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Sparking a Dolphin's Curiosity: Individual Differences in Dolphins' Reactions to Surprising and Expectation-Violating Events

Malin Katarina Lilley
University of Southern Mississippi

SPARKING A DOLPHIN'S CURIOSITY: INDIVIDUAL DIFFERENCES IN

DOLPHINS' REACTIONS TO SURPRISING AND

EXPECTATION-VIOLATING EVENTS

by

Malin Katarina Lilley

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Dr. Stanley Kuczaj, Thesis Director

Approved:

____

Dr. Donald Sacco, Committee Chair
Assistant Professor, Psychology

____

Dr. Richard Mohn, Committee Member
Associate Professor, Educational Research and Administration

____

Dr. Deirdre Yeater, Committee Member
Associate Professor, Psychology, Sacred Heart University

____

Dr. D. Joe Olmi,
Department Chair, Psychology

____

Dr. Karen S. Coats
Dean of the Graduate School

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ABSTRACT

SPARKING A DOLPHIN'S CURIOSITY: INDIVIDUAL DIFFERENCES IN DOLPHINS' REACTIONS TO SURPRISING AND EXPECTATION-VIOLATING EVENTS

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May 2017

Non-scientific literature consistently describes dolphins as "curious animals," but there has been little systematic research on curiosity in dolphins. Curiosity in humans and certain non-human animal species, including birds and non-human primates, has been studied by examining individual differences in exploration and reactions to novel stimuli. Additionally, research has explored how human infants and non-human animals react when an event violates their expectations. The present study explored dolphins' reactions to spontaneously surprising and expectation-violating stimuli. The reactions of dolphins, 15 bottlenose (*Tursiops truncatus*) and 6 rough-toothed (*Steno bredanensis*), at Gulf World Marine Park were analyzed in response to events that were spontaneously surprising and a possible violation of expectations paradigm. The results of this study supported the hypothesis that there would be a wide range of individual differences in dolphins' reactions to the stimuli, including differences between species, sex, age class, and personality ratings. Subjects had a longer gaze duration, produced more bubble bursts and bubble trails, opened their mouths more, and were visibly startled more frequently while viewing a spontaneously surprising stimulus. Contrary to hypotheses, the subjects did not behave differently when shown an expectation-violating stimulus compared to a control stimulus. The results of this study provide insight into individual differences in

dolphins’ curiosity-related behavior and stimuli that elicit the curiosity of these animals, both of which can improve environmental enrichment and the welfare of dolphins in human care.

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DEDICATION

To Rehman - Thank you for believing in me and sharing this adventure with me.

To my family - This would not have been possible without your encouragement and support of my aspirations. Thank you for telling me from such a young age that I could be whatever I set out to be and never doubting my dreams of studying dolphins.

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"Dolphins are curious." This statement is one of the most popular descriptions of these well-known marine mammals ("Dolphins-World," 2014). Other adjectives used to describe dolphins, such as "intelligent" and "playful," are currently the subject of scientific investigation and are important to define for the future study of marine mammal behavior and cognition. Similarly, the nature of dolphins' curiosity is also important for future study and understanding of this species but has not been well characterized by the existing research literature.

Birds, rats, non-human primates, and fish have all been the subject of research aimed at identifying personality traits, such as neophobia (fear of novelty) and neophilia (affinity for novelty), and placing individuals along the shy-bold continuum (Dellu, Mayo, Piazza, Le Moal, & Simon, 1993; Hughes, 1997; Wilson, Clark, Coleman, & Dearstyne, 1994). These studies generally use an open field test or measure an individual's reaction to a novel object in order to determine the individual's level of curiosity. Another paradigm, called violation of expectations (VOE), has been used in research with several species of non-human primates and young children to determine if an event is perceived as unexpected. In this paradigm, the length of time a subject spends looking at an event that violated expectations or exploring the object from the event is compared to the subject's reaction to an event that does not violate expectations. The differences in behavior between the two conditions increase our understanding of what the subject finds interesting and understands about the world, as individuals are likely to have a longer gaze duration for an unexpected event. (Hauser & Spaulding, 2006; Santos, Barnes, & Mahajan, 2005; Stahl & Feigenson, 2015).

The proposed study aims to explore what dolphins find interesting and examine individual differences in curiosity. Curiosity can be an adaptive trait that fosters creativity, innovation, and adaptation to novel stimuli (Byrne, 2013; Kuczaj, in press). Given the complex social and ecological environment of dolphins, curiosity is likely to be a beneficial trait for finding food and learning about other conspecifics. For the present study, it is hypothesized that some dolphins will be more curious than others, dolphins will find some types of events to be more interesting than other types, and dolphins will display their curiosity in different ways.

Measuring Curiosity

Curiosity in humans has been defined a number of ways and can be broken into various subcomponents, including knowledge-seeking and sensation-seeking, which are both part of the perceptual curiosity construct (Collins, Litman, & Spielberger, 2004). Humans not only seek to investigate unfamiliar stimuli using their senses, but they also seek causal explanations for why something happens. A general definition of curiosity is a trait-like disposition and a state of subjective uncertainty, both of which lead to exploratory behavior (Byman, 2005). The trait of curiosity in humans is predominately assessed through questionnaires completed by the study subjects themselves with limited analysis of a person's behavior from an observer's perspective (Byman, 2005).

In contrast, research on curiosity in animals relies on observable behaviors such as exploration of new spaces or manipulation of novel objects, both of which are considered indicative of curiosity (Glickman & Sroges, 1966). Previous literature examining intrinsic exploration has employed methods of elevated mazes, open fields, novel objects, tasks that must be completed for an environmental change, and forced choice tasks; however, for an accurate measure of curiosity, a free choice test should be used, which does not require learning a particular response (Hughes, 1997). In this experimental design, subjects can choose to devote time and interest to a particular stimulus or avoid it in a way that is not dependent on a previously learned task.

Curiosity as a Trait

Shyness and boldness are often discussed as traits that can be possessed by humans and animals, where individual variation exists in an organism's tendency to seek novelty (Wilson et al., 1994). Within a population, it is beneficial to have some individuals who are willing to take risks with the benefit of finding new resources, while other individuals remain sheltered from novelty and possible danger (Wilson et al., 1994). Wilson et al. (1994) discussed several mechanisms for this variation including genetics, experience, and population density. Though an individual may be classified as shy or bold, it is important to note that the traits of neophobia and neophilia do not lie on the same continuum, but are both factors influencing an individual's propensity for exploration (Reader, 2015). For example, a novel stimulus in the environment may trigger vigilant behavior in a neophilic animal, but if that same individual is also neophobic, it will avoid interaction with the stimulus (Greenberg & Mettke-Hofman, 2001).

An additional distinction that is important to make is that exploration and search are unique components of curiosity (Reader, 2015). While exploration does not necessarily have a particular goal, search is focused on gathering information about a specific stimulus. Furthermore, intrinsic motivation involves the gathering of information, which may be used in future scenarios, but is not directly linked to present goals (Reader, 2015). Examining curiosity in a variety of species can reveal important information about cognitive processes, survival strategies, and what types of information are useful to a particular species (Byrne, 2013).

Kuczaj (in press) argued that curiosity is a catalyst for creativity and innovation in many species. The drive to explore and investigate novelty and unfamiliar situations is what leads individuals to discover new foraging techniques or behavioral traditions such as sweet potato washing in Japanese monkeys or the ability of great tits (Parus major) and blue tits (Cyanistes caeruleus) to open milk bottles. Furthermore, individual differences of curiosity within a species influence the behavioral diversity of individuals and other group members (Kuczaj, in press). In particular, the "watchful cautious" animals may benefit most from the curiosity of group mates because they observe a bolder individual's interaction with some novelty while avoiding potential risks themselves. In Kuczaj, Yeater, and Highfill (2012), some dolphins hid behind other individuals and looked over the bold individual's "shoulder" as they interacted with a novel device that produced bubble rings. These "watchful cautious" animals later interacted with the bubbles themselves, but they seemed to use the behavioral reactions from peers as cues to guide their own interactions. Future research on individual differences in curiosity will help to reveal the importance of this trait in the ability of individuals, social groups, and species to be innovative and creative (Kuczaj, in press).

Individual differences in curiosity-related measures have been reported in a number of other species and contexts. Research has found that age, sex, and experience influence how rats respond to novel objects (Renner, Bennett, & White, 1992; Renner, 1987). Comparable to previous models of rat personality, the personality model in the great tit also includes measures of exploratory behavior that are influenced by age and sex (Groothuis & Carere, 2005). Other studies of avian behavior have found that individuals vary on measures of neophobia, exploration, and innovation as well. Curiosity-related traits are beneficial for a species of neotropical raptor because curiosity allows the birds to discover new resources and foraging techniques and adapt to a variety of conditions (Biondi, Bó, & Vassallo, 2010). Individual variation on traits of curiosity benefits a population because some individuals will be more open to exploration of new resources and other individuals will be more neophobic and less likely to be in dangerous situations.

Curiosity as a personality trait has also been explored in non-human primates. Chimpanzees have stable personality traits, including boldness and exploration persistence, that remain consistent over a wide variety of contexts (Massen, Antonides, Arnold, Bionda, & Koski, 2013). Personality factors in chimpanzees have been corroborated with behavioral data collected by independent observers, supporting the predictive validity of ratings by caregivers (Freeman et al., 2013). Boldness, exploration persistence, extraversion, and openness decrease as animals age, similar to personality change as humans age (King, Weiss, & Sisco, 2008; Massen et al., 2013). The above discussion of animal personality describes individual differences in behavior as recorded by human observers or the result of an experiment. Another area of research focuses on providing effective environmental enrichment for animals in zoological facilities and adds to the discussion of assessing curiosity.

The introduction of novel stimuli is often used by zoological facilities to create a variable environment and reduce stereotypic behavior of animals. A study on the effects of environmental enrichment in mink found that while some individuals examined and manipulated novel objects placed in the habitat, other animals, who had previously exhibited more stereotypic behavior, became inactive and avoided the novelty (Dallaire, Meagher, & Mason, 2012). Because the above research revealed individual differences in how animals react to novelty, it is important for zoological facilities to become knowledgeable of these differences in order to better care for the animals.

Unlike research in birds, chimpanzees, and mink, no systematic behavioral observations have been conducted for cetaceans on measures of curiosity. Previous research on personality in bottlenose dolphins (hereafter referred to as dolphins) has relied upon ratings by humans familiar with the study subjects (Highfill & Kuczaj, 2007; Kuczaj, Highfill, & Byerly, 2012). One goal of the proposed study is to investigate behaviors associated with curiosity that can be used to compare differences between individuals and the species as a whole. Recently, one study assessed the response of dolphins to several types of environmental enrichment and found individual variation in how often they interacted with each type of enrichment (Eskelinen, Winship & Borger-Turner, 2015). In another study, dolphins displayed individual differences in the total number of interactions with a novel object, though the specific behaviors associated with the interactions are not reported (Lopes, Borger-turner, Eskelinen, & Kuczaj, 2016). Although dolphins are often labeled as curious, some dolphins are more likely than others to explore and show interest in novel stimuli (Kuczaj, Highfill, & Byerly, 2012). Thus, the hypotheses for this study are that while most dolphins will be interested in the novel stimuli of the experiment, some dolphins will be more curious than others and certain stimuli may be more interesting than other stimuli that are presented to the dolphins.

Additionally, an individual's social status may influence his or her interaction with environmental enrichment. In a study of dolphins' ability to cooperate and a study that involved dolphins solving an underwater maze, dominant animals in each study appeared to monopolize the experimental apparatus such that subordinate animals interacted with the apparatus less and were less likely to solve the problem (Clark, Davies, Madigan, Warner, & Kuczaj, 2013; Kuczaj, Winship, & Eskelinen, 2015). The subordinate animals were not necessarily less curious, but social factors may have kept them from displaying their curiosity.

Violation of Expectations

One reason animals may be curious about an external stimulus is that it is unfamiliar to them. In much of the research on curiosity, novel objects are placed in the animal's environment and the subject's reaction is recorded (Glickman & Sroges, 1966). Another stimulus that could be unfamiliar to an animal is an event that is in some way different than previous events the animal has experienced. Piaget (1952) described a similar situation with human infants as a "moderately discrepant" event because although part of the event is familiar to the individual, there is some aspect of it that is unfamiliar. Infants begin integrating new information from the environment with their existing schemas at an early age and eventually test the properties of objects during play in order to better understand them (Piaget, 1952). Dolphins' play is also reflective of the learning that Piaget described (Kuczaj & Eskelinen, 2014; Kuczaj, Makecha, Trone, Paulis, & Ramos, 2006). When playing with bubbles, some dolphins modify their behavior in order to learn about the properties of the bubbles, highlighting the significance of play in cognitive development and knowledge acquisition.

Being able to determine what is surprising to a particular animal reveals what expectations the animal might have about different aspects of the physical world such as object permanence, gravity, or numerosity (Needham & Baillargeon, 1993; Santos et al., 2005; Wang, Baillargeon, & Brueckner, 2004). This paradigm, known as violation of expectations (VOE), has been used primarily to determine what infants and non-human primates understand about the world (Hauser & Spaulding, 2006; Povinelli & Dunphy-Lelii, 2001; Stahl & Feigenson, 2015). The studies conducted thus far explore a broad range of scenarios and even go so far as to examine in which species and at what age individuals explore the causality of expectation-violating events.

Young children spend increasing amounts of time exploring novel stimuli as the complexity of the stimuli increases, indicating that children not only recognize novelty in their environment, but also devote attention that is proportional to how much new information is present (Switzky, Haywood, & Isett, 1974). By 4.5 months of age, humans understand that support is necessary to keep objects from falling. Infants spend more time looking at a stimulus that violates an expectation, such as a box remaining suspended in the air, even though a hand released it, compared to situations where a box falls when it is released or a box is continuously held (Needham & Baillargeon, 1993). Further research has found that 4-month-old infants understand size properties of hidden objects, as the infants spend more time looking at objects that seem to disappear in or behind another object that is too small to conceal the first object (Aguiar & Baillargeon, 2003; Wang et al., 2004). The VOE paradigm has also been used to argue that children as young as 5-months-old can perceive that a self-propelled box has a goal (Luo & Baillargeon, 2008).

Further extrapolation of this paradigm tested infants' tendency to learn about objects that had violated the infants' expectations. In paradigms that displayed properties of object support, object solidity, and object behavior, it was found that 11-month-old infants learned more about objects that had violated their expectations, and, when given the opportunity, the infants spent more time interacting with the expectation-violating object and specifically tested the property of the object that was violated (Stahl & Feigenson, 2015). For example, if infants saw a toy truck pushed off the edge of a shelf, but the truck remained suspended in mid-air, the infants later dropped the truck repeatedly. In another part of the study, when infants saw a ball that appeared to roll through a solid piece of wood and then heard the ball make a sound, they were more likely to attribute the specific sound to the ball versus another sound that was paired with an object that did not violate expectations. These results demonstrate that expectation-violating events are quick to catch the attention of infants, thereby encouraging information-seeking behavior. In the case of 11-month-old infants, enhanced learning and increased exploratory behavior results from the curiosity generated by violated expectations. In the present study, it was expected that dolphins would be more likely to look at the object that was involved in the violation when given the option of looking at both the object that violated expectations and the objects that did not.

Children often seek causal explanations for events or stimuli about which they are curious. When shown categories of objects that either activated a light or did not, children, ages 2-6 years, engaged in hypothesis testing for objects that appeared to violate previously demonstrated properties of functionality (Legare, 2012). In a separate study, children were told to stand a wooden cylinder on its end in a specific area in order to receive a reward (Povinelli & Dunphy-Lelii, 2001). In a test trial, the ends of the cylinder were rounded instead of flat, making it impossible for the cylinder to stand without support. Children, ages 3-5 years, sought causal explanations for this apparent discrepancy by looking at or touching the end of the blocks. The study also compared the behavior of chimpanzees in the same situation. In contrast to the behavior of the children, chimpanzees did not inspect the ends of the blocks but instead continued to try to set the block on end, suggesting that chimpanzees do not seek causal explanations for object behavior in the same manner that young children do. Though the chimpanzees did not seek the same causal explanations, the experimental paradigm did not assess if individuals understood the blocks were no longer functional.

The VOE paradigm has been used to test understanding of physical transformations by free-ranging Rhesus monkeys and found that the monkeys were able to infer causal agents of physical transformations in novel scenarios (Hauser & Spaulding, 2006). For example, the monkeys looked for a longer period of time at an apple that appeared to be cut by a glass of water versus an apple that appeared to be cut by a knife, thus supporting the idea that the Rhesus monkeys can infer that a knife is more likely the causal agent of a cut apple than a glass of water. The authors argue that the subjects were not familiar with and should have no prior associations with the objects used in the experiment, thus demonstrating that monkeys can infer information about a causal agent. Despite the fact that non-human primates may not seek causal explanations for an event or even understand all forms of causality, they may still be aware of what outcomes are more likely to happen in a given situation.

The VOE paradigm has also been used to test understanding of simple arithmetic in lemurs and support relations in rooks (Bird & Emery, 2010; Santos et al., 2005). Both of these studies revealed that at least some animals perceive the world in a similar manner to human infants. Lemurs looked longer at an event where two objects were sequentially occluded but only one was present when the occluding panel was removed and rooks looked longer at an event where an object appeared to float without being supported. Based on research in humans and other species, it was hypothesized that dolphins in the present study would also look longer at expectation-violating events.

Dolphins' Perception of the World

Research on dolphins' sensory abilities and typical behavior patterns is important to consider when investigating dolphin curiosity. Dolphins are able to discriminate between familiar and unfamiliar human individuals, as individual animals spend different amounts of time looking at humans who are unfamiliar versus familiar (Hill, Yeater, Gallup, Guarino, Lacy, Dees, & Kuczaj, 2016; Thieltges, Lemasson, Kuczaj, Böye, & Blois-Heulin, 2011). While the dolphins in Thieltges et al. (2011) looked longer at unfamiliar humans, the dolphins in Hill et al. (2016) looked longer at familiar humans.

The question of object permanence relates to the proposed study because it is important to consider how dolphins react to objects that disappear from view. Previous research indicates that dolphins are able to track objects that have been occluded by a larger object (Jaakkola, Guarino, Rodriguez, Erb, & Trone, 2010; Johnson, Sullivan, Buck, Trexel, & Scarpuzzi, 2014; Singer & Henderson, 2015). This means that dolphins should have a mental representation of an object remaining behind an occluded area when it has not reappeared, even if they expect it to reappear. It also means that they are likely to find it unusual if one object appears to transform into another object while occluded.

Dolphins in the wild and captivity have demonstrated an interest in natural and man-made objects. In a comparison of object play between wild and captive animals, it was found that captive animals spent more time playing with a variety of objects, while the wild dolphins interacted mostly with sand; however, differences in object availability and the amount of time the subjects were within view of the camera were different for each group (Greene, Melillo-Sweeting, & Dudzinski, 2011). Despite environmental and sampling differences, the Greene et al. (2011) findings on age group differences were supported by Eskelinen et al. (2015) who found that young animals interact with environmental enrichment the most. In an analysis of sex differences, Eskelinen et al. (2015) found captive adult males interact more with objects compared to females, while Greene et al. (2011) found wild adult males interact with objects less than wild females. Thus, in the proposed study it was hypothesized that juvenile dolphins and adult males may be more interested in novel objects and novel events compared to individuals, not in these groups; however, an alternative hypothesis was that juveniles may not find the events to violate expectations as frequently as the adult dolphins or, in contrast, the juveniles might be more curious about the experimental apparatus, regardless of the condition.

Dolphins can display surprise in different ways. Some may produce bubble bursts or startle in response to a stimulus. Bubble bursts have been reported as indicative of surprise or play in dolphins and belugas (*Delphinapterus leucas*) when they are solving a puzzle, witnessing surprising or unexpected events, or playing (Clark et al., 2013;

Delfour & Aulagnier, 1997; Hill et al., 2011; Pryor, 1990). Characterizing the reactions of dolphins to surprise events will be an important aspect of this study.

Open mouth behavior has most commonly been reported as an aggressive behavior, occurring simultaneously with head-to-head orientations, s-postures, jaw claps, abrupt vertical head movements, and chasing behavior (Herzing, 1996; Overstrom, 1983). Studies of mirror self-recognition also report open mouth behaviors, some of which are classified as contingency checking behavior and appear different to the aggressive open mouth behavior that occurs in social situations (Marten & Psarkos, 1995; Mitchell, 1995; Reiss & Marino, 2001; Sarko, Marino, & Reiss, 2002). Others have suggested that in non-aggressive contexts, open mouth behaviors may indicate interest and excitement (Dudzinski, 1998; Marten & Psarkos, 1995). It is not expected that open mouth behavior in the present study would indicate aggression, but possibly interest, surprise, and/or excitement in response to the experimental stimuli, as the stimuli are unlikely to invoke aggression.

Given the emphasis on providing enriching and variable environments to captive animals, it is important to consider the significance of how animals react to novel stimuli added to their environment. Research such as that of Eskelinen et al. (2015) seeks to examine what enrichment is the most effective for particular individuals or groups of dolphins. In the case of the Eskelinen et al. (2015) study, adult females interacted with the enrichment less than males. If enrichment is added to a captive environment and the animal chooses to interact with it, this could mean that the animal finds the stimulus more interesting than the environment prior to adding enrichment, but does not necessarily mean that the animal was bored before the stimulus was added. Research by Dallaire et al. (2012) suggests that interaction with a new stimulus indicated that the animal had been bored prior to the introduction of novelty. In contrast, Fureix and Meagher (2015) discuss how activity levels do not necessarily correlate with boredom. A bored animal could be active by engaging in stereotypic behavior such as circle swimming or could remain still in the corner of the enclosure. Alternatively, an animal could be mentally engaged while swimming, perhaps by visually investigating people outside the enclosure, or the animal could be still because it is contently resting after a meal. It appears, then, that animals that are bored could be more likely to examine the events presented during the present study. Additionally, animals that were not bored may have had more engaging stimuli in their environment and thus may not have attended to the stimuli presented as part of this study. In any case, the study reported here did not aim to determine if boredom played a role in individuals' interest in the stimuli of the present study, as this would have required more extensive behavioral observation.

Purpose of Study

In order to explore individual differences in curiosity and determine if dolphins find certain events to violate expectations in a similar way to previous research in other species, a two-part study was conducted. The first part aimed to explore how dolphins responded to a surprising event, which was a jack-in-the-box. The second part aimed to explore how dolphins reacted when viewing an event that is hypothesized to violate expectations of object continuity, specifically when an object passed through an opaque part of a tube and appeared to transform to another object. The hypotheses of this study were: a) the dependent variable of gaze duration will be longer for events and objects that are surprising and violate expectations; b) there will be other behaviors in addition to extended looking time, such as bubble bursts, bubble trails, open mouth behaviors, and startle responses that will also occur more often in trials where a surprising or expectation-violating event occurs; c) there will be individual differences in displays of curiosity behavior.

CHAPTER II - METHODS

In order to examine individual differences in dolphins' curiosity and how dolphins react to surprising events, spontaneously surprising and VOE events were displayed for subjects to watch and their reactions were recorded. This study was conducted in two experiments. The first experiment involved a spontaneously surprising event (jack-in-the-box), while the second experiment involved an event where one object appeared to transform to a different object when it passed behind an opaque barrier.

The subjects of this study were 15 bottlenose dolphins (*Tursiops truncatus)* and 6 rough-toothed dolphins (*Steno bredanensis*) housed at Gulf World Marine Park in Panama City Beach, Florida. See Table 1 for a list of subjects' species, sex, and age. Estimated age is used for individuals who were stranding rescues and age classes were defined as calf (0-2 years), juvenile (3-7 years), sub-adult (8-10 years), and adult (11+ years), per Lopes et al. (2016). All twenty-one subjects completed the first experiment of the study; however, 4 subjects were excluded from the second experiment, due to two subjects not being present in the habitat and two subjects' failure to observe trials from each of the three conditions.

Procedure

Data was collected opportunistically when one or more animals were present in front of the underwater window where the study was conducted and dolphins were free to approach or swim away from the window at any time during the trial. The experimental apparatus included an opaque screen placed in front of an underwater habitat window. The screen was in place 5 minutes prior to the start of each experimental session to allow for habituation to the screen.

Table 1

Subjects in Experiment One

Subject ID	**Species**	**Sex**	**Age Class**
1	Bottlenose	F	Calf
2	Bottlenose	F	Adult
3	Bottlenose	M	Adult
4	Bottlenose	F	Juvenile
5	Bottlenose	M	Adult
6	Bottlenose	F	Calf
7	Bottlenose	F	Adult
8	Bottlenose	M	Juvenile
9	Bottlenose	F	Adult
10	Bottlenose	F	Adult
11	Bottlenose	M	Juvenile
12	Bottlenose	F	Adult
13	Bottlenose	F	Juvenile
14	Bottlenose	M	Juvenile
15	Rough-toothed	M	Adult
16	Rough-toothed	F	Adult
17	Rough-toothed	M	Adult
18	Rough-toothed	F	Sub-adult
19	Rough-toothed	F	Adult
20	Rough-toothed	M	Juvenile
21	Bottlenose	M	Juvenile

In the first phase of the experiment (Table 2), the subjects were shown two different objects, a static cylinder, and a jack-in-the-box. After the habituation period, the first condition began with the control object displayed in front of the opaque screen for 5 minutes, during which time a musical tune was played from the object. The control object was a cylinder that remained stationary and emitted music (Fig. 1). After a 5-minute trial was completed, the music stopped and the object was removed. After a period of 1 minute, the experimental object was placed in front of the screen for a 5-minute trial. The experimental object was a square box and the surprising event was a small stuffed character popping out of the box when an animal was within 2 meters of the object (Fig. 2). The experimental object played a musical tune that was different from tune for the control object. After the object emerged, the box was reset after 1-2 seconds. It was then opened again after a random amount of time between 1 and 15 seconds had passed or once a dolphin approached within 2 meters of the object, whichever happened first. For every trial, a video recording was taken from the perspective of the opaque screen.

Figure 1. Control object

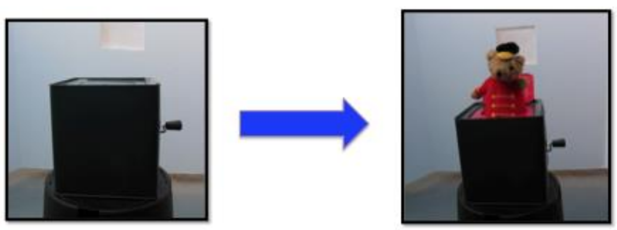

Figure 2. Experimental object with surprise event

Each subject or group was shown one of each trial per day, for 5 days. The presentation of conditions was counterbalanced so that on some days, subjects were first presented with the control object followed by the jack-in-the-box, and on other days, the presentation order was reversed. During a test trial, conducted 24 hours after the last trial, the surprising and non-surprising stimuli were both placed in front of the underwater viewing window equidistant from the center of the opaque screen where the camera was located. The jack-in-the-box was not opened during the test trial. Video recordings were taken for a 5-minute trial for each subject.

Table 2

Overview of Procedure for Experiment One

1. Set up opaque screen in front of underwater glass viewing window.
2. Display experimental object for 5 minutes, with a surprise event when animal approaches (random interval between 1 and 15seconds).
3. Wait one minute with no object present.
4. Display control object for 5 minutes.
5. Repeat the above procedure once every day for 5 days, alternating object order.
6. On day 6, display objects in a test trial where both objects are present for 5 minutes.

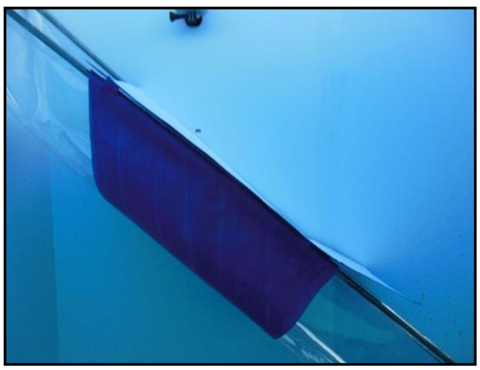

Figure 3. Apparatus for VOE paradigm

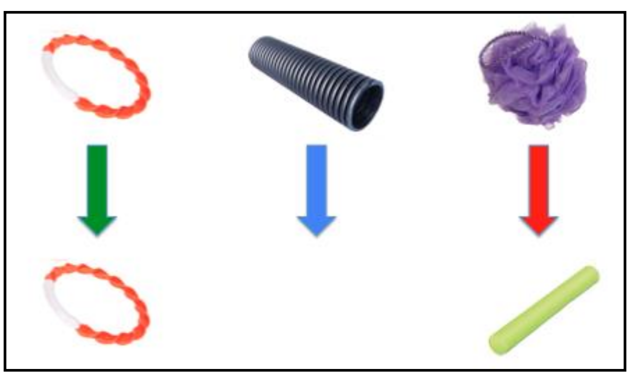

Figure 4. Object Transformations 1, 2, and 3

The second phase of the experiment aimed to use the concept of an event violating the subjects' expectations to also create a surprise reaction (Table 3). The experimental setup consisted of a clear plastic tube that was 20cm in diameter and one meter tall. In the middle of the tube was a 30cm long opaque section (Fig. 3). This tube was positioned diagonally in front of the screen that was used in the first phase of the study and positioned to be in front of an underwater viewing window. Each subject was exposed sequentially to 3 different conditions with 5 trials for each condition. If individuals saw partial trials, enough trials were conducted such that each individual saw 5 full trials of each condition before the test condition. All trials were video recorded for 30 seconds following the object transformation.

Table 3

Overview of Procedure for Experiment Two

1. Set up opaque screen and apparatus in front of underwater glass viewing window.
2. Display opaque screen for 5 minutes.
3. Display object transformation 1, as animal approaches.
4. Wait 30 seconds or until animal approaches again.
5. Display object transformation 2.
6. Wait 30 seconds or until animal approaches again.
7. Display object transformation 3.
8. Repeat the above procedure 5 times.
9. Display all 3 objects in a test trial for 5 minutes.

In the first condition, a control object was dropped into the tube when a dolphin approached within 2 meters. The object fell through the tube and passed through the opaque section to land at the bottom of the tube. In the second experimental condition, the object fell down the tube but did not reappear after the opaque section. In the third experimental condition, an object was dropped into the tube and disappeared into the opaque section but another object appeared from the opaque section and fell to the bottom of the tube. After 5 trials of each condition were completed, a test trial was conducted where all three objects that were initially dropped were placed in front of the window for 5 minutes and the behavior of the dolphins was video recorded. The objects used for this phase, shown in Figure 4, were chosen in consultation with animal care staff and were familiar to the subjects; however, objects were counterbalanced in which transformation condition they are assigned to for each group of individuals typically housed together to control for any effects due to a particular object in a particular transformation condition.

Finally, trainers familiar with each subject completed personality ratings for 12 items related to curiosity. The data collection sheet is displayed in Appendix A.

Video Analysis

Gaze duration was defined as the amount of time a dolphin, using the subject's eye as a reference point, was clearly visible from the perspective of the experimental set-up. Every time a subject approached the apparatus, the subject's identification was noted along with the length of time the subject's eye was visible, and frequency of open mouths, bubbles trails, bubble bursts, and startle responses. See Table 4 for data recording. In the test trials of each phase, gaze duration for each object was recorded, as well as number of orientations, open mouths, and bubble behaviors directed at each object. Reliability between two independent coders was established to be at least .8 (80%) on 20% of the data for each of the behaviors analyzed.

Table 4

Data Coded for Each Visit

	Codes	**Explanation**
Condition	SURCON	Surprise Control
	SUREXP	Surprise Experimental
	SURTEST	Surprise Test
	VOEONE	Violation of Expectation Condition 1: Object to same object
	VOETWO	Violation of Expectation Condition 2: Object to nothing
	VOETHREE	Violation of Expectation Condition 3: Object to other object
Trial #	1-5 or test	
Subject ID	1-21	
Gaze Duration	1-?	In seconds the amount of time subject is <2m from apparatus
Open Mouths	0-?	Subject's mouth is open if >10°
Bubble Trail	0-?	Subject releases bubbles in trail
Bubble Burst	0-?	Subject releases in burst
Startle Response	0-?	Number of times the subject is visibly flinches
Test Trial Only		
Surprise	Time Con	In seconds, duration that subject is within 2m and closest to control object
	Time Exp	In seconds, duration that subject is within 2m and closest to experimental object
VOE	Time ONE	In seconds, duration that subject is within 2m and closest to control object 1
	Time TWO	In seconds, duration that subject is within 2m and closest to object 2
	Time THREE	In seconds, duration that subject is within 2m and closest to control object 3

Statistical Analysis

In experiment one, 21 subjects participated (9 males, 12 females) with ages ranging from 4-months-old to 32-years-old. These subjects are listed in Table 1. The independent variables consisted of condition, sex, and species. The dependent variables analyzed consisted of gaze duration measured as a percentage of time the subject was exposed to the stimuli, number of open mouth behaviors displayed in a five-minute trial, number of bubble trail behaviors displayed in a five-minute trial, number of bubble burst behaviors displayed in a five minute trial, and number of startle responses displayed in a five minute trial. The data were average for each individual's trials within each condition. A log transformation was performed on the data for each dependent variable in this experiment because data for each of these variables had a severely positively skewed distribution. Mixed ANOVAs were performed for each dependent variable using sex, species, and condition as independent variables. In an exploratory examination of differences between subjects, mixed ANOVAs were conducted for each dependent variable using condition and subject identity as independent variables. An additional mixed ANOVA examined age differences across conditions for gaze duration. These analyses are reported at the end of the results sections.

In experiment two, 17 subjects participated (8 males, 9 females) with ages ranging from 4-months-old to 32-years-old. Two of the subjects in experiment one were not present at the time of experiment two, and two other subjects did not complete trials in all three experimental conditions and were thus excluded from analyses for experiment two. The included subjects are listed in Table 5. The independent variables in experiment two consisted of three different object transformation conditions, sex, and species. The dependent variables consisted of gaze duration measured in seconds, number of open mouth behaviors displayed in a 30-second trial, number of bubble trail behaviors displayed in a 30-second trial, and number of bubble burst behaviors displayed in a 30-

second trial. No startle responses were recorded in part two of the experiment. The data were averaged for each individual's trials within each condition. Data for each of these variables, excluding gaze duration, had a severely positively skewed distribution. Therefore, a log transformation was performed on the data for open mouth, bubble trail, and bubble burst behaviors in experiment two. Mixed ANOVAs were performed for each dependent variable using sex, species, and condition as independent variables. In an exploratory examination of differences between subjects, mixed ANOVAs were conducted for each dependent variable using condition and subject identity as independent variables. These analyses are reported at the end of the results sections.

Data for ratings was first analyzed using principle axis factoring to determine factor loadings. Scores for each factor found were calculated for all subjects and then these scores were correlated with measures of gaze duration.

Additionally, repeated measures ANOVAs were conducted for the test trials, in which subjects were shown all stimuli simultaneously for a period of 5 minutes. Eleven subjects participated in the test trial for experiment one and 12 subjects participated in the test trial for experiment two.

Table 5

Subjects in Experiment Two

Subject ID	**Species**	**Sex**	**Age Class**
1	Bottlenose	F	Calf
2	Bottlenose	F	Adult
3	Bottlenose	M	Adult
4	Bottlenose	F	Juvenile
5	Bottlenose	M	Adult
7	Bottlenose	F	Adult
8	Bottlenose	M	Juvenile
9	Bottlenose	F	Adult
10	Bottlenose	F	Adult
11	Bottlenose	M	Juvenile
12	Bottlenose	F	Adult
13	Bottlenose	F	Juvenile
14	Bottlenose	M	Juvenile
15	Rough-toothed	M	Adult
17	Rough-toothed	M	Adult
19	Rough-toothed	F	Adult
21	Bottlenose	M	Juvenile

CHAPTER III – RESULTS

Experiment One: Condition, Sex, and Species Differences

A mixed ANOVA was conducted to compare differences in gaze duration between conditions and sex. Box's M was violated (p<.05), but Levene's test was not violated for either condition (p>.05), which means that the results should be interpreted with slight caution. No significant interaction between condition and sex was found, F (1,19) = .009, p=.925, η^2= .000, nor was there a significant main effect of sex, F (1,19) = 1.563, p=.226, η^2= .076, with males (Control: M= 4.1340, SD= 3.55026; Jack-in-the-box: M= 9.4471, SD= 6.98539) not having a significantly shorter percent of time gazing at stimuli than females (Control: M= 10.6850, SD= 14.31577; Jack-in-the-box: M= 16.5285, SD= 19.15922), as displayed in Figure 5. There was a significant effect of condition, F (1,19) = 12.660, p<.01, η^2= .400, with a significantly greater percentage of gaze duration for the Jack-in-the-box condition (M= 13.4936, SD= 15.30701) compared to the control condition (M=7.8774, SD= 11.34879), as displayed in Figure 6.

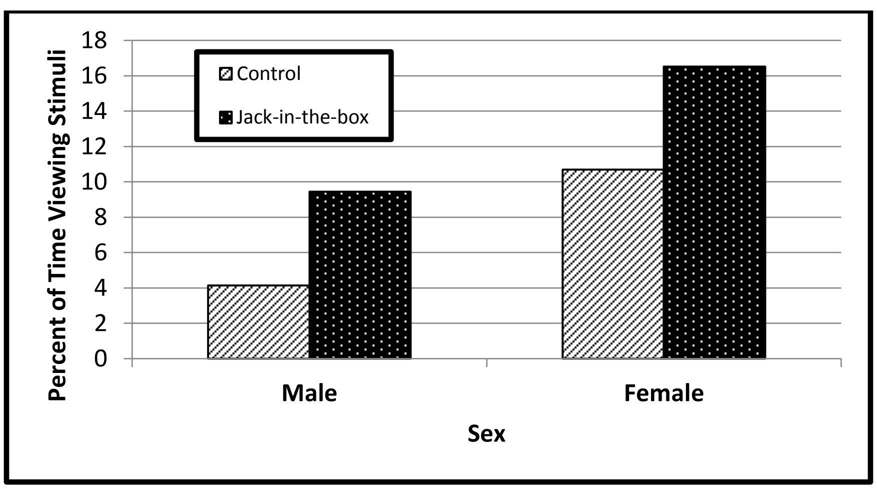

Figure 5. Gaze Duration Across Sex and Condition

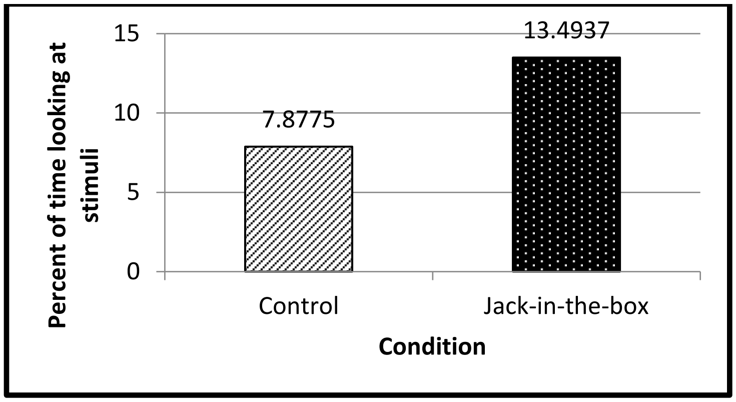

Figure 6. Gaze Duration in Each Condition

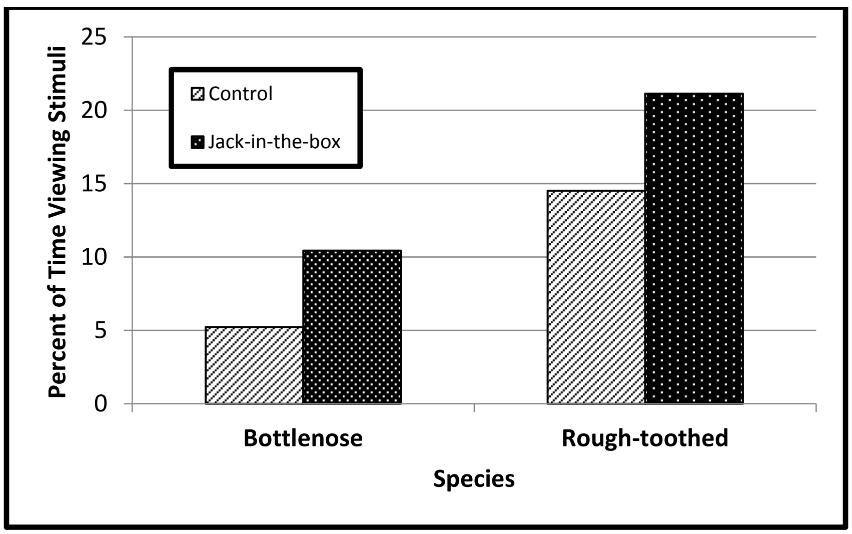

Figure 7. Gaze Duration Across Species and Condition

A mixed ANOVA was also conducted to compare differences in gaze duration between conditions and species. Box's M was violated (p<.05), and Levene's test was also violated for the control condition (p>.05), but was not violated for the jack-in-the-box condition (p<.05), which means that the results should be interpreted with caution. There was no significant interaction between condition and species, F (1,19) = .154, p=.700, η^2= .008, nor was there a significant main effect of species, F (1,19) = 2.453, p=.134, η^2= .114, with bottlenose dolphins (Control: M= 5.2223, SD= 3.63144; Jack-in-the-box: M= 10.4379, SD= 8.58092) not having a significantly shorter percent of time gazing at stimuli than rough-toothed dolphins (Control: *M*= 14.5153, *SD*= 20.10551; Jack-in-the-box: *M*= 21.1330, *SD*= 25.15955), as displayed in Figure 7.

The frequency of the open mouth behavior was compared across condition and sex using a mixed ANOVA. Box's M was violated ($p<.05$), but Levene's test was not violated for either condition ($p>.05$), which means that the results should be interpreted with slight caution. No significant interaction between condition and sex was found, F (1,19) = .045, p=.833, η^2= .002, nor was there a significant main effect of sex, F (1,19) = .779, p=.388, η^2= .039, with males (Control: *M*=.4687, *SD*= .48053; Jack-in-the-box: *M*= .9276, *SD*= .84202) not having significantly more open mouths per trial females (Control: *M*= .6758, *SD*= .91087; Jack-in-the-box: *M*= 1.3913, *SD*= 2.10360). There was a marginally significant effect of condition, F (1,19) = 3.685, p=.070, η^2= .162, with a significantly greater number of open mouths per trial for the Jack-in-the-box condition (*M*= 1.1926, *SD*= 1.66515) compared to the control condition (*M*=.5870, *SD*= .74815), as displayed in Figure 8.

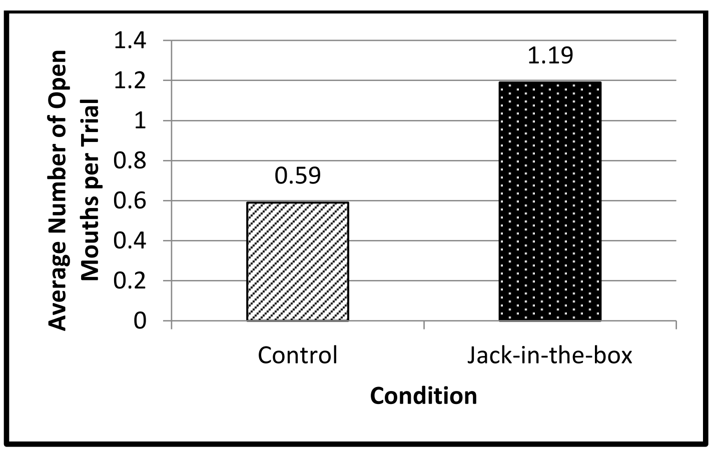

Figure 8. Number of Open Mouths in Each Condition

A mixed ANOVA was used to compare the frequency of open mouth behavior across condition and species. Levene's test was violated for the control condition ($p<.05$), but was not violated for the jack-in-the-box condition (*p*>.05), which means that the results should be interpreted with caution. No significant interaction between condition and species was found, F (1,19) = .503, p=.487, η^2= .026, nor was there a significant main effect of species, F (1,19) = 1.706, p=.207, η^2= .082, with bottlenose dolphins (Control: *M*= .7299, *SD*= .83245; Jack-in-the-box: *M*= 1.51193, *SD*= 1.84849) not having significantly less more open mouths per trial rough-toothed dolphins (Control: *M*= .2300, *SD*= .29050; Jack-in-the-box: *M*= .3757, *SD*= .63440).

The frequency of bubble trails produced per trial was compared between condition and sex using a mixed ANOVA. Box's M was violated (*p*<.05), but Levene's test was not violated for either condition (*p*>.05), which means that the results should be interpreted with slight caution. No significant interaction between condition and sex was found, F (1,19) = .473, p=.500, η^2= .024, nor was there a significant main effect of sex, F (1,19) = .396, p=.537, η^2= .020, with males (Control: *M*=.3736, *SD*= .34058; Jack-in-the-box: *M*= 1.0218, *SD*= 1.14341) not having significantly less bubble trails per trial females (Control: *M*= .9555, *SD*= 2.31600; Jack-in-the-box: *M*= 1.2898, *SD*= 3.26562). There was no significant effect of condition, F (1,19) = 1.313, p=.266, η^2= .065, with no significantly greater number of bubble trails per trial for the Jack-in-the-box condition (*M*= 1.17506, *SD*= 2.53116) compared to the control condition (*M*=.7061, *SD*=1.75602).

A mixed ANOVA was conducted to compare the frequency of bubble trail production between species and condition. Box's M was violated (*p*<.05), but Levene's test was violated for both condition (*p*<.05), which means that the results should be interpreted with caution. No significant interaction between condition and species was found, F (1,19) = 3.193, p=.090, η^2= .144, nor was there a significant main effect of species, F (1,19) = 3.193, p=.090, η^2= .144, with bottlenose dolphins (Control: M=.4092, SD= .57427; Jack-in-the-box: M= .6391, SD= .97307) not having significantly less bubble trails per trial rough-toothed dolphins (Control: M= 1.4483, SD= 3.23812; Jack-in-the-box: M= 2.5147, SD= 4.46772). Though the above tests of species differences in bubble trails are not significant, they are should be investigated in future research due to a relatively low p-value.

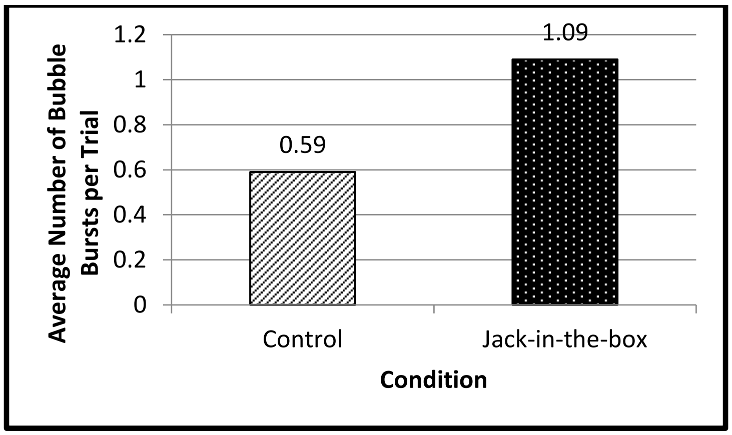

Figure 9. Number of Bubble Bursts in Each Condition

The frequency of bubble burst production was compared across sex and condition using a mixed ANOVA. Box's M was violated (p<.05), but Levene's test was not violated for either condition (p>.05), which means that the results should be interpreted with slight caution. No significant interaction between condition and sex was found, F (1,19) = 2.225, p=.152, η^2= .105, nor was there a significant main effect of sex, F (1,19) = 1.773, p=.199, η^2= .085, with males (Control: M=.1976, SD= .39315; Jack-in-the-box: M= .4911, SD= .37743) not having significantly less bubble trails per trial than females (Control: M= .8852, SD= 1.52583; Jack-in-the-box: M= 1.5327, SD= 2.32566). There was a significant effect of condition, F (1,19) = 4.361, p=.050, η^2= .187, with a significantly greater number of bubble bursts per trial for the Jack-in-the-box condition

(M= 1.0863, SD= 1.81954) compared to the control condition (M=.5905, SD=1.20991), as seen in Figure 9.

A mixed ANOVA was also used to compare frequency of bubble burst production across species and condition. Box's M was violated ($p<.05$) and Levene's test was violated for both conditions ($p<.05$), which means that the results should be interpreted with caution. No significant interaction between condition and species was found, F (1,19) = .054, p=.819, η2= .003, nor was there a significant main effect of species, F (1,19) = 3.078, p=.095, η2= .139, with bottlenose dolphins (Control: M=.2429, SD= .34429; Jack-in-the-box: M= .7443, SD= 1.03012) not having significantly less bubble trails per trial than rough-toothed dolphins (Control: M= 1.4593, SD= 2.06286; Jack-in-the-box: M= 1.9413, SD= 3.00722).

The frequency of startle responses across sex and condition was analyzed using a mixed ANOVA. Levene's test was violated in both conditions ($p<.05$), thus the results should be interpreted with caution. No significant interaction between condition and sex was found, F (1,19) = 1.357, p=.258, η^2= .067, nor was there a significant main effect of sex, F (1,19) = .357, p=.258, η^2= .067, with males (Control: M=.0218, SD=.06533; Jack-in-the-box: M= .2718, SD= .31689) not having significantly more startle responses per trial than females (Control: M= 0, SD= 0; Jack-in-the-box: M= .2385, SD=.38476). Additionally, there was not a significant effect of condition, F (1,19) = 1.357, p=.258, η^2= .067, with no significantly greater number of startle responses per trial for the Jack-in-the-box condition (M= .2528, SD= .34910) compared to the control condition (M=.0093, SD=.04277).

The frequency of startle responses across species and condition was analyzed using a mixed ANOVA. Levene's test was violated in the control condition ($p<.05$) but not the jack-in-the-box condition ($p<.05$), thus the results should be interpreted with caution. No significant interaction between condition and species was found, $F(1,19) = .388$, $p=.541$, $\eta2= .020$, nor was there a significant main effect of species, $F(1,19) = .388$, $p=.541$, $\eta2= .020$, with bottlenose dolphins (Control: M=0, SD=0; Jack-in-the-box: M= .2347, SD= .30515) not having significantly more startle responses per trial than rough-toothed dolphins (Control: M= .0327, SD= .09002; Jack-in-the-box: M= .2980, SD=.47257).

Experiment Two: Condition, Sex, and Species Differences

A mixed ANOVA was used to compare gaze duration across conditions and sexes. Box's M ($p <.05$) was violated; however, Mauchly's test of sphericity ($p>.05$) was not violated and Levene's was not violated for all conditions ($p>.05$), meaning results should be approached with slight caution. No significant interaction between condition and sex was found, $F(2,30) = 2.654$, $p=.087$, $\eta2= .150$, nor was there a significant main effect of sex, $F(1,15) = .025$, $p=.877$, $\eta2= .002$, with males (Condition One: M=14.0750, SD=3.74767; Condition Two: M= 13.5450, SD= 3.29838; Condition Three: M=16.1000, SD=5.13030) not having significantly longer gaze duration than females (Condition One: M=15.2889, SD=6.52925; Condition Two: M= 13.2926, SD= 4.82637; Condition Three: M= 14.0759, SD=4.50123). Additionally, there was a marginally significant effect of condition, $F(2,30) = 3.097$, $p=.060$, $\eta2= .171$, as seen in Figure 10. A post hoc examination with a Bonferroni correction revealed that gaze duration for Condition Two was marginally lower than Condition Three ($p=.061$); however, there were no significant differences between Condition One and Three (p=1.000) or Condition One and Two (p=.398).

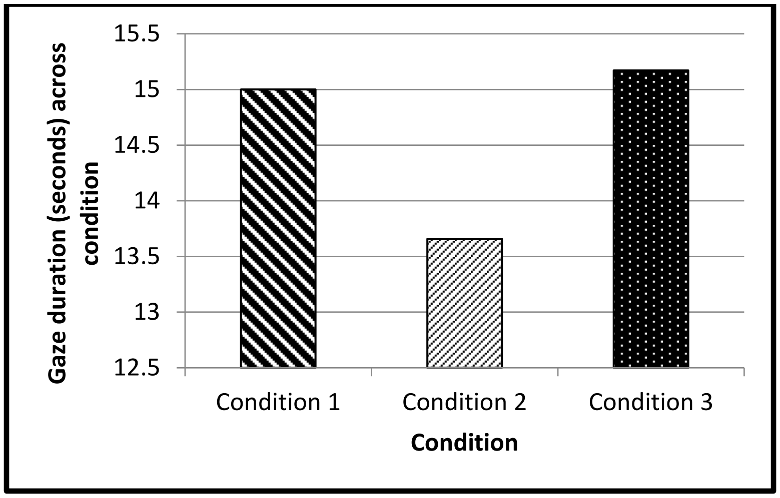

Figure 10. Gaze Duration Between Conditions

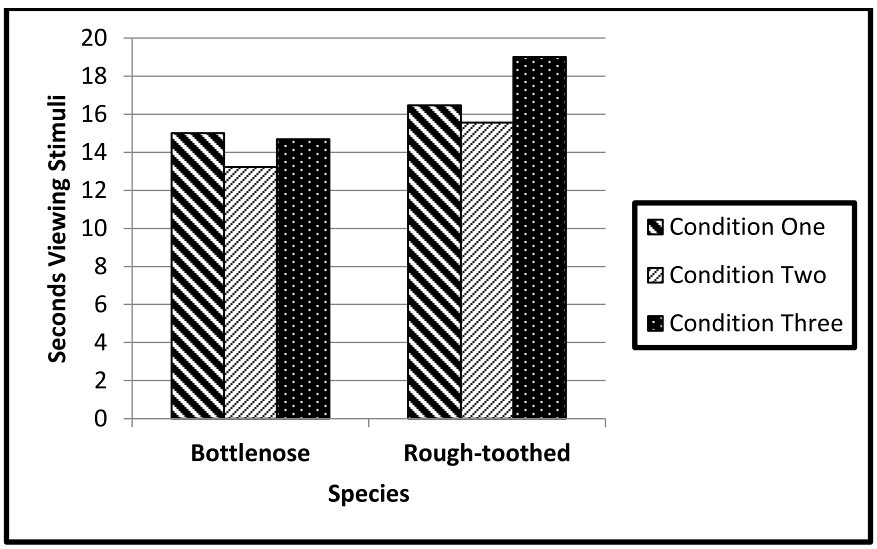

Figure 11. Gaze Duration Across Condition and Species

Differences in gaze duration across species and condition were also examined using a mixed ANOVA. Mauchly's test of sphericity (p>.05) was not violated and Levene's was not violated for all conditions (p>.05). No significant interaction between condition and species was found, F (2,30) = 1.119, p=.340, η^2= .069, nor was there a significant main effect of species, *F* (1,15) = 1.323, *p*=.268, η^2= .081, with rough-toothed dolphins (Condition One: *M*=16.4667, *SD*=4.61447; Condition Two: *M*= 15.5333, *SD*= 5.14328; Condition Three: *M*=19.0000, *SD*=7.11056) not having significantly longer gaze duration than bottlenose dolphins (Condition One: *M*=14.3429, *SD*=5.49037; Condition Two: *M*= 12.9452, *SD*= 3.85586; Condition Three: *M*= 14.1774, *SD*=3.97202). Results are displayed in Figure 11.

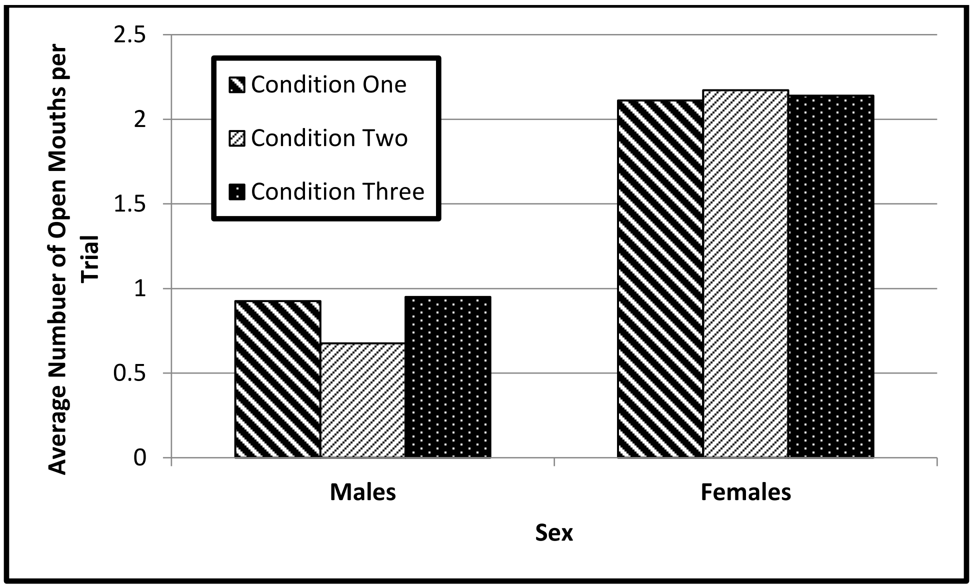

Figure 12. Number of Open Mouths Across Sex and Condition

A mixed ANOVA was used to compare the frequency of open mouths across conditions and sex. Box's M (p >.05) was not violated, Mauchly's test of sphericity (p>.05) was not violated and Levene's was not violated for Condition One and Two (p>.05) but was violated for Condition Three (p <.05), meaning results should be approached with slight caution. No significant interaction between condition and sex was found, F (2,30) = .663, p=.523, η2= .042, nor was there a significant main effect of condition, F (2,30) = .308, p=.737, η2= .020. However, there was a marginally significant main effect of sex, F (1,15) = 4.466, p=.052, η2= .229, with females (Condition One:

M=2.111, SD=1.69738; Condition Two: M= 2.1722, SD= 1.37457; Condition Three: M=2.1389, SD=1.51116) having significantly more open mouths per trial compared to males (Condition One: M=.9250, SD=.59462; Condition Two: M= .6750, SD= .52304; Condition Three: M=.9500, SD=.63920), as seen in Figure 12.

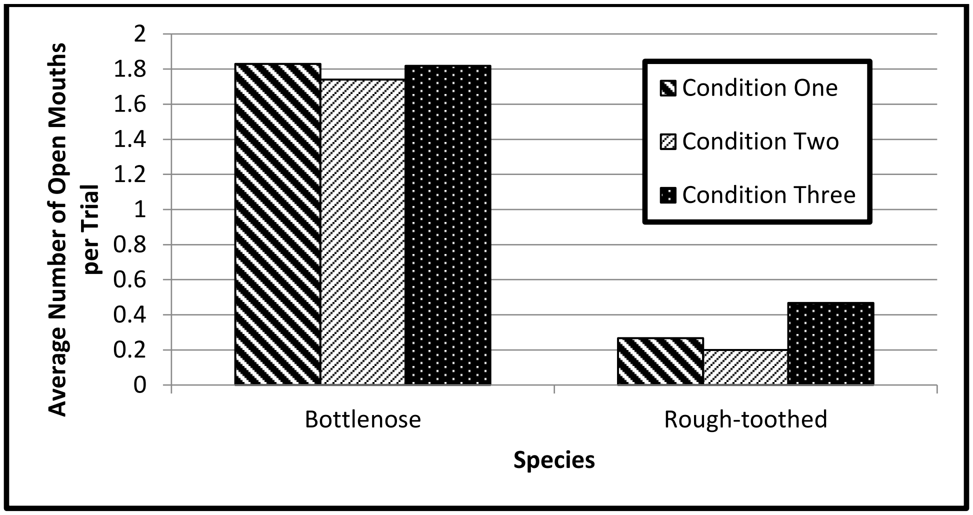

Figure 13. Frequency of Open Mouths Across Species and Condition

Differences in the frequency of open mouth behaviors were also compared across species and condition using a mixed ANOVA. Mauchly's test of sphericity (*p*>.05) was not violated and Levene's was not violated for Condition One and Two (*p*>.05) but was violated for Condition Three (*p* <.05), meaning results should be approached with slight caution. No significant interaction between condition and species was found, *F* (2,30) = .305, *p*=.739, η^2= .020; however there was a significant effect of species, *F* (1,15) =5.036, *p*<.05, η^2= .251, with bottlenose dolphins (Condition One: *M*=1.8286, *SD*=1.38754; Condition Two: *M*= 1.7393, *SD*= 1.25854; Condition Three: *M*=1.8179, *SD*=1.31319) having significantly more open mouths per trial compared to rough-toothed dolphins (Condition One: *M*=.2667, *SD*=.46188; Condition Two: *M*= .2000, *SD*= .20000; Condition Three: *M*=.4667, *SD*=.30551), as seen in Figure 13.

A mixed ANOVA was conducted in order to compare the frequency of bubble trail production across conditions and sex. Box's M (p <.05) was violated; however, Mauchly's test of sphericity (p>.05) was not violated and Levene's was not violated for all conditions (p>.05), meaning results should be approached with slight caution. No significant interaction between condition and sex was found, F (2,30) = .002, p=.998, η^2= .000, nor was there a significant main effect of condition, F (2,30) = 1.091, p=.349, η^2= .068. Additionally, there was no significant main effect of sex, F (1,15) = .546, p=.471 η^2= .035, with males (Condition One: *M*=.2250, *SD*=.34538; Condition Two: *M*= .2250, *SD*=.27124; Condition Three: *M*=.3250, *SD*=.36936) not producing significantly more bubble trails per trial compared to females (Condition One: *M*=.1556, *SD*=.39721; Condition Two: *M*= .1333, *SD*= .28284; Condition Three: *M*=.2667, *SD*=.53852).

The frequency of bubble trail production was also compared across species and condition using a mixed ANOVA. Mauchly's test of sphericity (p>.05) was not violated and Levene's was not violated for Condition Two and Three (p>.05) but was violated for Condition One (p <.05), meaning results should be approached with slight caution. No significant interaction between condition and species was found, F (2,30) = 2.030, p=.149, η^2= .119; however there was a significant effect of species, F (1,15) =26.006, p<.001, η^2= .634, with rough-toothed dolphins (Condition One: *M*=.8667, *SD*=.41633; Condition Two: *M*= .4667, *SD*= .30551; Condition Three: *M*=.8667, *SD*=.70238) producing significantly more bubble trails per trial compared to bottlenose dolphins (Condition One: *M*=.0429, *SD*=.08516; Condition Two: *M*= .1143, *SD*= .23157; Condition Three: *M*=.1714, *SD*=.29202), as seen in Figure 14.

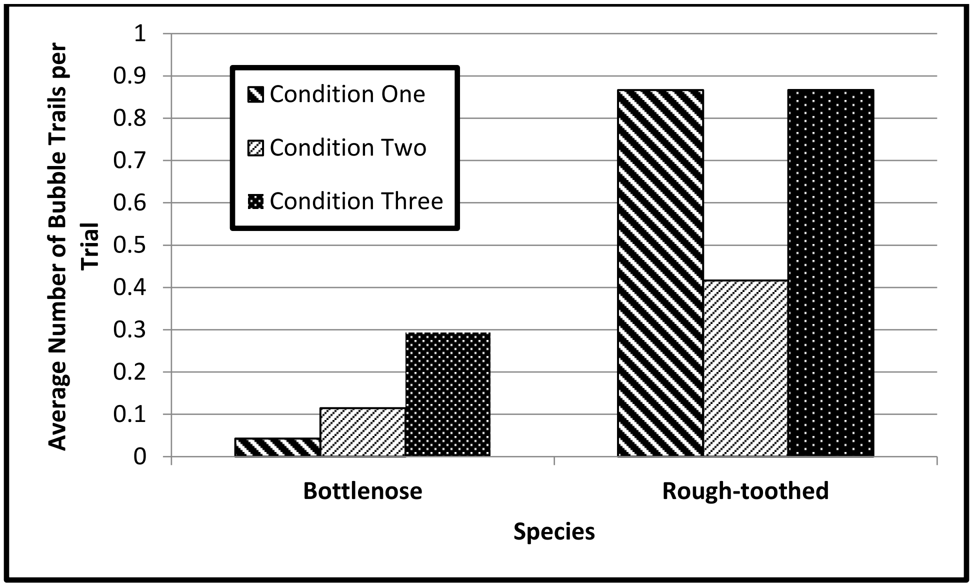

Figure 14. Frequency of Bubble Trails Across Species and Condition

A mixed ANOVA was used to compare the frequency of bubble burst production between conditions and sexes. Box's M (p <.05) was violated, Mauchly's test of sphericity (p<.05) was violated which means that the Greenhouse-Geisser values were used in the comparisons between conditions, and Levene's test was violated for all conditions (p <.05), meaning that the results of this test should be interpreted with caution. No significant interaction between condition and sex was found, F (2,30) = .589, p=.508, η^2= .038, nor was there a significant main effect of condition, F (2,30) = .414, p=.597, η^2= .027. There was a significant main effect of sex, F (1,15) =12.966, p<.001, η^2= .464, with females (Condition One: *M*=.8111, *SD*=.60919; Condition Two: *M*= 1.0278, *SD*=.80277; Condition Three: *M*=.9833, *SD*=.71937) producing significantly more bubble bursts per trial compared to males (Condition One: *M*=.2000, *SD*=.261861; Condition Two: *M*= .2250, *SD*= .24928; Condition Three: *M*=.1250, *SD*=.14880), as seen in Figure15.

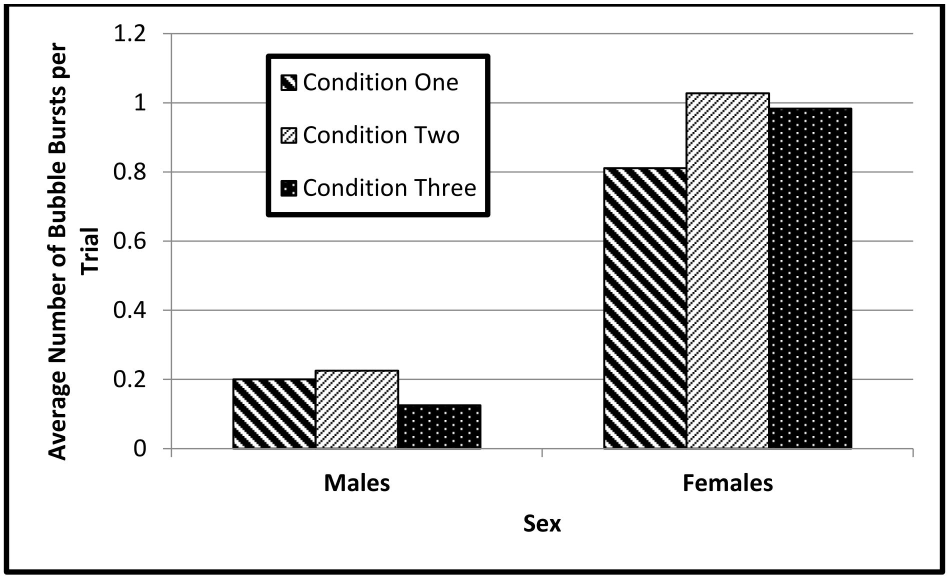

Figure 15. Frequency of Bubble Bursts Across Sex and Condition

The frequency of bubble burst production was compared across species and condition using a mixed ANOVA. Mauchly's test of sphericity ($p<.05$) was violated which means that the Greenhouse-Geisser values were used in the comparisons between conditions, and Levene's test was violated for all Condition Two and Three ($p <.05$) but not for Condition One ($p >.05$), meaning that the results of this test should be interpreted with caution. No significant interaction between condition and species was found, F (2,30) = .446, p=.582, η2= .029, nor was there was a significant effect of species, F (1,15) =.826, p=.378, η2= .052, with bottlenose dolphins (Condition One: M=.6071, SD=.57974; Condition Two: M= .7179, SD= .77698; Condition Three: M=.6321, SD=.73840) not producing significantly more bubble bursts per trial compared to rough-toothed dolphins (Condition One: M=.1333, SD=.23094; Condition Two: M= .3333, SD= .23094; Condition Three: M=.3333, SD=.23094).

Experiment One: Exploring Individual Differences

Gaze duration was compared across conditions and between subjects using a mixed ANOVA. Both Box's M ($p<.001$) and Levene's test (Control, $p<.001$; Jack-in-the-box, $p<.001$) revealed violations in the assumptions of normality of the data, indicating that results should be interpreted conservatively. A significant interaction was found between condition and subjects, $F(20,84)= 1.789$, $p<.05$, $\eta^2=.299$. A simple effects analysis was performed and found significant differences between conditions within subject 4 ($F(1,84)= 24.052$, $p<.001$, $\eta^2=.223$), subject 10 ($F(1,84)= 4.240$, $p<.05$, $\eta^2=.048$), subject 12 ($F(1,84)= 5.513$, $p<.05$, $\eta^2=.062$), subject 17 ($F(1,84)= 4.693$, $p<.05$, $\eta^2=.053$), subject 18 ($F(1,84)= 7.468$, $p<.01m.082$), and subject 21 ($F(1,84)= 5.854$, $p<.05$, $\eta^2=.065$). See Figure 16.

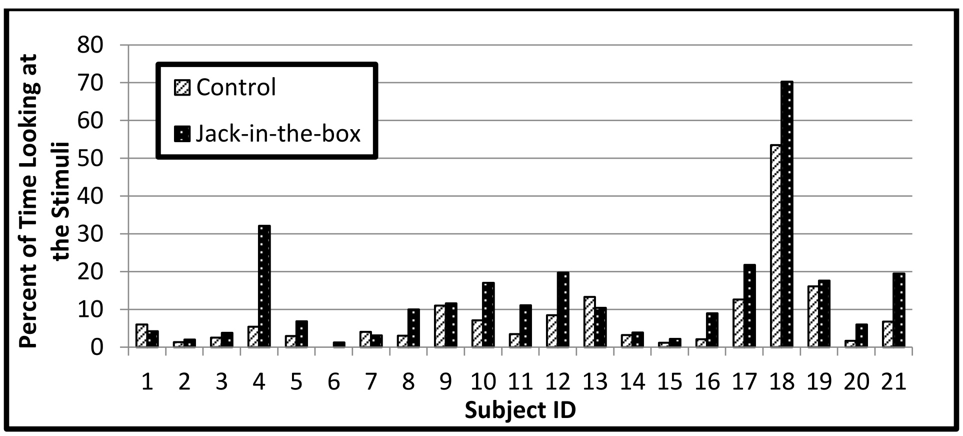

Figure 16. Gaze Duration Across Condition and Subject for Experiment One

Additionally, there was also a main effect of subject, F(1,20)= 4.877, p<.001, η2=.537. Because the data violates Levene's, Games-Howell was used as a post hoc test, though none of the comparisons were found to be significant, likely due to the large number of comparisons that were tested. See Appendix B for significance values.

A mixed ANOVA was used to test for differences in the frequency of open mouth behaviors between conditions and also between subjects. Both Box's M ($p<.001$) and Levene's test (Control, $p<.001$; Jack-in-the-box, $p<.001$) revealed violations in the assumptions of normality of the data, indicating that results should be interpreted conservatively. There was no significant interaction between subject and condition, F (20,84)= .853, $p=.664$, $\eta^2=.169$. No significant main effect of subject was found for the number of open mouths, F (20,84)= 1.217, $p=.261$, $\eta^2=.225$.

The frequency of bubble trail production was also examined across subjects and between conditions using a mixed ANOVA. Again, both Box's M ($p<.001$) and Levene's test (Control, $p<.001$; Jack-in-the-box, $p<.001$) revealed violations in the assumptions of normality of the data, indicating that results should be interpreted conservatively. There was no significant interaction between subject and condition, F (20,84)= 1.414, $p=.139$, $\eta^2=.252$. Additionally, a significant difference between subjects was also found, F (1,20)= 6.868, $p<.001$, $\eta^2=.621$, as shown in Figure 17. Due to such a large number of comparisons, a post hoc Games-Howell test did not reveal any significant differences between any of the subject comparisons. See Appendix B for significance values.

A mixed ANOVA was performed to test for between subject and across condition differences in the frequency of bubble bursts. Again, both Box's M ($p<.001$) and Levene's test (Control, $p<.001$; Jack-in-the-box, $p<.001$) revealed violations in the assumptions of normality of the data, indicating that results should be interpreted conservatively. There was no significant interaction between condition and subject, F (20,84)= 1.394, $p=.149$, $\eta^2=.249$. In addition, a significant main effect of subject was found, F (1,20)= 3.177, $p<.001$, $\eta^2=.431$, as displayed in Figure 18; however, a post hoc

Games-Howell test did not reveal any significant differences between any of the subject comparisons, which was likely due to the large number of comparisons that were calculated. See Appendix B for significance values.

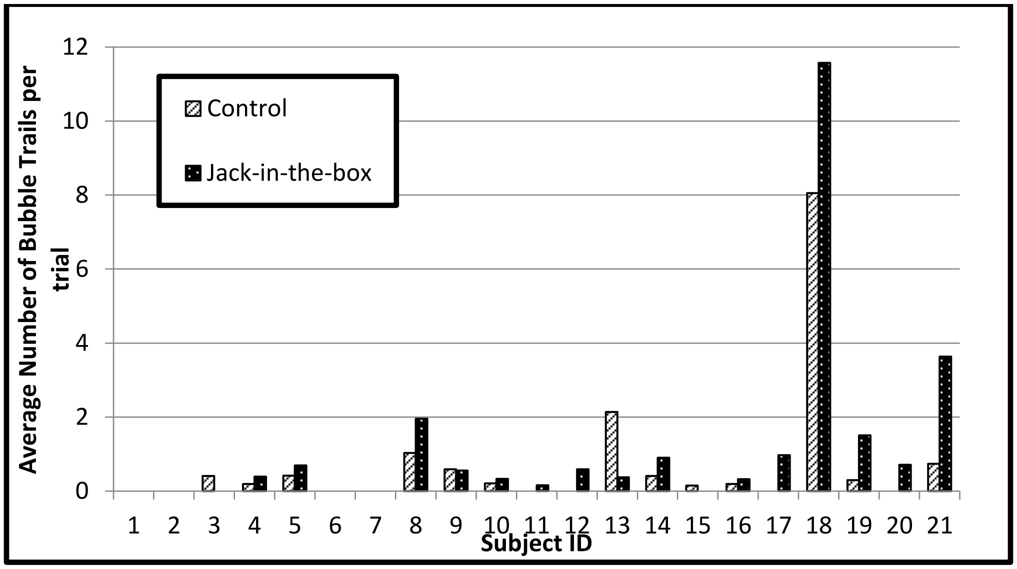

Figure 17. Number of Bubble Trails for Each Subject

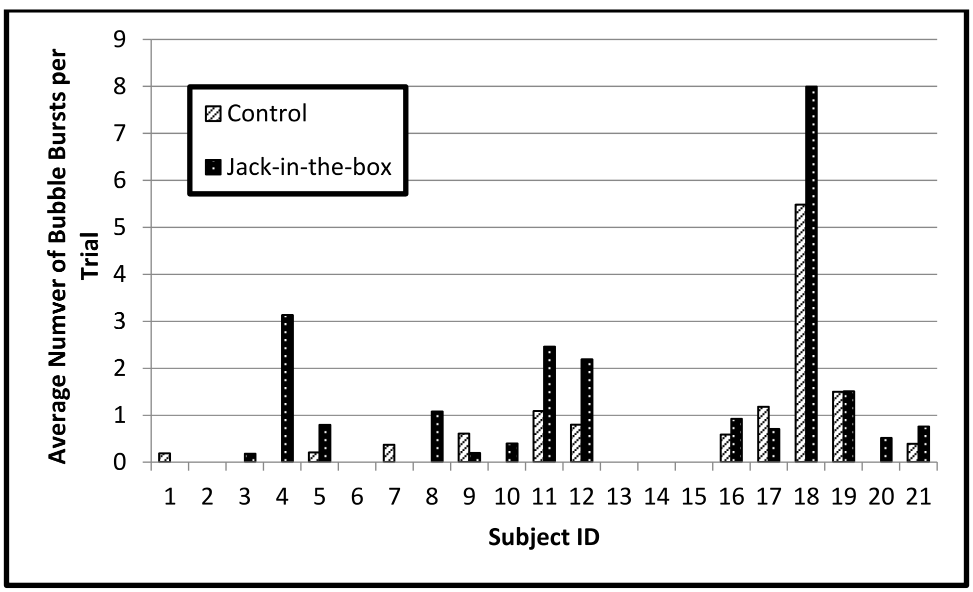

Figure 18. Number of Bubble Bursts for Each Subject

The frequency of the startle responses between conditions and across subjects was also assessed with a mixed ANOVA. Levene's test (Control, $p<.001$; Jack-in-the-box,

$p<.001$) revealed violations in the assumptions of normality of the data, indicating that results should be interpreted conservatively. There was no interaction in the data between subject and condition, $F(20,84)= 1.204$, $p=.272$, $\eta^2=.223$. No main effect of subject was found for frequency of startle responses, $F(20,84)= 1.220$, $p=.260$, $\eta^2=.225$.

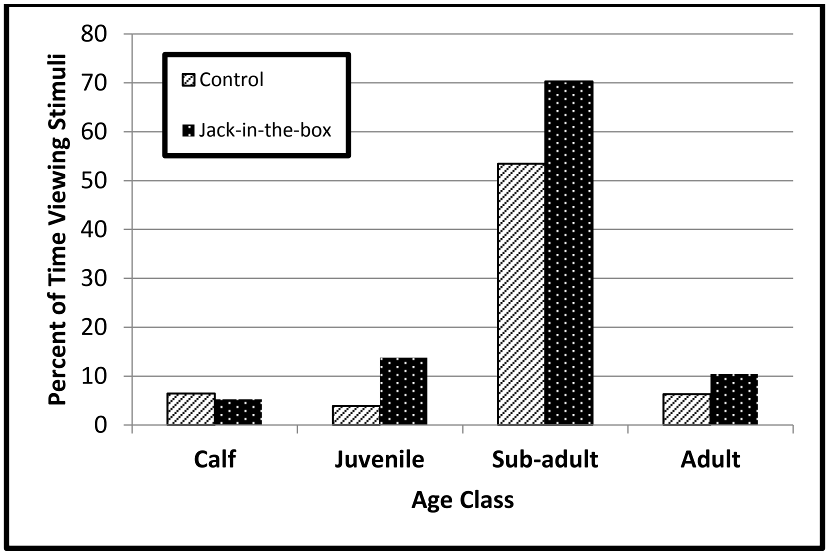

Figure 19. Gaze Duration Across Age Class and Condition

Finally, a mixed ANOVA was used to compare differences in gaze durations between age classes. Levene's test (Control, $p<.05$; Jack-in-the-box, $p=.235$) and Box's M ($p<.05$) revealed violations in the assumptions of normality of the data, indicating that results should be interpreted conservatively. A significant interaction between condition and species, $F\ (3,17)= 3.406$, $p<.01$, $\eta^2=.375$, is shown in Figure 19. Additionally, a main effect of age class was also found, $F\ (3,17)= 18.977$, $p<.001$, $\eta^2=.770$. A post hoc Bonferroni test revealed that sub-adults had significantly longer gaze durations than calves ($p<.001$), juveniles ($p<.001$), and adults ($p<.001$), while no other age classes differed from the others. This result is only exploratory and should be interpreted with caution due to the small sample size and the possibility of individual differences driving this effect and not differences in age.

The results of repeated measures ANOVAs for the test trial where both objects were displayed simultaneously revealed no significant differences between the objects for gaze duration, F (1,10)= 1.363, p=.270, η^2=.120, number of orients toward each object, F (1,10)= 1.561, p=.240, η^2=.135, number of times subjects pressed their eye against the glass to view each object, F (1,10)= 2.222, p=.167, η^2=.182, number of open mouths directed at each object, F (1,10)= .645, p=.441, η^2=.061, number of bubble bursts produced near each object, F (1,10)= .672, p=.432, η^2=.063, nor number of bubble trails produced near each object, F (1,10)= 1.678, p=.224, η^2=.144.

Experiment Two: Exploring Individual Differences

Gaze duration between subjects and across conditions was analyzed using a mixed ANOVA. Box's M (p= .367) and Mauchly's test of sphericity (p= .328) were not violated; however, Levene's was violated for condition two (p= .009), but not condition one (p= .348 or condition three (p= .555), meaning results should be approached with caution. No significant interaction between subject and condition was found, F (2,124)= .519, p= .983, η^2=.118.. A main effect of subject was found, F(16,62)=3.241, p<.001, η^2=.455. A post hoc Games-Howell test revealed a number of significant differences in gaze duration between several individuals. Subjects 4 and 8 were different (p<.01), as well as subjects 4 and 9 (p<.001), subjects 4 and 10 (p<.01), subjects 4 and 14 (p<.05), subjects 9 and 11 (p<.05), and subjects 9 and 17 (p<.05). See Appendix C for a list of significance values. The results between individuals and across conditions are displayed in Figure 20.

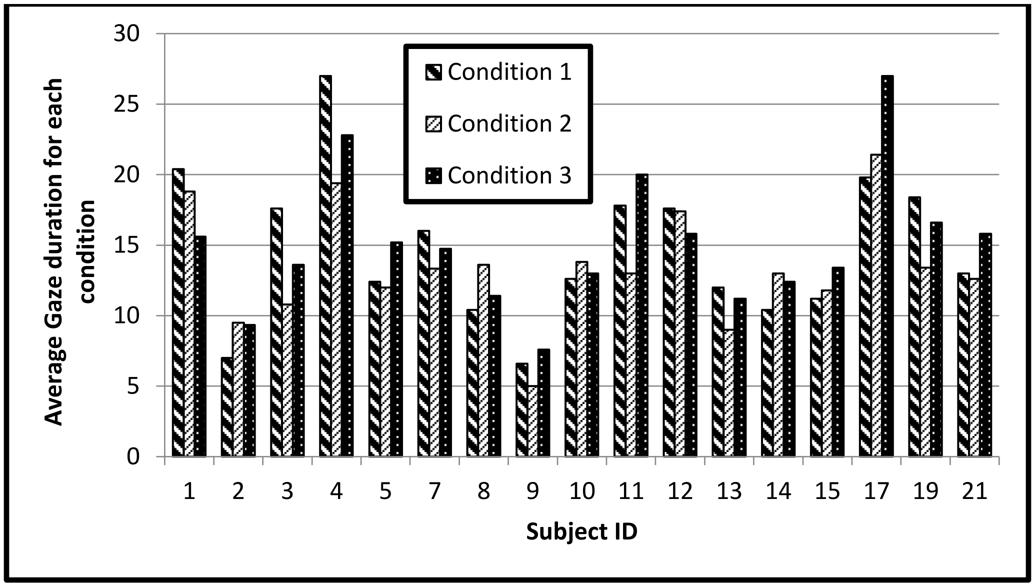

Figure 20. Gaze Duration Across Subjects and Conditions

The frequency of open mouth behaviors was also examined across individuals and between subjects using a mixed ANOVA. Box's M (p= .695) and Mauchly's test of sphericity (p= .279) were not violated; however, Levene's was violated for condition one (p<.001), condition two (p<.01), and condition three (p<.01). The interaction between subject and condition was not significant, F (32,124)= .971, p=.520, η^2=.200. A significant main effect of subject was found, F (16,62)= 9.985, p<.001, η^2=.720. A post hoc Games-Howell comparison found differences between a total of twenty-nine different comparisons. Means are displayed in Figure 21 and significance values are listed in Appendix C.

Bubble trail production was also examined using a mixed ANOVA. Box's M was not violated, p=.817; however, Mauchly's test of sphericity was violated, p<.05, so Greenhouse-Geisser values were used for tests of within-subject effects. Additionally, Levene's was violated for all conditions, p<.001. No significant interaction between subject and condition was found, F(32,124)= .931, p=.573, η^2=.194. A significant main effect of subject was found, $F(16,62)= 3.689$, $p<.001$, $\eta^2=.488$. A post hoc analysis using Games-Howell found that none of the comparisons were significant, likely due to the large number of comparisons that were made. Figure 22 displays the means for each individual and Appendix C lists the significance values for all comparisons.

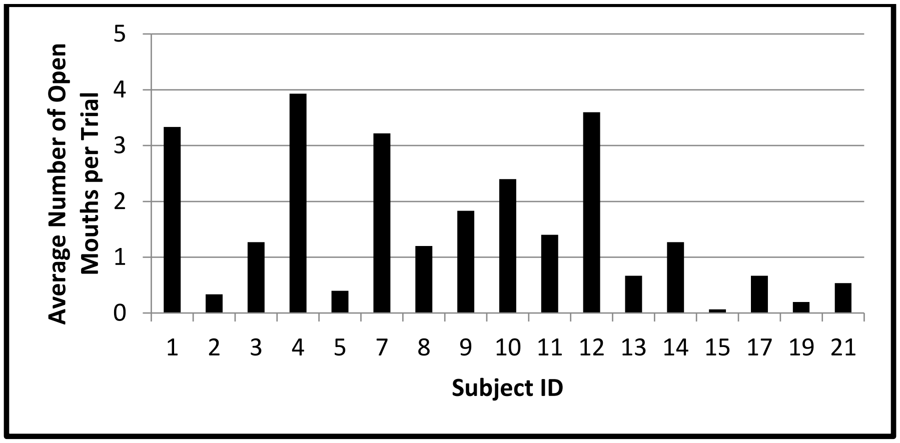

Figure 21. Number of Open Mouths Across Subjects

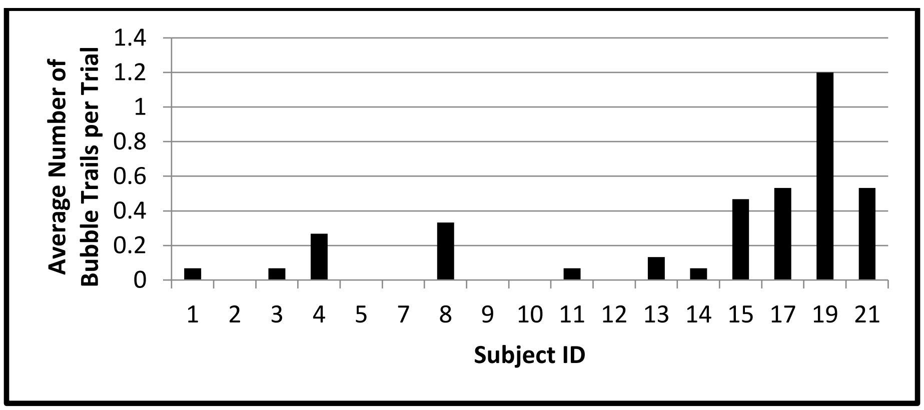

Figure 22. Number of Bubble Trails Across Subjects

A mixed ANOVA was used to compare bubble burst production across conditions and between subjects. Box's M was not violated, $p= .817$; however, Mauchly's test of sphericity was violated, $p<.05$, so Greenhouse-Geisser values were used for tests of within-subject effects. Additionally, Levene's was violated for condition one ($p<.01$), condition two ($p<.001$), and condition three ($p<.001$). No significant interaction between subject and condition was found, F (32,124)= .483, p=.980, η^2=.111. A significant main effect of subject was found, F (16,62)= 6.272, p<.001, η^2=.618. A post hoc test using Games-Howell found that subject 1 was significantly different than seven other subjects. Appendix C lists the significance values for all comparisons and Figure 23 displays the means for each individual.

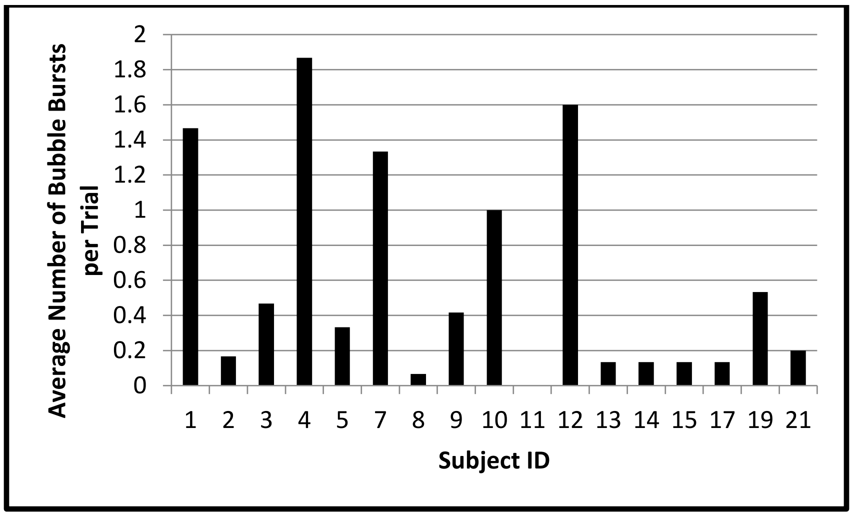

Figure 23. Number of Bubble Bursts Across Subjects

The results of a repeated measures ANOVAs for the test trial where three objects were displayed simultaneously revealed that Mauchly's test was not violated, p=.297, and there were no significant differences between the objects for gaze duration, F(2,22)= .590, p=.563, η^2=.051. A repeated measures ANOVA test for number of orients to each object revealed no violation of Mauchly's test, p=.648, and no significant differences between objects, F(2,22)= .292, p=.750, η^2=.026. The number of open mouths directed at each object was compared using a repeated measures ANOVA which revealed that Mauchly's test was violated, p=.036, and so Greenhouse-Geisser test was used, finding no significant difference between objects, F(2,22)= .805, p=.420, η^2=.068. A repeated measures ANOVA of number of bubble bursts found that Mauchly's test was not violated, p=.113, and there was no significant difference between objects, $F(2,22)$= .341, p=.734, η^2=.028. There was also no significant difference in the number of bubble trails produced near each object, as found with a repeated measures ANOVA, $F(2,20)$= .233, p=.795, η^2=.023, and Mauchly's test not violated, p= .779.

Ratings

All trainer ratings on twelve different items were assessed for factors using principle axis factoring. KMO was found to be .777 and Bartlett's test of sphericity was found to be significant (p<.001), both of which indicate that a solution was possible. Communalities ranged from .371 to .730, as displayed in Table 6. The model explained a 51.12% of the total variance. The scree plot, as well as theory, indicated that there were two separate factors. The pattern matrix indicated that a factor called "Curious" had strong factor loadings of curiosity (.730), observant (.695), intelligent (.729), creative (.663), excitable (.640), exploratory (.607), and a negative loading of simple (-.625). The second factor called "Timid" had factor loadings of timid (.751), fearful (.744), and cautious (.609) and negative factor loadings of confident (-.707) and bold (-.729). These values are displayed in Table 7. The factors had a -.139 correlation with each other. Factor 1 (Curious) had a Cronbach's alpha of .849 and factor 2 (Timid) had a Cronbach's alpha of .837.

Table 6

Communalities for Trainer Ratings

Item	Communalities
Curious	0.562
Confident	0.73
Observant	0.478
Timid	0.595
Fearful	0.548
Intelligent	0.521
Cautious	0.371
Bold	0.533
Creative	0.473
Excitable	0.412
Simple	0.43
Exploratory	0.481

Table 7

Factor Loadings for Each Item

Item	Curious	Timid
Curious	0.73	
Intelligent	0.729	
Observant	0.695	
Excitable	0.64	
Creative	0.633	
Exploratory	0.607	
Simple	-0.625	
Timid		0.751
Fearful		0.744
Cautious		0.609
Bold		-0.729
Confident		-0.707

Table 8

Scores For Subjects on Each Factor

Subject	**Curious**	**Timid**
1	27.25	8
2	15.2	5
3	28.75	1.75
4	29.6667	-2.6674
5	26.75	-0.25
6	15.5	2
7	35	-0.75
8	27.25	-2
9	30.3333	-2.3334
10	25.7142	7.5715
11	19.75	5.5
12	31.6	-3.4
13	32.9999	-1
14	31.3333	12.8323
15	21.1666	3.8334
16	18.8	-0.8
17	30.4	0.6
18	25	0.6
19	33.3334	-0.8333
20	19.3334	3.5
21	32.6667	5.3333

The scores on both factors were calculated for each subject by combining the average ratings of items on that factor and using the reverse scores of negatively loaded items. The factor scores for each animal are displayed in Table 8. The factor scores of each animal were then correlated with the gaze durations of the animals in part one of the experiment. The log transformed data violated the Shapiro-Wilk test of normality for total gaze duration (.682, df= 21, p>.001) and also gaze duration for the Jack-in-the-box condition (.760, df= 21, p>.001), but was not violated for the factors of Curious (.823, df= 21, p=.1) and Timid (.682, df= 21, p=.111). Additionally, the Q-Q plots of these variables revealed more violations of normality assumptions and thus, Spearman's rho was used to determine the significance of correlations. The correlation between subjects' gaze duration at the Jack-in-the-box condition and their scores on the curious factor was not significant, ($r_s(21) = .356$, $p=.113$). The correlation between gaze duration for both conditions and the curious factor was approaching significance, ($r_s(21) = .425$, $p=.055$). This indicates that overall interest in stimuli presented to the animals is related to the ratings provided by trainers familiar with the subjects. The overall gaze duration and factor timid also had a correlation approaching significance ($r_s(21) = -.398$, $p=.074$), such that ratings on the factor timid were negatively related to overall gaze duration. Gaze duration for the Jack-in-the-box condition and the factor timid were not significantly correlated, ($r_s(21) =- .375$, $p=.094$).

CHAPTER IV – Discussion

Two main goals of this study were to characterize the surprise reaction of dolphins and examine individual differences in dolphins' curiosity. Overall, the results indicate that the subjects were more interested in the spontaneously surprising stimulus and displayed a wide range of individual differences in their reactions to the stimuli in experiment one. Unexpectedly, the object transformation that was hypothesized to violate expectations in experiment two did not capture subjects' interest more than the control condition. Further examination of each behavior quantified as a dependent variable as well as differences in species, sex, and age classes provides a more complete picture of surprise and curiosity in dolphins.

The jack-in-the-box stimulus was shown to be significantly more interesting to the subjects compared to the control condition. Overall, the subjects spent approximately 13.5% of the trial viewing the jack-in-the-box stimulus compared to 7.9% of the time viewing the control stimulus. These results support the idea that enrichment devices capable of surprising the dolphins may be more effective than an inanimate object. Moreover, even though the results of species and sex differences were not statistically different, the descriptive statistics reveal that different types of enrichment may be more effective for each sex or species. The simple effects analysis revealed that 6 individuals viewed the jack-in-the-box stimulus for a significantly longer amount of time, though all of the subjects but 3 had an average longer gaze duration for the jack-in-the-box. Of the 3 subjects behaving in the opposite pattern, two were calves. A large amount of variation between trials within an individual likely resulted in a lack of significance for many individuals as well as a lack of significant differences between individuals, as individual average jack-in-the-box viewing times ranged from only 1% for subject 6 to 70% for subject 18. These results are consistent with other studies that have found individual differences in dolphins' interest in enrichment and experimental stimuli (Eskelinen et al., 2015; Greene et al. 2011; Hill et al., 2016; Yeater, Hill, Baus, Farnell, & Kuczaj, 2014).

Other behaviors also more likely to occur while viewing the surprising stimulus were open mouths and bubble bursts, though bubble trails and startle responses occurred more frequently but not significantly so. Approximately 2 times more open mouths occurred, 1.7 times more bubble trails were produced, 1.8 times more bubble bursts were produced, and 27.8 times more startle responses occurred while subjects viewed the jack-in-the-box stimulus.

The previous claims that bubble bursts are indicative of surprise, play and excitement (e.g. Clark et al., 2013; Delfour & Aulagnier, 1997; Hill et al., 2011; Pryor, 1990) were substantiated by the results of this study. In addition, bubble trails were also produced more, though not significantly, in the jack-in-the-box condition, which suggests that they might also be associated with surprise and excitement. Due to a lack of vocal recording during data collection, it is unknown whether or not vocalizations were associated with bubble production that was observed and therefore also unknown if the subjects vocalized significantly more during the jack-in-the-box condition.

The open mouth behavior displayed by the subjects of this study does not appear to indicate aggression or agitation towards the experimental stimuli. The open mouth behaviors were sometimes related to bubble play that occurred while the subjects were viewing the stimulus, indicating a playful state (Kuczaj & Eskelinen, 2014). No jawclaps, s-postures, or abrupt vertical head movements were directed towards the experimental stimuli or produced in conjunction with the open mouth behaviors as was previously recorded in studies of aggression in dolphins (Herzing, 1996; Overstrom, 1983). Furthermore, most instances of aggressive behavior that include open mouth displays are when dolphins are oriented head-to-head with each other or are chasing another animal (Overstrom, 1983); however, in the present study, open mouth behaviors often occurred as the subject was parallel to and pressed up against the viewing window. It has been suggested that the open mouth behavior in the absence of signs of aggression may be signs of excitement and/or play (Dudzinski, 1998; Marten & Psarkos, 1995). After comparison to the contexts of open mouth behavior reported in previous research, the results of the present study suggest the open mouth behavior in the context of surprising or curiosity-eliciting stimuli may indicate interest and/or surprise and not aggression in this particular context.

The startle response, which has received little attention in the literature on dolphins' reactions to surprising events (Clark et al., 2013; Delfour & Aulagnier, 1997; Hill et al., 2011; Pryor, 1990), was found in this study to occur more frequently in response to the jack-in-the-box, resembling a human's startle in response to the same stimulus. In the present study, it is likely that the difference between conditions was not statistically significant due to the relatively small number of times this response occurred within a small number of individuals. Interestingly, the startle response did not occur every instance that the jack-in-the-box opened. As the stimulus opened without any preceding cues and on a random interval, it is unlikely that the dolphins were able to accurately anticipate the surprising event in order to inhibit a startle response. The lack of responses may be due to the animals' attention to other environmental stimuli or conspecifics in the habitat, or the possibility that the dolphins' startle was not a reflex reaction, but under conscious control. Regardless, the startle responses did not seem to be negative, as most subjects did not swim away but stayed to continue viewing the stimulus after they had just startled. Additionally, no jawclaps were recorded as directed at the experimental apparatus throughout the duration of the experiment, which would have indicated the subjects' aggression and negative reaction to the apparatus.

Species differences found that the rough-toothed dolphins in this study looked approximately two times longer at the stimuli presented compared to the bottlenose dolphins. While this could be due to the particular individuals participating in the present study, this difference may represent a species-level difference in curiosity.

In the present study, females spent more time looking at the stimuli compared to males. This is partially consistent with previously published literature. Greene et al. (2011) found that females interacted more with objects, while Eskelinen et al. (2015) found that adult males were most likely to interact with environmental enrichment. The results of Eskelinen may have been due to many of the females caring for their calves. In the present study, only one calf was housed with her mother at the time of data collection, which meant that other females did not have calves to otherwise occupy their time. Another contributing factor may have been the frequent occurrence of socio-sexual behavior of the males housed together. This behavior may have diverted the male subjects' attention from the experimental apparatus.

A comparison of age classes found sub-adults to have a longer gaze duration during experiment one than each of the other age classes. In addition, each age class, except for the calves, had a longer gaze duration for the jack-in-the-box condition. This result was not unexpected, given the mixed findings from previous studies. Young animals are generally considered to be more curious than older animals, which is consistent with human behavior as well (King et al., 2008; Massen et al., 2013). Future research should aim to compare age classes in more depth, as the subjects in this study were not evenly distributed across age classes, and individual differences are likely to have dramatically influenced the results.

When infants found an object to behave in an unexpected way in the Stahl and Feigenson (2015) study, they were more likely to later look longer at that object and even manipulate it when given the opportunity. In order to compare these results to dolphins' interest in the objects used in the present study, both jack-in-the-box and control objects were presented simultaneously for the subjects to view. No behavioral differences in gaze duration, bubble production, orientation, or open mouths were recorded between the conditions, indicating that dolphins did not find the stationary jack-in-the-box stimulus to be more interesting than the control object. This was an unexpected finding as it was hypothesized that the subjects would anticipate the surprising action of the jack-in-the-box stimulus and thus devote more attention to the stimulus that they had spent a significantly greater amount of time viewing in the preceding trials. Subjects may have chosen to only devote their attention to the jack-in-the-box when it was actively moving or subjects may have not remembered which object had previously behaved in an engaging manner, though the objects were visibly discriminable. Even considering the visual discrimination abilities of the subjects as all experiments should do (Kuczaj & Lilley, 2016), subjects should have been able to discriminate between the objects used in the present study, thus it was likely that the results of the test trial were due to a lack of interest in non-moving objects or a lack of memory for the previously engaging stimulus. Replication of this procedure should be done in other studies to further explore why this result may have occurred.

The results of experiment two found mostly non-significant differences both between conditions and individuals. Despite most individuals showing an interest in the object transformations with which they were presented, gaze duration for condition three was significantly longer only compared to condition two, meaning that the subjects did not find an object transforming to another object more interesting than the object remaining the same. This is in contrast to the results of Singer et al. (2015) which found dolphins having a longer gaze duration for the expectation-violating condition where a bucket seemed to vanish behind a screen. The results of experiment two were also in contrast to the results of many other studies in both human infants and non-human animals exploring concepts of object permanence, object solidity, and causality (Hauser & Spaulding, 2006; Povinelli & Dunphy-Lelii, 2001; Stahl & Feigenson, 2015). Individual differences were still found in experiment two, with several different comparisons being statistically significant. Gaze duration ranged from an average of 6 seconds for subject 9 to 23 seconds for subject 4.

There were few significant differences in other behaviors for experiment two. No differences in open mouths, bubble bursts, or bubble trails between conditions were found. Post hoc tests revealed that the only significant difference between individuals was for bubble bursts, in which subject 1 was found to have significantly more bubble bursts than seven other subjects. Despite the individual differences in bubble burst production, there were no significant differences between conditions which suggests that bubble bursts are also produced in situations that are not necessarily surprising. The bubble bursts produced during the present study may be attributed to a number of factors, including general interest in the moving experimental stimuli, the sight of familiar objects that are frequently used as secondary reinforcement, a communicative signal for other conspecifics, or possibly a stereotyped response.

In experiment two, few species or sex differences were found. Females had significantly more open mouths and bubble bursts than males, while bottlenose had more open mouths than rough-toothed dolphins and rough-toothed dolphins had more bubble trails than bottlenose dolphins. Subjects usually viewed the experimental apparatus for several seconds after an object transformation, indicating their general interest in the apparatus, objects, or the movement of the apparatus; however, it does not appear that subjects found condition three to be an unusual occurrence, nor does it seem that any particular species, sex, or age class found this transformation of particular interest. Furthermore, no significant differences in behavior were found during the test trial of experiment two. Though unexpected, these results may indicate that dolphins do not find the apparent transformation of one object to another object to be of particular interest. Object transformations may not be an ecologically or evolutionarily important event for dolphins. As suggested by Kuczaj and Lilley (2016), dolphins may be surprised by some irregularities in their environment, such as the difference in sinking or floating behavior of ice, with which other non-human animals and human infants would likely be unfamiliar. Nevertheless, future research should aim to explore this concept using varied experimental set-ups, different expectation-violating scenarios, and a larger sample size.

The factor scores calculated from trainer ratings were correlated with gaze duration of the subjects. The factor "curious" was approaching significance for being correlated with the combined gaze duration of subjects in experiment one. The factor "timid" was also approaching significance of a negative correlation with the combined gaze duration of subjects in experiment one. These correlations indicate that despite a wide range of individual difference in behavior, trainer ratings are related to quantifiable curiosity-related behavior of dolphins. This result supports the findings of dolphin personality ratings used in previous studies (Highfill & Kuczaj, 2007; Kuczaj, Highfill, & Byerly, 2012). Though just one curiosity-related behavior, gaze duration, was used to correlate with the trainer ratings, future research can aim to further explore the connection between trainer ratings for all aspects of personality and several other behavioral measures. This study does provide some evidence that ratings and dolphin behavior are related for measures of curiosity.

Engaging environmental enrichment has been found to increase variation in the behavior of many animals housed at zoological facilities (Swaisgood & Shepardson, 2006). Furthermore, ratings of animal personality have also been used to inform welfare decisions such as housing and breeding (Tetley & O'Hara, 2012). Personality ratings could also be used to make decisions regarding environmental enrichment. As seen in the present study, subjects' engagement with the jack-in-the-box stimulus could be dependent on species, sex, age, and personality differences. Though there is much left to learn about animals' emotions, it is clear that further investigation can improve animal welfare. De Vere and Kuczaj (2016) suggested a number of recommendations for the study of animal emotions, which the present study addressed in some aspect, including the use of multiple methods (i.e. ratings and behavior), focusing on positive emotions (i.e. surprise and curiosity-related behavior), and the use of personality ratings to help assess emotions. Surprise and the curiosity that follows a surprising event are both involved in the learning process and seem to occur in a number of species (Kuczaj, in press; Piaget, 1952). Focusing on these experiences in captive animals may help enrich their daily lives.

When surprised, dolphins are likely to open their mouth, produce bubbles, continue looking at the surprising stimulus, and may even startle visibly. This pattern of behavior suggests that dolphins find surprising stimuli to be engaging. The dolphins in the present study did not respond to a VOE object transformation with an increase in interest compared to a control condition. This could suggest that dolphins found the movement of all objects, regardless of the transformation, to be of equal interest. Hill et al. (2016) found that dolphins looked longer at humans who were actively moving, for both familiar and unfamiliar human stimuli. An interesting comparison would be to introduce another condition to experiment one in which a stimulus moved in the same motion as the jack-in-the-box but at a predictable and slow rate. This would reveal whether the general motion of an object would result in the same curiosity-related behaviors or if the spontaneous and unpredictable event of the jack-in-the-box opening is necessary to elicit the reaction found in experiment one of the present study.

Conclusion

The present study was able to explore individual differences in curiosity-related behavior and found that differences in species, sex, age, and personality, as rated by trainers, can influence the extent to which dolphins are interested in a surprising stimulus. Furthermore, a jack-in-the-box stimulus appeared to elicit a surprise reaction from the dolphins, including a startle response similar to that in humans. This study highlights the need to understand individual differences when considering environmental enrichment. Though the jack-in-the-box stimulus was of interest to almost all of the study subjects, it was more engaging for some animals compared to others. Contrary to hypotheses, a VOE paradigm did not elicit an increase in subjects' interest more than the control condition, which adds to the literature on VOE paradigms in non-human animals. Overall, this study has helped to characterize what makes a surprising stimulus for dolphins and also to characterize a reaction of surprise in dolphins.

APPENDIX A – Dolphin Personality Scale

Dolphin Personality Scale

Dolphin Name: ____

Rater: ____

Number of years training dolphins: ____________________________

Number of years working with this dolphin: ______________________

Instructions: Please rate this dolphin in terms of the list of adjectives and definitions of those adjectives provided below. Indicate the answer that you think best describes this dolphin for each adjective by marking or circling the corresponding box.

Example: If a dolphin is viewed as slightly exploratory, the box with "slightly exploratory" would be indicated as shown below.

Exploratory: Animal seeks out or investigates novel situations or objects.

Exploratory → → → → → → → → → ....**Not Exploratory**

Extremely Exploratory	Quite Exploratory	Slightly Exploratory	Neutral	Slightly Not Exploratory	Quite Not Exploratory	Extremely Not Exploratory

Thank you for helping with dolphin research!

Curious: Animal appears to be interested in new situations or objects.

Curious → → → → → → → → → ....**Not Curious**

Extremely Curious	Quite Curious	Slightly Curious	Neutral	Slightly Not Curious	Quite Not Curious	Extremely Not Curious

Confident: Animal is quick to approach a novel situation or object.

Confident → → → → → → → → → ....**Not Confident**

Extremely Confident	Quite Confident	Slightly Confident	Neutral	Slightly Not Confident	Quite Not Confident	Extremely Not Confident

Observant: Animal is ready, attentive, watchful; appears to pay attention to surroundings.

Observant → → → → → → → → → ....**Not Observant**

Extremely Observant	Quite Observant	Slightly Observant	Neutral	Slightly Not Observant	Quite Not Observant	Extremely Not Observant

Timid: Animal is hesitant, apprehensive, tentative in novel situations or in the presence of novel objects.

Timid .... **Not Timid**

Extremely Timid	Quite Timid	Slightly Timid	Neutral	Slightly Not Timid	Quite Not Timid	Extremely Not Timid

Fearful: Animal reacts excessively to real or imagined threats by displaying aggressive behaviors.

Fearful .... **Not Fearful**

Extremely Fearful	Quite Fearful	Slightly Fearful	Neutral	Slightly Not Fearful	Quite Not Fearful	Extremely Not Fearful

Intelligent: Animal appears to learn easily; Quick to understand.

Intelligent .... **Not Intelligent**

Extremely Intelligent	Quite Intelligent	Slightly Intelligent	Neutral	Slightly Not Intelligent	Quite Not Intelligent	Extremely Not Intelligent

Cautious: Animal exhibits care in its actions.

Cautious .. **Not Cautious**

Extremely Cautious	Quite Cautious	Slightly Cautious	Neutral	Slightly Not Cautious	Quite Not Cautious	Extremely Not Cautious

Bold: Animal is daring, not restrained or tentative. Not timid, shy or coy.

Bold .... **Not Bold**

Extremely Bold	Quite Bold	Slightly Bold	Neutral	Slightly Not Bold	Quite Not Bold	Extremely Not Bold

Creative: Animal approaches situations and addresses problems in novel creative ways (e.g., finds various ways to play with a toy).

Creative **Not Creative**

Extremely Creative	Quite Creative	Slightly Creative	Neutral	Slightly Not Creative	Quite Not Creative	Extremely Not Creative

Excitable: Animal is readily roused into action; relatively responsive to stimuli.

Excitable **Not Excitable**

Extremely Excitable	Quite Excitable	Slightly Excitable	Neutral	Slightly Not Excitable	Quite Not Excitable	Extremely Not Excitable

Simple: Animal engages in routine behaviors. Does not have a complex behavioral repertoire.

Simple .... **Not Simple**

Extremely Simple	Quite Simple	Slightly Simple	Neutral	Slightly Not Simple	Quite Not Simple	Extremely Not Simple

Exploratory: Animal seeks out or investigates novel situations or objects.

Exploratory .... **Not Exploratory**

Extremely Exploratory	Quite Exploratory	Slightly Exploratory	Neutral	Slightly Not Exploratory	Quite Not Exploratory	Extremely Not Exploratory

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APPENDIX B – Experiment One Post hoc Significance Values

Subject	Subject	Gaze duration p-value	Open mouth p-value	Bubble Trail p-value	Bubble burst p-value
1	2	0.993	0.842	.	0.998
1	3	1	1	0.998	1
1	4	0.953	1	0.658	0.938
1	5	1	0.842	0.988	0.998
1	6	0.787	0.842	.	0.998
1	7	1	1	.	1
1	8	1	1	0.98	0.999
1	9	0.819	1	0.394	1
1	10	0.997	0.998	0.998	0.981
1	11	1	1	0.998	1
1	12	0.838	1	0.998	0.979
1	13	0.984	0.962	0.881	0.998
1	14	1	0.983	0.942	0.998
1	15	0.975	0.842	0.998	0.998
1	16	1	0.909	0.948	0.999
1	17	0.979	1	0.998	0.984
1	18	0.294	0.895	0.328	0.71
1	19	0.996	0.994	0.99	0.97
1	20	1	0.984	0.935	1
1	21	0.994	1	0.978	0.987
2	3	1	0.995	0.998	0.998
2	4	0.793	0.995	0.658	0.909
2	5	0.999	.	0.988	0.984
2	6	1	.	.	.
2	7	1	0.998	.	0.998
2	8	0.979	0.894	0.98	0.991
2	9	0.206	0.939	0.394	0.998
2	10	0.894	0.983	0.998	0.972
2	11	0.757	0.877	0.998	0.94
2	12	0.434	0.959	0.998	0.965
2	13	0.726	0.998	0.881	.
2	14	1	0.951	0.942	.
2	15	1	.	0.998	.
2	16	0.998	0.998	0.948	0.994
2	17	0.866	0.712	0.998	0.962
2	18	0.238	0.998	0.328	0.697

2	19	0.955	0.998	0.99	0.953
2	20	1	0.998	0.935	0.951
2	21	0.88	0.928	0.978	0.941
3	4	0.864	1	1	0.937
3	5	1	0.995	1	0.998
3	6	0.914	0.995	0.998	0.998
3	7	1	1	0.998	1
3	8	0.999	1	0.995	0.999
3	9	0.312	1	0.99	1
3	10	0.955	0.998	1	0.981
3	11	0.932	1	1	1
3	12	0.557	1	1	0.978
3	13	0.846	1	0.97	0.998
3	14	1	1	0.999	0.998
3	15	1	0.995	1	0.998
3	16	1	0.999	1	0.999
3	17	0.921	1	1	0.983
3	18	0.26	0.998	0.346	0.71
3	19	0.979	1	1	0.97
3	20	1	1	1	1
3	21	0.944	1	0.991	0.986
4	5	0.95	0.995	1	0.998
4	6	0.709	0.995	0.658	0.909
4	7	0.936	1	0.658	0.964
4	8	0.985	1	0.997	0.999
4	9	1	1	0.991	0.996
4	10	1	1	0.979	1
4	11	0.988	1	1	0.962
4	12	1	1	1	1
4	13	1	0.998	0.978	0.909
4	14	0.875	0.999	1	0.909
4	15	0.779	0.995	0.964	0.909
4	16	0.971	0.997	1	1
4	17	1	1	1	1
4	18	0.681	0.996	0.353	0.921
4	19	1	0.999	1	1
4	20	0.906	0.999	1	0.973
4	21	1	1	0.993	0.999
5	6	0.913	.	0.988	0.984
5	7	1	0.998	0.988	1

5	8	1	0.894	1	1
5	9	0.833	0.939	1	1
5	10	0.996	0.983	0.998	0.999
5	11	1	0.877	1	1
5	12	0.838	0.959	1	1
5	13	0.983	0.998	1	0.984
5	14	1	0.951	1	0.984
5	15	0.995	.	0.997	0.984
5	16	1	0.998	1	1
5	17	0.977	0.712	1	1
5	18	0.289	0.998	0.381	0.772
5	19	0.996	0.998	1	0.999
5	20	1	0.998	1	1
5	21	0.993	0.928	0.999	1
6	7	1	0.998	.	0.998
6	8	0.803	0.894	0.98	0.991
6	9	0.097	0.939	0.394	0.998
6	10	0.787	0.983	0.998	0.972
6	11	0.323	0.877	0.998	0.94
6	12	0.313	0.959	0.998	0.965
6	13	0.553	0.998	0.881	.
6	14	0.646	0.951	0.942	.
6	15	0.999	.	0.998	.
6	16	0.933	0.998	0.948	0.994
6	17	0.794	0.712	0.998	0.962
6	18	0.224	0.998	0.328	0.697
6	19	0.92	0.998	0.99	0.953
6	20	0.969	0.998	0.935	0.951
6	21	0.778	0.928	0.978	0.941
7	8	1	0.996	0.98	1
7	9	0.865	1	0.394	1
7	10	0.993	0.993	0.998	0.989
7	11	1	1	0.998	1
7	12	0.841	0.996	0.998	0.989
7	13	0.976	1	0.881	0.998
7	14	1	1	0.942	0.998
7	15	1	0.998	0.998	0.998
7	16	1	1	0.948	1
7	17	0.967	1	0.998	0.996
7	18	0.269	1	0.328	0.724

7	19	0.992	1	0.99	0.984
7	20	1	1	0.935	1
7	21	0.989	0.998	0.978	1
8	9	0.984	1	1	1
8	10	1	1	0.987	1
8	11	1	0.992	0.998	1
8	12	0.962	1	0.998	1
8	13	0.999	0.951	1	0.991
8	14	1	0.968	1	0.991
8	15	0.953	0.894	0.986	0.991
8	16	1	0.925	0.996	1
8	17	0.995	1	1	1
8	18	0.318	0.918	0.525	0.779
8	19	0.999	0.978	1	1
8	20	1	0.966	0.999	1
8	21	1	1	1	1
9	10	1	0.999	0.614	0.998
9	11	0.982	0.999	1	1
9	12	1	1	1	0.999
9	13	1	0.982	0.999	0.998
9	14	0.311	0.991	1	0.998
9	15	0.142	0.939	0.582	0.998
9	16	0.948	0.964	0.994	1
9	17	1	1	1	1
9	18	0.421	0.959	0.379	0.76
9	19	1	0.995	1	0.999
9	20	0.593	0.99	1	1
9	21	1	1	0.999	1
10	11	1	0.993	1	0.989
10	12	1	1	1	1
10	13	1	0.988	0.918	0.972
10	14	0.962	0.99	0.98	0.972
10	15	0.874	0.983	1	0.972
10	16	0.999	0.986	1	1
10	17	1	0.999	1	1
10	18	0.473	0.985	0.335	0.956
10	19	1	0.99	0.996	1
10	20	0.982	0.989	0.995	0.992
10	21	1	1	0.984	1
11	12	0.961	0.995	1	0.989

11	13	1	1	0.986	0.94
11	14	0.937	1	1	0.94
11	15	0.587	0.877	1	0.94
11	16	1	0.982	1	1
11	17	0.996	0.998	1	0.995
11	18	0.332	0.967	0.352	0.725
11	19	1	1	1	0.983
11	20	0.996	1	1	1
11	21	1	0.997	0.994	0.999
12	13	1	0.98	0.99	0.965
12	14	0.574	0.986	1	0.965
12	15	0.4	0.959	1	0.965
12	16	0.923	0.971	1	1
12	17	1	1	1	1
12	18	0.504	0.968	0.354	0.922
12	19	1	0.989	1	1
12	20	0.694	0.985	1	0.993
12	21	1	1	0.994	1
13	14	0.859	1	1	.
13	15	0.681	0.998	0.914	.
13	16	0.996	1	0.976	0.994
13	17	1	0.904	1	0.962
13	18	0.446	1	0.463	0.697
13	19	1	1	1	0.953
13	20	0.931	1	0.991	0.951
13	21	1	0.971	1	0.941
14	15	0.997	0.951	0.977	.
14	16	1	1	1	0.994
14	17	0.929	0.949	1	0.962
14	18	0.266	0.999	0.39	0.697
14	19	0.983	1	1	0.953
14	20	1	1	1	0.951
14	21	0.952	0.982	1	0.941
15	16	0.994	0.998	0.999	0.994
15	17	0.855	0.712	1	0.962
15	18	0.238	0.998	0.334	0.697
15	19	0.951	0.998	0.995	0.953
15	20	1	0.998	0.993	0.951
15	21	0.862	0.928	0.983	0.941
16	17	0.988	0.807	1	1

16	18	0.301	1	0.35	0.82
16	19	0.998	1	1	1
16	20	1	1	1	1
16	21	0.998	0.952	0.992	1
17	18	0.674	0.785	0.375	0.841
17	19	1	0.981	1	1
17	20	0.95	0.953	1	0.998
17	21	1	1	0.999	1
18	19	0.711	1	0.425	0.921
18	20	0.27	1	0.359	0.733
18	21	0.501	0.947	0.685	0.781
19	20	0.988	1	1	0.989
19	21	1	0.988	1	1
20	21	0.975	0.981	0.995	1

APPENDIX C – Experiment Two Post-hoc Significance Values

Subject	**Subject**	**Gaze duration p-value**	**Open mouth p-value**	**Bubble Trail p-value**	**Bubble burst p-value**
1	2	0.888	0.024*	0.996	0.199
1	3	0.995	0.397	1	0.393
1	4	0.879	1	0.996	1
1	5	0.963	0.013*	0.996	0.069
1	7	1	1	0.996	0.999
1	8	0.667	0.407	0.967	0.022*
1	9	0.151	0.342	0.996	0.228
1	10	0.882	0.974	0.996	0.985
1	11	1	0.534	1	0.027*
1	12	1	1	0.996	1
1	13	0.738	0.029*	1	0.027*
1	14	0.793	0.305	1	0.027*
1	15	0.859	0.009*	0.517	0.027*
1	17	0.986	0.061	0.554	0.027*
1	19	1	0.008*	0.649	0.542
1	21	0.999	0.034*	0.517	0.036*
2	3	0.995	0.737	0.996	1
2	4	0.646	0.003*	0.909	0.413
2	5	0.998	1	.	1
2	7	0.959	0.502	.	0.797
2	8	1	0.704	0.803	1
2	9	1	0.061	.	0.989
2	10	0.996	0.004*	.	0.618
2	11	0.904	0.905	0.996	0.977
2	12	0.939	0.023*	.	0.218
2	13	1	1	0.996	1
2	14	1	0.342	0.996	1
2	15	1	0.208	0.296	1
2	17	0.672	0.977	0.354	1
2	19	0.975	0.946	0.559	0.994
2	21	1	1	0.296	1
3	4	0.29	0.169	0.996	0.723
3	5	1	0.791	0.996	1
3	7	1	0.966	0.996	0.966
3	8	1	1	0.967	0.997
3	9	0.471	0.999	0.996	1

3	10	1	0.652	0.996	0.955
3	11	0.998	1	1	0.974
3	12	1	0.348	0.996	0.461
3	13	0.999	0.981	1	1
3	14	1	1	1	1
3	15	1	0.423	0.517	1
3	17	0.511	0.999	0.554	1
3	19	1	0.578	0.649	1
3	21	1	0.978	0.517	1
4	5	0.138	0*	0.909	0.43
4	7	0.932	0.974	0.909	1
4	8	0.001*	0.172	1	0.254
4	9	0*	0.039*	0.909	0.688
4	10	0.009*	0.335	0.909	1
4	11	0.161	0.291	0.996	0.216
4	12	0.695	1	0.909	1
4	13	0.08	0.006*	1	0.303
4	14	0.031*	0.078	0.996	0.303
4	15	0.067	0*	0.998	0.303
4	17	1	0.016*	0.995	0.303
4	19	0.744	0*	0.893	0.866
4	21	0.69	0.01*	0.998	0.359
5	7	0.997	0.507	.	0.835
5	8	1	0.76	0.803	0.999
5	9	0.442	0.036*	.	1
5	10	1	0.001*	.	0.665
5	11	0.965	0.929	0.996	0.948
5	12	0.997	0.013*	.	0.165
5	13	1	1	0.996	1
5	14	1	0.392	0.996	1
5	15	1	0.732	0.296	1
5	17	0.312	0.993	0.354	1
5	19	1	0.998	0.559	0.999
5	21	1	1	0.296	1
7	8	0.936	0.97	0.803	0.654
7	9	0.552	0.995	.	0.966
7	10	0.988	1	.	1
7	11	1	0.976	0.996	0.594
7	12	1	0.999	.	0.999
7	13	0.937	0.624	0.996	0.716

7	14	0.964	0.973	0.996	0.716
7	15	0.978	0.387	0.296	0.716
7	17	0.983	0.73	0.354	0.716
7	19	1	0.43	0.559	0.995
7	21	1	0.617	0.296	0.775
8	9	0.152	1	0.803	0.771
8	10	1	0.667	0.803	0.315
8	11	0.339	1	0.967	0.996
8	12	0.855	0.357	0.803	0.086
8	13	1	0.973	0.997	1
8	14	1	1	0.967	1
8	15	1	0.395	1	1
8	17	0.097	0.999	1	1
8	19	0.978	0.544	0.946	0.891
8	21	1	0.97	1	0.988
9	10	0.099	0.487	.	0.947
9	11	0.017*	1	0.996	0.566
9	12	0.222	0.297	.	0.363
9	13	0.896	0.306	0.996	0.923
9	14	0.447	1	0.996	0.923
9	15	0.541	0.013*	0.296	0.923
9	17	0.017*	0.591	0.354	0.923
9	19	0.441	0.016*	0.559	1
9	21	0.873	0.345	0.296	0.986
10	11	0.77	0.781	0.996	0.247
10	12	0.981	0.936*	.	0.988
10	13	0.999	0.045	0.996	0.405
10	14	1	0.532	0.996	0.405
10	15	1	0*	0.296	0.405
10	17	0.166	0.111	0.354	0.405
10	19	0.999	0*	0.559	0.996
10	21	1	0.063	0.296	0.503
11	12	1	0.483	0.996	0.078
11	13	0.661	0.996	1	0.904
11	14	0.666	1	1	0.904
11	15	0.802	0.648	0.517	0.904
11	17	0.686	1	0.554	0.904
11	19	1	0.789	0.649	0.76
11	21	1	0.995	0.517	0.606
12	13	0.893	0.026*	0.996	0.103

12	14	0.937	0.262	0.996	0.103
12	15	0.967	0.009*	0.296	0.103
12	17	0.915	0.054	0.354	0.103
12	19	1	0.008*	0.559	0.624
12	21	1	0.03*	0.296	0.129
13	14	1	0.827	1	1
13	15	1	0.798	0.783	1
13	17	0.148	1	0.772	1
13	19	0.979	0.977	0.719	0.965
13	21	1	1	0.783	1
14	15	1	0.141	0.517	1
14	17	0.133	0.974	0.554	1
14	19	0.993	0.217	0.649	0.965
14	21	1	0.827	0.517	1
15	17	0.18	0.623	1	1
15	19	0.997	1	0.988	0.965
15	21	1	0.898	1	1
17	19	0.908	0.867	0.996	0.965
17	21	0.821	1	1	1
19	21	1	0.994	0.988	0.993

APPENDIX D - IRB Approval Letter

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional.review.board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
  Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 16050901
PROJECT TITLE: Ratings of Curiosity-related Traits in Dolphins
PROJECT TYPE: New Project
RESEARCHER(S): Malin Lilley
COLLEGE/DIVISION: College of Education and Psychology
DEPARTMENT: Psychology
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 06/17/2016 to 06/16/2017
Lawrence A. Hosman, Ph.D.
Institutional Review Board

APPENDIX E – IACUC Approval Letter

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE

118 College Drive #5116 | Hattiesburg, MS 39406-0001
Phone: 601.266.6791 | Fax: 601.266.4377 | iacuc@usm.edu | www.usm.edu/iacuc

NOTICE OF COMMITTEE ACTION

The proposal noted below was reviewed and approved by The University of Southern Mississippi Institutional Animal Care and Use Committee (IACUC) in accordance with regulations by the United States Department of Agriculture and the Public Health Service Office of Laboratory Animal Welfare. The project expiration date is noted below. If for some reason the project is not completed by the end of the approval period, your protocol must be reactivated (a new protocol must be submitted and approved) before further work involving the use of animals can be done.

Any significant changes should be brought to the attention of the committee at the earliest possible time. If you should have any questions, please contact me.

PROTOCOL NUMBER:	**16041405**
PROJECT TITLE:	**How Do Dolphins React to Surprising and Non-Surprising Events?**
PROPOSED PROJECT DATES:	**04/2016 - 09/2018**
PROJECT TYPE:	**New**
PRINCIPAL INVESTIGATOR(S):	**Stan Kuczaj**
DEPARTMENT:	**Psychology**
FUNDING AGENCY/SPONSOR:	**N/A**
IACUC COMMITTEE ACTION:	**Full Committee Approval**
PROTOCOL EXPIRATON DATE:	**September 30, 2018**

Frank Moore, PhD
IACUC Chair

Date 4/14/2016

REFERENCES

Aguiar, A., & Baillargeon, R. (2003). Perseverative responding in a violation-of-expectation task in the 6.5-month-old infants. *Cognition*, *88*, 277–316. http://doi.org/10.1016/S0

Biondi, L. M., Bó, M. S., & Vassallo, A. I. (2010). Inter-individual and age differences in exploration, neophobia and problem-solving ability in a Neotropical raptor (Milvago chimango). *Animal Cognition*, *13*, 701–710. http://doi.org/10.1007/s10071-010-0319-8

Bird, C. D., & Emery, N. J. (2010). Rooks perceive support relations similar to six-month-old babies. *Proceedings. Biological Sciences / The Royal Society*, *277*, 147–151. http://doi.org/10.1098/rspb.2009.1456

Byman, R. (2005). Curiosity and sensation seeking: A conceptual and empirical examination. *Personality and Individual Differences*, *38*, 1365–1379. http://doi.org/10.1016/j.paid.2004.09.004

Byrne, R. W. (2013). Animal curiosity. *Current Biology*, *23*, R469–R470. http://doi.org/10.1016/j.cub.2013.02.058

Clark, F. E., Davies, S. L., Madigan, A. W., Warner, A. J., & Kuczaj, S. A. (2013). Cognitive enrichment for bottlenose Dolphins (Tursiops truncatus): Evaluation of a novel underwater maze device. *Zoo Biology*, *32*, 608–619. http://doi.org/10.1002/zoo.21096

Collins, R. P., Litman, J. A., & Spielberger, C. D. (2004). The measurement of perceptual curiosity. *Personality and Individual Differences*, *36*, 1127–1141. http://doi.org/10.1016/S0191-8869(03)00205-8

Dallaire, J. A., Meagher, R. K., & Mason, G. J. (2012). Individual differences in stereotypic behavior predict individual differences in the nature and degree of enrichment use in caged American mink. *Applied Animal Behaviour Science*, *142*, 98–108. http://doi.org/10.1016/j.applanim.2012.09.012

Delfour, F., & Aulagnier, S. (1997). Bubbleblow in beluga whales (Delphinapterus leucas): A play activity? *Behavioural Processes*, *40*, 183–186. http://doi.org/10.1016/S0376-6357(97)00782-1

Dellu, F., Mayo, W., Piazza, P. V. V, Le Moal, M., & Simon, H. (1993). Individual differences in behavioral responses to novelty in rats. Possible relationship with the sensation-seeking trait in man. *Personality and Individual Differences*, *15*, 411–418. http://doi.org/10.1016/0191-8869(93)90069-F

de Vere, A., & Kuczaj, S. (2016). Where are we in the study of animal emotions? *WIREs Cognitive Science.* doi: 10.1002/wcs.1399

"Dolphins-World." (2014). Accessed March 6, 2015. http://dolphins-world.com."

Dudzinski, K. M. (1998). Contact behavior and signal exchange in Atlantic spotted dolphins (*Stenella frontalis*). *Aquatic Mammals*, *24*, 129–142.

Eskelinen, H. C., Winship, K. A., Borger-T, & Urner, J. L. (2015). Sex, Age, and Individual Differences in Bottlenose Dolphins (Tursiops truncatus) in Response to Environmental Enrichment, *2*, 241–253. http://doi.org/10.12966/abc.08.04.2015

Freeman, H. D., Brosnan, S. F., Hopper, L. M., Lambeth, S. P., Schapiro, S. J., & Gosling, S. D. (2013). Developing a comprehensive and comparative questionnaire for measuring personality in chimpanzees using a simultaneous topdown/bottom-up design. *America*, *75*, 1–20. http://doi.org/10.1016/j.micinf.2011.07.011.Innate

Fureix, C., & Meagher, R. K. (2015). What can inactivity (in its various forms) reveal about affective states in non-human animals? A review. *Applied Animal Behaviour Science*, *171*, 8–24. http://doi.org/10.1016/j.applanim.2015.08.036

Glickman, S. E., & Sroges, R. W. (1966). Curiosity in Zoo Animals Stable. *Behaviour*, *26*, 151–188. http://doi.org/10.1163/156853966X00074

Greenberg, R., & Mettke-Hofman, C. (2001) Ecological aspects of neophobia and exploration in birds. *Current Ornithology*, *16*, 119-178.

Greene, W., Melillo-Sweeting, K., & Dudzinski, K. (2011). Comparing Object Play in Captive and Wild Dolphins. *International Journal of Comparative Psychology*, *24*, 292–306.

Groothuis, T. G. G., & Carere, C. (2005). Avian personalities: characterization and epigenesis. *Neuroscience & Biobehavioral Reviews*, *29*, 137–150. http://doi.org/10.1016/j.neubiorev.2004.06.010

Hauser, M., & Spaulding, B. (2006). Wild rhesus monkeys generate causal inferences about possible and impossible physical transformations in the absence of experience. *Proceedings of the National Academy of Sciences of the United States of America*, *103*, 7181–7185. http://doi.org/10.1073/pnas.0601247103

Herzing, D. (1996). Vocalizations and associated underwater behavior of free-ranging Atlantic spotted dolphins, *Stenella frontalis* and bottlenose dolphins, *Tursiops truncatus. Aquatic Mammals, 22*, 61-79.

Highfill, L. E., & Kuczaj II, S. A. (2007). Do Bottlenose Dolphins (Tursiops truncatus) Have Distinct and Stable Personalities? *Aquatic Mammals*, *33*(3), 380–389. http://doi.org/10.1578/AM.33.3.2007.380

Hill, H., Kahn, M., Brilliott, L., Roberts, B., Gutierrez, C., & Artz, S. (2011). Beluga (Delphinapterus leucas) Bubble Bursts: Surprise, Protection, or Play? *International Journal of Comparative Psychology*, *24*, 235–243.

Hill, H., Yeater, D., Gallup, S., Guarino, S., Lacy, S., Dees, T., Kuczaj, S. (2016). Responses to familiar and unfamiliar humans by belugas (*Delphinapterus leucas*), bottlenose dolphins (*Tursiops truncatus*), & Pacific white-sided dolphins (*Lagenorhynchus obliquidens*): A replication and extension. *International Journal of Comparative Psychology, 29.*

Hughes, R. N. (1997). Intrinsic exploration in animals: motives and measurement. *Behavioural Processes*, *41*, 213–226. http://doi.org/10.1016/S0376-6357(97)00055-7

Jaakkola, K., Guarino, E., Rodriguez, M., Erb, L., & Trone, M. (2010). What do dolphins (Tursiops truncatus) understand about hidden objects? *Animal Cognition*, *13*, 103–120. http://doi.org/10.1007/s10071-009-0250-z

Johnson, C. M., Sullivan, J., Buck, C. L., Trexel, J., & Scarpuzzi, M. (2014). Visible and invisible displacement with dynamic visual occlusion in bottlenose dolphins (Tursiops spp). *Animal Cognition*, *18*, 179–193. http://doi.org/10.1007/s10071-014-0788-2

King, J. E., Weiss, A., & Sisco, M. M. (2008). Aping humans: age and sex effects in chimpanzee (Pan troglodytes) and human (Homo sapiens) personality. *Journal of*

Comparative Psychology, *122*, 418–427. http://doi.org/10.1037/a0013125

Kuczaj, S. A. (in press). Animal creativity and innovation. In J. Call (Ed.), *APA Handbook of Comparative Psychology*. Washington, DC: APA. http://doi.org/129

Kuczaj, S. A., & Eskelinen, H. C. (2014). Why do Dolphins Play? *Animal Behavior and Cognition*, *2*, 113. http://doi.org/10.12966/abc.05.03.2014

Kuczaj, S., Highfill, L., & Byerly, H. (2012). The importance of considering context in the assessment of personality characteristics: evidence from ratings of dolphin personality. *International Journal of Comparative Psychology*, *25*, 309–329.

Kuczaj, S., & Lilley, M. (2016). Out of the Mouth of babes: Lessons from research on human infants. *Animal Behavior and Cognition, 3,* 212-223.

Kuczaj, S., Makecha, R., Trone, M., Paulis, R. D., & Ramos, J. (2006). Role of Peers in Cultural Innovation and Cultural Transmission: Evidence from the Play of Dolphin Calves. *International Journal of Comparative Psychology, 19*, 223–240. Retrieved from http://escholarship.org/uc/item/4pn1t50s.pdf

Kuczaj, S. A., Winship, K. A., & Eskelinen, H. C. (2015). Can bottlenose dolphins (Tursiops truncatus) cooperate when solving a novel task? *Animal Cognition*, *18*, 543–550. http://doi.org/10.1007/s10071-014-0822-4

Kuczaj, S., Yeater, D., & Highfill, L. (2012). How Selective is Social Learning in Dolphins ? *International Journal of Comparative Psychology, 25*, 221–236.

Legare, C. H. (2012). Exploring explanation: explaining inconsistent evidence informs exploratory, hypothesis-testing behavior in young children. *Child Development*, *83*, 173–185. http://doi.org/10.1111/j.1467-8624.2011.01691.x

Lopes, M. M., Borger-turner, J. L., Eskelinen, H. C., & Kuczaj, S. A. (2016). The Influence of Age, Sex, and Social Affiliation on the Responses of Bottlenose Dolphins (Tursiops truncatus) to a Novel Stimulus Over Time, *Animal Behavior and Cognition, 3*, 32–45. http://doi.org/10.12966/abc.02.03.2016

Luo, Y., & Baillargeon, R. (2008). Can a Self-propelled box have a goal? Psychological Reasoning in 5-month-old infants. *Psychological Science, 16*, 601–608.

Marten, K., & Psarkos, S. (1995). Using self-view television to distinguish between self-examination and social behavior in the bottlenose dolphin (*Tursiops truncatus*). *Consciousness and Cognition, 4*: 205-224.

Massen, J. J. M., Antonides, A., Arnold, A.M. K., Bionda, T., & Koski, S. E. (2013). A behavioral view on chimpanzee personality: Exploration tendency, persistence, boldness, and tool-orientation measured with group experiments. *American Journal of Primatology, 75*, 947–958. http://doi.org/10.1002/ajp.22159

Mitchell, R. (1995). Evidence of dolphin self-recognition and the difficulties of interpretation. *Consciousness and Cognition, 4*, 229-234.

Needham, A., & Baillargeon, R. (1993). Intuitions about support in 4.5-month-old infants. *Cognition, 47*, 121–148. http://doi.org/10.1016/0010-0277(93)90002-D

Overstrom, N. (1983). Association between burst-pulse sounds and aggressive behavior in captive Atlantic bottlenose dolphins (*Tursiops truncatus*). *Zoo Biology, 2*, 93-103.

Piaget, J. (1952). *The Origins of Intelligence in Children*. New York, NY: Norton & Company.

Povinelli, D. J., & Dunphy-Lelii, S. (2001). Do chimpanzees seek explanations? Preliminary comparative investigations. *Canadian Journal of Experimental Psychology = Revue Canadienne de Psychologie Expérimentale*, *55*, 185–93. http://doi.org/10.1037/h0087365

Pryor, K. (1990). *Non-acoustic Communication in Small Cetaceans: Glance, Touch, Position, Gesture, and Bubbles*. (J. Thomas & R. Kastelein, Eds.) *Sensory Ability of Cetaceans*. Springer US. http://doi.org/10.1007/978-1-4899-0858-2_37

Reader, S. M. (2015). Causes of Individual Differences in Animal Exploration and Search. *Topics in Cognitive Science*, *7*, n/a–n/a. http://doi.org/10.1111/tops.12148

Reiss, D., & Marino, L. (2001). Mirror self-recognition in the bottlenose dolphin: a case of cognitive convergence. *PNAS*, *98*, 5937-5942.

Renner, M. (1987). Experience-dependent changes in exploratory behavior in the adult rat (Rattus norvegicus): Overall activity level and interactions with objects. *Journal of Comparative Psychology*, *101*, 94–100. http://doi.org/10.1037//0735-7036.101.1.94

Renner, M., Bennett, A., & White, J. (1992). Age and sex as factors influencing spontaneous exploration and object investigation by preadult rats (Rattus norvegicus). *Journal of Comparative Psychology*, *106*, 217–27. http://doi.org/10.1037/0735-7036.106.3.217

Santos, L. R., Barnes, J. L., & Mahajan, N. (2005). Expectations about numerical events in four lemur species (Eulemur fulvus, Eulemur mongoz, Lemur catta and Varecia rubra). *Animal Cognition*, *8*, 253–62. http://doi.org/10.1007/s10071-005-0252-4

Sarko, D., Marino, L. & Reiss, D. (2002). A bottlenose dolphin's (*Tursiops truncatus*) responses to its mirror image: further analysis. *International Journal of Comparative Psychology, 15*, 69-76.

Singer, R., & Henderson, E. (2015). Object permanence in marine mammals using the violation of expectation procedure. *Behavioural Processes*, *112*, 108–113. http://doi.org/10.1016/j.beproc.2014.08.025

Stahl, A. E., & Feigenson, L. (2015). Observing the unexpected enhances infants' learning and exploration. *Science*, *348*(6230), 91–94. http://doi.org/10.1126/science.aaa3799

Swaisgood, R., & Shepardson, D. (2006). Environmental enrichment as a strategy for mitigating stereotypies in zoo animals: a literature review and meta-analysis. In G. Mason & J. Rushed (Eds.). *Stereotypic animal behavior: fundamentals and applications to welfare* (pp. 256-285). Wallingford, UK: Cabi.

Switzky, H., Haywood, H., & Isett, R. (1974). Exploration, Curiosity, and Play in Young Children: Effects of Stimulus Complexity. *Developmental Psychology*, *10*, 321–329. http://doi.org/10.1037/h0036443

Tetley, C., & O'Hara, S. (2012). Ratings of animal personality as a tool for improving the breeding, management, and welfare of zoo animals. *Animal Welfare, 21*, 463-476.

Thieltges, H., Lemasson, A., Kuczaj, S., Böye, M., & Blois-Heulin, C. (2011). Visual laterality in dolphins when looking at (un)familiar humans. *Animal Cognition*, *14*, 303–308. http://doi.org/10.1007/s10071-010-0354-5

Wang, S. H., Baillargeon, R., & Brueckner, L. (2004). Young infants' reasoning about hidden objects: Evidence from violation-of-expectation tasks with test trials only. *Cognition*, *93*, 167–198. http://doi.org/10.1016/j.cognition.2003.09.012

Wilson, D., Clark, A., Coleman, K., & Dearstyne, T. (1994). Shyness and boldness in humans and other animals. *Trends in Ecology & Evolution*, *9*, 442–446.

Yeater, D., Hill, H., Baus, N., Farnell, H., & Kuczaj, S. (2014). Visual laterality in belugas (*Delphinapterus leucas*) and Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) when viewing familiar and unfamiliar humans. *Animal Cognition*, *17*, 1245-1259.