in the tank for 30 minutes. Both toys were removed from the tank for one hour. This process was repeated with the two subsequent groups. Each group was selected in a random order, and to counterbalance, the "initial" and "test" stimuli were opposite for each octopus–for example, if one octopus experienced two golf balls for the first 30 minutes and one golf ball and one pink multi-suction toy for the last 30 minutes, the other octopus would experience two pink multi-suction toys for the first 30 minutes and one golf ball and one pink multi-suction toy for the last 30 minutes.

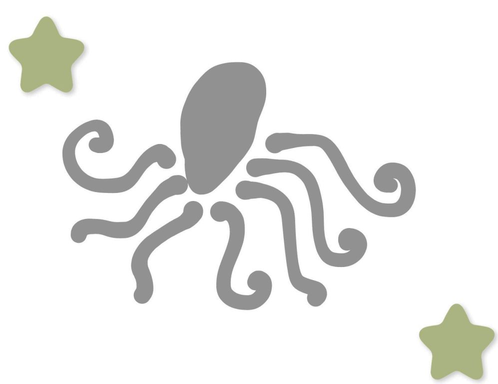


Figure 1a: Initial Phase Paradigm

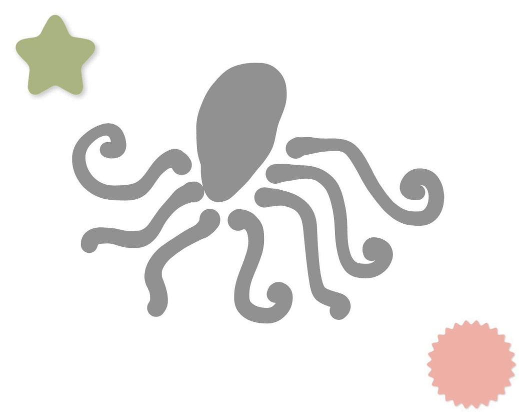


Figure 1b: Test Phase Paradigm

Novel Object Recognition versus Preferred Toy

For this final experiment, the two conditioned octopuses (C1 and C2) were selected again. These octopuses had already experienced an introduction to toys and selected “preferred” toys based on interaction time and number of contacts with each toy. Given that at least one toy in each group was deemed “preferred” by at least one of the conditioned two octopuses, novel object recognition was tested against preference. The same novel objection recognition task paradigm was used with the same groups of toys such that each octopus experienced the same 30-30-30 paradigm as the naïve octopuses. The purpose of this comparison–naïve octopuses with octopuses who had already experienced extended periods with toys–was to examine for any possible differences in preference or short-term working memory.

Statistics

Statistical analyses included Mann-Whitney *U* and Wilcoxon Signed Rank tests for novel object recognition comparison. Photoperiods were coded as “AM” as 1 and “PM” as 2 for analyses, and each interaction was randomly assigned a number to be plotted. A one-way ANOVA and Fisher’s Exact Test were used to assess whether photoperiods had a significant effect on toy interaction where photoperiod was the independent variable.

Results

There was high variability in the contact time between octopuses and the toys they selected (Figure 2); for instance, C1 preferred spherical toys whereas C2 preferred linear toys, though it should be noted that toy 1 and toy 4 are both golf balls and there is evidence to suggest that octopuses cannot see color (Nahmad-Rohen et al., 2022).

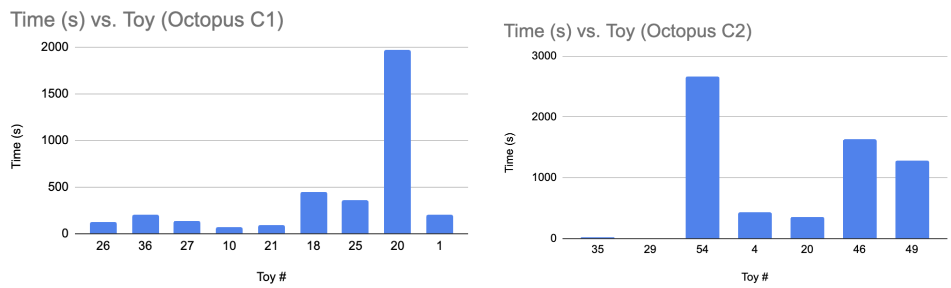


Figure 2: Interaction time by toy for each conditioned octopus. Notice the toy numbers are different across graphs, indicating their individual preferences in the preliminary testing phases (see Appendix B).

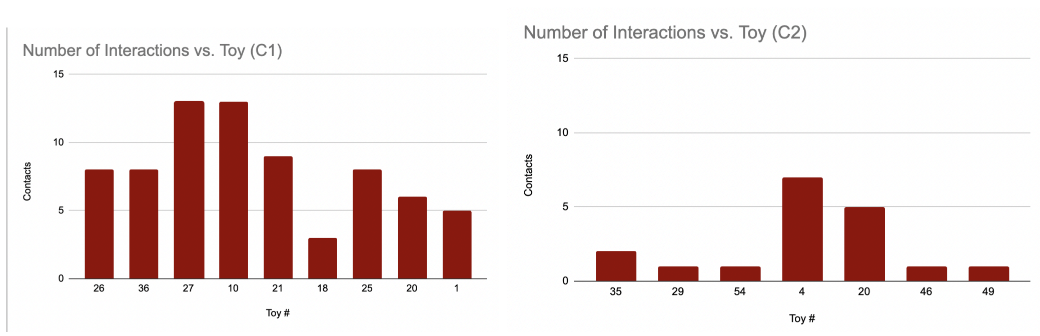


Figure 3: Number of individual interactions by toy for each conditioned octopus. Notice the toy numbers are different across graphs, indicating their individual preferences in the preliminary testing phases (see Appendix B).

Assessing the overall nature of suggested play behavior, some differences were seen between octopuses. One of the conditioned animals (C2) would “hold” toys for up to 45 minutes rather than returning to them in shorter, more frequent events. This can be constituted as play due to the deliberate nature of holding the object and the observation of “bite” marks (indentations left by its beak) left in the objects. Therefore, this behavior can indicate the potential for play, as it meets the Burghart requirements for play and does not mimic predatory or hunting (Hamlett, 2024) behavior.

The novel object recognition tasks were performed during an “AM” photoperiod (lights were on and people were moving freely about the lab space), raising the question of whether photoperiod affects the nature of toy interaction. The current data suggest photoperiod does not have a significant impact on overall time spent interacting with a toy (One-way ANOVA, p = 0.614) ; however, photoperiod did have a significant impact on the nature of interaction (tactile or resting) among the two conditioned octopuses during the 24-hour testing phases (Fisher's Exact Test, p = 0.0080). This finding directly violates the hypothesis that tactile behavior correlates with "PM" photoperiods, as while both octopuses did interact with toys in the "PM" photoperiod, tactile exploration was observed significantly in the "AM" photoperiod (Figure 4).

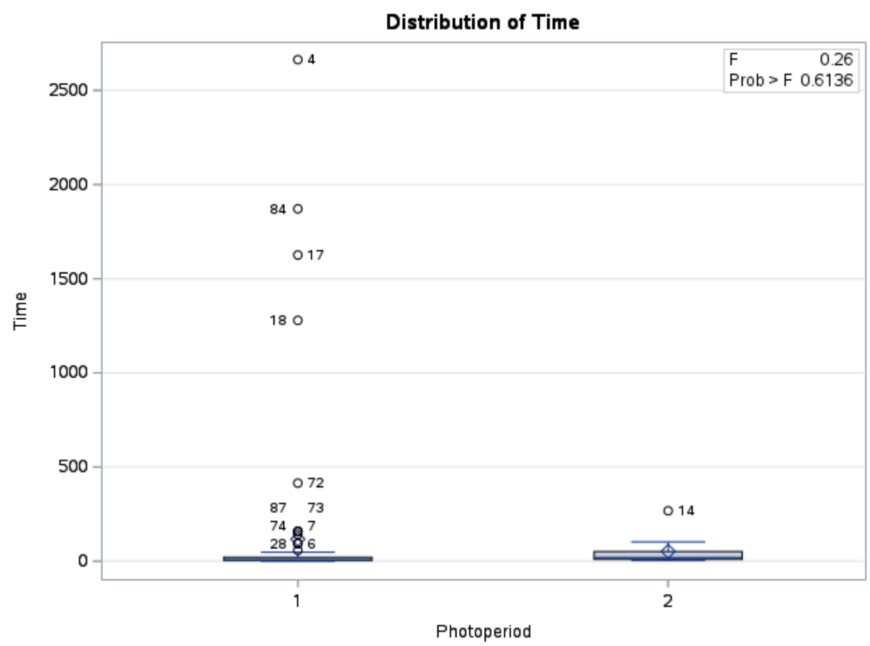


Figure 4: Time distribution in seconds (s) per photoperiod (AM=1, PM=2) for the conditioned octopuses (C1 and C2) with any preferred toy. Outliers where the animals interacted for a much longer amount of time were observed. Each interaction is arbitrarily numbered (e.g., interaction #4 was the longest).

In assessing whether octopuses seek novel objects in novel objects recognition tasks, there were no significant differences in exploring the two identical objects in the naïve animals (Mann-Whitney *U*, p = 0.658, z: -0.44) and the conditioned animals (Mann-Whitney *U*, p = 0.573, z: -0.56) at the 95% confidence interval in the former phase of the task. However, there were also no significant differences seen in interaction time between novel and familiar objects in the test phase between naïve animals (Mann-Whitney *U*, p = 0.236, z: -1.1847) and conditioned animals (Wilcoxon, p = 0.438, z: -0.944) at the 95% confidence interval. Observationally, however, we saw trends where both naïve and conditioned octopuses approached both objects across trials, demonstrating the animals' interest in both objects; the difference between these objects was overall insignificant.

Discussion

The findings in this study suggested that play behavior was seen with this sample of *O. bimaculoides*. The two conditioned octopuses (C1 and C2) experienced a substantial difference in initial toy preferences (Appendix B); it can be extrapolated that octopuses may experience individual differences in personality and preference. If the octopus exhibited play-like behavior, we would expect to see active, tactile motions, such as moving or holding the toy. Per Burghart (2005), play behavior is incompletely functional. To test this, we used toys which are not likely to be functionally relevant in an octopus's natural environment. Play behavior is also voluntary, and these octopuses were left with just the toy(s) in the tank without any possible incentive. Habituation periods were to allow each octopus to acclimate to its new environment and to minimize stressful conditions in order to facilitate willingness for play behavior. These behaviors were not manipulated or modified to mimic play, and each phase of experiments allowed the octopuses to explore each toy with ample time.

There are individual differences and a high variability between the two initial octopuses and the toys they selected in the preliminary phase; they both demonstrated interest in one of the suction spheres (toy 20) and the golf balls, but one octopus seemed to prefer round toys (i.e., the suction spheres) while the other seemed to prefer more linear toys (i.e., foam arms). As mentioned in the results, these interactions can imply play. Per the Burghart (2005) list, these animals did exhibit the criteria required to imply play. Even when the octopuses were holding the toys, all tactile behaviors in this context did not mimic hunting behaviors or otherwise to imply other functioning. The octopuses both returned to toys multiple times or held toys for extended periods of time, meeting criteria #2 and #4 on the list, as these behaviors were spontaneous, repeated, and voluntary–no researcher coaxed an animal to interact with a toy or enticed with food.

It was initially hypothesized that the octopuses may repeatedly return to interact with toys several times to exhibit intentional, tactile behavior, but one octopus deviated from this behavior. Holding the toy can fall under play seeing as C2 did exhibit this behavior for extended periods of time as opposed to returning to a toy sporadically. We hypothesized the animals would gravitate toward different textures and shapes in their tactile behavior, and while this was seen in the variability of the toys deemed "preferred" between C1 and C2, the octopuses likely had individual preferences in texture and shape, and more data with a larger sample size would be required to make a more definitive claim. However, these individual differences in play may be attributed to differences in personalities or history prior to capture.

The 24-hour period assessed for both photoperiods and overall interaction. While prior research suggests that juvenile octopuses (Sinn, 2008) experience nocturnal behavior, adults are suspected to be diurnal, as this study revealed a significant relationship between the photoperiod and the nature of the toy interactions. This significance suggests that a "daytime" or "AM" photoperiod is highly correlated with tactile behavior whereas a "nighttime" or "PM" photoperiod may be correlated with resting behavior. Therefore, it can be concluded that while the room is light and there is movement in the room, the octopus may be more likely to interact with a toy with more tactile movement amongst arms–although this is opposite of what we hypothesized, there is strong evidence that daytime photoperiods correlate with active and deliberate interaction with the toy(s) in the tank.

Analysis of whether *O. bimaculoides* experiences novelty-seeking behavior over any type of individual preference yielded insignificant results. The 30-minute window (Vergara-Ovalle et al., 2023) given during these experiments was to allow each octopus to explore both items in the tank fully, but a low sample size may have contributed to the high variance and number of outliers seen in the data, leading to insignificant results. However, concurrent with prior research in *O. vulgaris* (Nahmad-Rohen et al., 2022), all experiments in this study show evidence that *O. bimaculoides* does not see color. This information may be useful in future experiments that also utilize object analysis with *O. bimaculoides*. Due to the low number of animals in this study, outliers in the data also have quite a large impact, especially in assessing novel object recognition between groups. While there were no significant results suggesting novel object recognition, the p-value was significantly lower when comparing interaction time between novel and familiar objects in the test phase between naïve and conditioned animals, suggesting the potential for significance given an adequate sample size. Alternate hypotheses can also be proposed here; novel object recognition trends may not differ based on prior exposure to toys, and individual preference may trump interest in novel objects.

While this study represents a new approach, individual differences in octopus behavior, preferences, sex-specific differences (if any), and personalities cannot be accounted for with the low sample size. Other factors also affect the time an octopus spends outside of its jar, such as the total time it has been living in the enclosure, its size and age, and its routine and feeding time. Another experimental confound regarding novel object recognition tasks in the naïve animals is the fact that N1 and N2 (the naïve animals) were in completely deprived environments and had no exposure to toys prior to novel object recognition experiments. Thus, the first round of novel object recognition tasks was N1 and N2's first exposure to anything else in the tank besides food, but this means they had been exposed to toys in some capacity for the following trials, negating full naïvety. To account for these confounds, future experiments can account for these factors with a larger sample size to mix trials to counterbalance. Future research may also look to analyze enrichment in captivity, as octopuses may exhibit different behaviors in a more "enriched" environment.

There are also methods to counterbalance potentially confounding variables, like time spent with each toy or adding and subtracting toys. One proposed way to further this study is to re-randomize toy groups to have multiple trials of the same toy. Furthermore, introducing entire commonly liked groups of individual toys at a time at 24-48 hour intervals may assess if the octopus prefers certain toys within each group. Lastly, further test repetitions post-initial experimentation may further counterbalance. Overall, this was a pilot study, and future studies may require a larger sample size to better test the claims defined in this study.

Ultimately, there is a significant lack of research regarding play behavior in *O. bimaculoides*. Due to the low sample size, outliers have a large impact and can pose as a confound. Future experiments examining play can utilize this research to go in several directions. The largest confound in this study is the low sample size, purely due to the amount of animals that were able to be ethically housed given lab space and a short experimental window. Both general play experiments (following Burghart criteria and assessing whether play behavior is able to be seen) and more specific experiments on novel object recognition, motor control, or preference to textures and/or shapes can benefit from this study.

Future experiments can utilize many of the findings outlined in this study. To assess individual preference, the 24-hour tasks can be repeated with a larger sample size to possibly yield more overlap in preferred toys. Enrichment can be assessed through captivity conditions–tanks can be kept in a variety of conditions to analyze potential effects enrichment has on play behavior. While this study did not possess evidence for novel object recognition, past research has; future studies can repeat these tasks with a larger sample size to test these trends.

Motor control was not heavily considered in these experiments, but external stimuli in the room, which arm(s) were used during interaction (arms are numbered 1-4 right and left, e.g., 2L or 4R), the number of total arms used during each interaction (Bidel et al., 2022), and the parts of the arms utilized (proximal, intermediate, distal) were examined as supplementary factors, but were not the primary focus of the analysis. Future research may also analyze the specific motor control functions of each arm, as the octopus arm is a complicated phenomenon with a vast potential for research.

This pilot study set groundwork for future research to go in many directions. The behavior observed in this study did meet the criteria to be considered play, and this is arguably the first study that can state that *O. bimaculoides* does experience play behavior in captivity. Observations in preference for shapes and textures as well as significant results arguing for the correlation between tactile behavior and daytime photoperiods can also give researchers a better understanding of what well-rounded play behavior may look like. This study ultimately opens the opportunity to utilize these findings to further examine overall play behavior, enrichment, motor control and tactile exploration, and working memory in *O. bimaculoides*.

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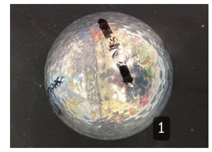
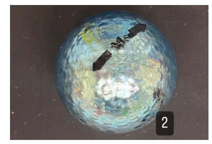
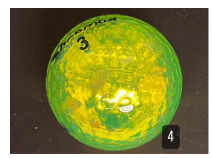
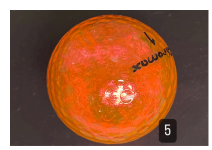
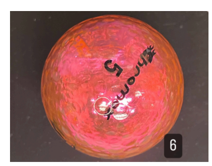
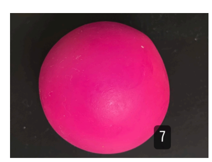
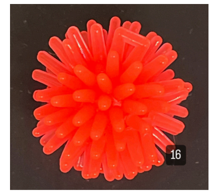
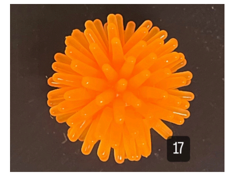
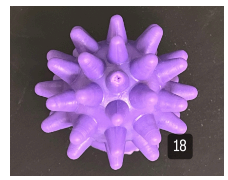
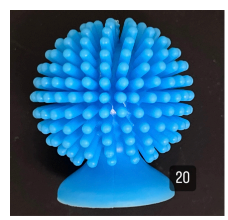
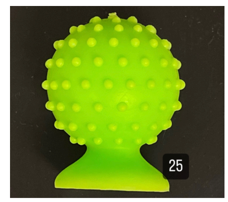
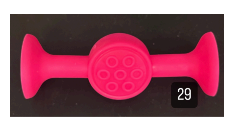
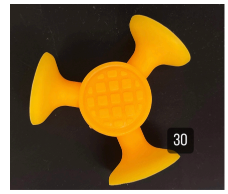
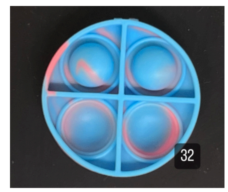
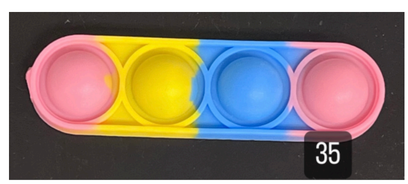
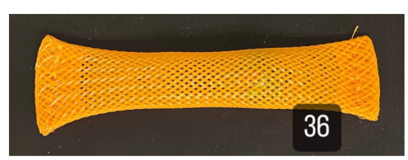
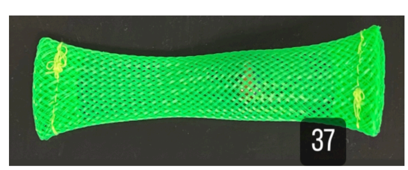
Appendix A

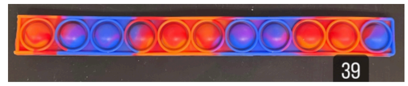
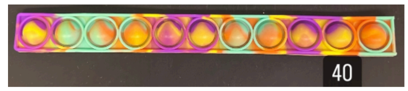
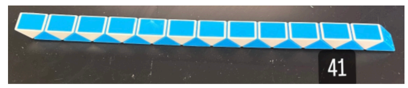
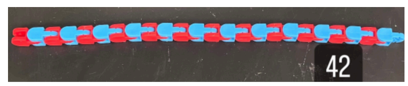
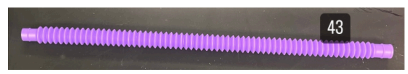
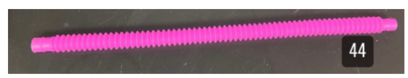
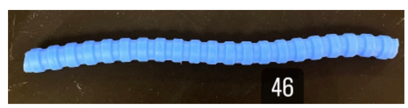
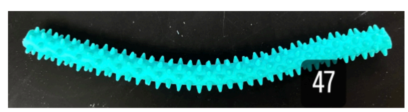
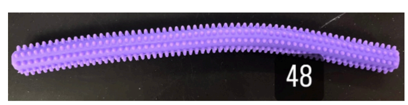
Number	Description	Measurements	Image
1	Silver golf ball	4cm diameter	
2	Blue golf ball	4cm diameter	
3	Gold golf ball	4cm diameter	
4	Green golf ball	4cm diameter	
5	Orange golf ball	4cm diameter	
6	Pink golf ball	4cm diameter	
7	Pink malleable ball	5cm diameter	
8	Light pink star	5cm x 5cm (2cm width)	

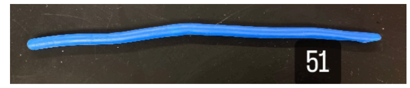
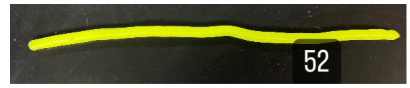
9	Hot pink star	5cm x 5cm (2cm width)	
10	Red star	5cm x 5cm (2cm width)	
11	Orange star	5cm x 5cm (2cm width)	
12	Yellow star	5cm x 5cm (2cm width)	
13	Green star	5cm x 5cm (2cm width)	
14	Blue star	5cm x 5cm (2cm width)	
15	Purple star	5cm x 5cm (2cm width)	

16	Pink small sphere	2cm diameter	
17	Orange small sphere	2cm diameter	
18	Purple spike suction sphere	3.5 diameter with spikes, 4cm height with stand	
19	Blue spike suction sphere	3.5 diameter with spikes, 4cm height with stand	
20	Blue dotted suction sphere	3cm dia. x 3.5cm height with stand	
21	Pink dotted suction sphere	3cm dia. x 3.5cm height with stand	
22	Yellow ridged suction sphere	3cm dia. x 3.5cm height with stand	

23	Orange ridged suction sphere	3cm dia. x 3.5cm height with stand	
24	Red dotted suction sphere	3cm dia. x 3.5cm height with stand	
25	Green dotted suction sphere	3cm dia. x 3.5cm height with stand	
26	Blue flat suction	3cm x 1cm, 4cm height with stand	
27	Purple multi-suction	circle: 3cm x 1cm; each suction is 3cm dia. and 2cm length including the legs. about 6.5cm across in total	
28	Orange multi-suction	3cm x 1 cm, each suction is 3cm across; total height 6cm	
29	Pink multi-suction	2.5cm x 1cm, each suction is 3cm across and total height is 8cm	

30	Yellow multi-suction	circle: 3cm x 1cm, each suction is 3cm in diameter; and 2cm length from the center	
31	Green multi-suction	circle: 3cm x 1cm, each suction is 3cm in diameter; and 1.5cm length from the center. total height 6cm x 6cm	
32	Circular small pop-it toy	3.5cm x 0.5cm	
33	Heart small pop-it toy	3cm across at widest point, 0.5 at smallest. 0.5cm wide	
34	Square small pop-it toy	3cm x 1cm	
35	Small pop-it toy	6cm x 0.5cm	
36	Orange marble netted tube	10.5cm x 3cm	
37	Green marble netted tube	10.5cm x 3cm	

38	Plastic tunnel	7cm x 2cm (1.5cm diameter opening)	
39	Blue/red long pop-it	18cm x 0.5cm	
40	Multicolored long pop-it	18cm x 0.5cm	
41	Blue/white blocks	23cm x 1cm	
42	Blue/red circular blocks	27.5cm x 1cm	
43	Purple translucent plastic arm	41cm x 2cm	
44	Pink translucent plastic arm	41cm x 2cm	
45	Red foam arm with ridges	18.5cm x 1cm	
46	Blue foam arm with ridges	18.5cm x 1cm	
47	Teal foam arm with spikes	18.5cm x 1cm	
48	Purple foam arm with spikes	18.5cm x 1cm	
49	Green dotted foam arm	18.5cm x 1cm	
50	Yellow foam arm with craters	18.5cm x 1cm	

51	Thin blue smooth foam arm	22cm x 0.5cm	
52	Thin yellow smooth foam arm	22cm x 0.5cm	
53	Thin light blue smooth foam arm	22cm x 0.5cm	
54	Thick green smooth foam arm	28cm x 1cm	

Appendix B

Preliminary Testing Results: Octopus C1

Toy Number	Interaction Criteria Met	Triage Round
8	No	1
36	Yes	1
54	No	1
25	Yes	1
38	No	1
7	No	1
50	No	1
27	Yes	1
4	Yes	1
34	No	1
10	Yes	2
51	No	2
13	No	2
18	Yes	2
35	No	2
30	No	2
21	Yes	2
20	Yes	2
24	No	2
12	No	2
52	No	3
1	Yes	3
39	No	3
17	No	3
41	No	3
9	No	3
43	No	3

26	Yes	3
53	No	3
45	No	3

Preliminary Testing Results: Octopus C2

Toy Number	Interaction Criteria Met	Triage Round
25	No	1
35	Yes	1
44	No	1
45	No	1
20	Yes	1
12	No	1
4	Yes	1
42	No	1
19	No	1
5	Yes	1
41	No	2
46	Yes	2
33	No	2
23	No	2
26	No	2
18	No	2
27	No	2
13	No	2
30	No	2
54	Yes	2
11	No	3
22	No	3
21	No	3

29	Yes	3
17	No	3
39	No	3
49	Yes	3
10	No	3
37	No	3
38	No	3