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The University of Southern Mississippi

CAN DOLPHINS COOPERATE TO SOLVE A NOVEL TASK?

by

Kelley Ann Winship

A Thesis  
Submitted to the Graduate School  
of The University of Southern Mississippi  
in Partial Fulfillment of the Requirements  
for the Degree of Master of Arts

Approved:

Dr. Stan Kuczaj  
Committee Chair

Dr. John Harsh

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Dr. Karen Coats  
Dean of the Graduate School

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## ABSTRACT

### CAN DOLPHINS COOPERATE TO SOLVE A NOVEL TASK?

by Kelley Ann Winship

May 2015

Bottlenose dolphins cooperate in a variety of contexts, including foraging, acquiring mates, playing, and assisting distressed conspecifics. To better understand the capacity for cooperative behaviors, animals are often given tasks that require pairs of animals to coordinate their actions in order to receive a reward. This paper reports the results of an aquatic version of one such task: cooperative rope-pulling. Three groups of captive bottlenose dolphins (*Tursiops truncatus*) were given an apparatus that could most easily be opened by the two animals working together. Two untrained adult males at one location were successful in opening the apparatus together, sharing the food and engaging in cooperative behaviors following their success. These results demonstrate that dolphins can solve a novel task via cooperation, but the failure of the other dolphins to do so suggests that personality, dominance, and social structure influence willingness to cooperate.

## DEDICATION

I am eternally indebted to my parents, who have been more supportive than I could have imagined in my life-long endeavor to study marine mammals. Thank you for all of the books, videos, and, most importantly, the experiences that kept my passion alive.

## ACKNOWLEDGMENTS

I would like to thank my committee: Stan Kuczaj, for his knowledge and guidance; Holli Eskelinen, for her advice in all areas of research and life; and John Harsh for his statistical prowess. This project could not have been completed without help from Conrad Eskelinen, for building and modifying the many apparatuses; the trainers and staff at Dolphins Plus, Dolphin Cove, and Island Dolphin Care for allowing me the opportunity to collect this data; the Dolphins Plus research interns; and Brittany Jones for her insight and pep-talks.

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## CHAPTER I

## INTRODUCTION

Cooperative behavior, defined as two or more individuals acting together to achieve a common goal (Boesch & Boesch, 1989), is seen across the animal kingdom in a wide variety of contexts. Fish and bird species cooperatively mob a potential predator as a method of defense (Dugatkin & Godin, 1992), with similar mobbing behavior being observed in capuchins (*Cebus capucinus*) when attacked by a jaguar (*Panthera onca*) (Tórréz, Robles, González, & Crofoot, 2012) and in Australian fur seals (*Arctocephalus pusillus doriferus*) when attacked by a great white shark (*Carcharodon carcharias*) (Kirkwood & Dickie, 2005). Many carnivorous mammal species benefit from a higher litter growth rate due to communal or biparental care (Creel & Creel, 1991). Lions (*Panthera leo*) (Packer, Scheel, & Pusey, 1990; Scheel & Packer 1991; Stander, 1992), wolves (*Canis lupis*) (Mech, 2007; Mech & Boitani, 2003; Packard, 2003; Peterson, & Ciucci, 2003), and African wild dogs (*Lycaon pictus*) (Creel & Creel, 1995) all practice hunting behaviors considered cooperative in nature. Chimpanzees (*Pan troglodytes*) are noted to cooperate in hunting, resolving territorial disputes, defending against predators such as snakes and leopards, and assisting conspecifics when captured in a snare (Boesch & Boesch, 1989). Cooperation also occurs in the aquatic environment. Large groups of crabeater seals (*Lobodon carcinophaga*) have been seen engaging in what appears to be a cooperative foraging effort in the Antarctic (Gottfried, 2014), fish species will engage in symbiotic cleaning events (Brown, Creed, Skelton, Rollins, & Farrell, 2012), and lionfish (*Dendrochirus zebra*) use fin displays to initiate cooperative hunting interactions (Lönstedt, Ferrari, & Chivers, 2014). Such cooperative instances in most marine organisms are limited to a single situation, such as food acquisition. Dolphins, however,

have showed the capacity for cooperation in many different scenarios: reproduction, play, foraging, and epimeletic behavior.

Several dolphin species have been observed practicing epimeletic behavior, in which the animals aid sick, injured, and even deceased pod mates (Caldwell & Caldwell, 1966). The behavior is divided into two forms: nurturant, helping behavior directed towards calves, and succorant, helping behavior directed towards adults (Caldwell & Caldwell, 1966). In this paper, only epimeletic behavior involving the assistance of two or more animals is examined, as cooperation requires the combined actions of at least two individuals. Early instances of reported cooperative epimeletic behavior involve dolphins cooperating to support an injured animal at the surface so that it could breathe safely until it had recovered enough to swim away (Siebenaler & Caldwell, 1956). A deceased juvenile male rough-toothed dolphin (*Steno bredanensis*) washed ashore after presumably several days of being kept afloat by two other dolphins that were seen assisting it prior to the stranding (de Moura, Rodrigues, & Siciliano, 2009). A mother rough toothed dolphin carried her deceased calf for several days, with a few of her pod mates escorting her, chasing away any gulls that approached the newborn, as well as even carrying the calf themselves (Ritter, 2007). Five common dolphins (*Delphinus capensis*) formed a raft-like formation in order to support a dying individual at the surface (Park et al., 2012). In South Africa, two bottlenose dolphins (*Tursiops sp.*) carried a dead calf at the surface, holding the animal up with either their rostrums or pectoral fins (Cockcroft & Sauer, 1990). While a paralyzed juvenile dolphin was assisted by an adult female in Port Phillip, Australia, the other two members of the group often placed themselves between the observation boat and the swimming pair, even swimming toward the vessel aggressively (Warren-Smith & Dunn, 2006).

Male dolphins in Shark Bay, Australia form small, cooperative alliances to either herd individual females to prevent them from mating with other males, or form larger alliances in order to take on other, competing groups of roving males (Connor, Smolker, & Richards, 1992). These alliances have been shown to consist of three levels, which appear to vary in stability based on the relatedness of the dolphins (Connor, Watson-Capps, Sherwin, & Krützen, 2010). First-order alliances in this region are more likely to be composed of males that are closely related (Krützen et al., 2003). In the Bahamas, genetic testing performed on male alliances of *Tursiops truncatus* showed that males were also more likely to form alliances with kin than was expected by chance (Parsons et al., 2003). However, in some locations kinship is not an apparent method of alliance selection, suggesting that other variables may be in play (Möller, Beheregaray, Harcourt, & Krützen, 2001). The cooperation of these alliances results in their combined safety from other groups of dolphins, as well as an increased chance of their genes being passed on to the next generation.

Dolphins are known for their play behaviors, and there is a collaborative and cooperative nature in these animals' play (Connor, Wells, Mann, & Read, 2000; Mann & Smuts, 1999; Paulos, Trone, & Kuczaj, 2010; Wursig, 2002). Captive animals may play with their conspecifics by beaching in order to be pushed back into the water (Paulos et al., 2010), taking turns both pushing and being pushed around their tank (Kuczaj & Highfill, 2005), or by pulling their tank mates around inside of a hula-hoop (Kuczaj & Walker, 2012). The animals also initiate and maintain cooperative play behaviors with human keepers (Kuczaj & Highfill, 2005). Wild cooperative play in rough toothed dolphins (*Steno bredanensis*) (Kuczaj & Highfill, 2005; Kuczaj & Yeater, 2007), and

spinner dolphins (*Stenella longirostris*) (Silva, Silva, & Sazima, 2005) involve the animals playing with debris found in the ocean.

Cetaceans also cooperate while foraging. Dusky dolphins (*Lagenorhynchus obscurus*) (Vaughn, Muzi, Richardson, & Würsig, 2011; Würsig & Würsig, 1979, 1980) and spinner dolphins (*Stenella longirostris*) (Benoit-Bird & Au, 2009) herd schools of fish to the surface, keeping them tightly contained in a bait ball, allowing each member of the pod to feed while other members maintain the organization of the ball. Such prey herding is a common foraging tactic in cetaceans, with killer whales (*Orcinus orca*) and humpback whales (*Megaptera noviangliae*) even using bubbles to aggregate the fish in a tight area (for review, see Heithaus & Dill, 2002). Guiana dolphins (*Sotalia guianensis*) use four different hunting methods that all require group participation (Tardin, Especie, Nery, D'Azeredo, & Simão, 2011). Bottlenose dolphins also cooperate while foraging. In the Florida Bay, pods of *Tursiops truncatus* forage by creating a mud plume wall around species of mullet, and then simultaneously lunging into the circle and catching the jumping fish (Torres & Read, 2009). In the marshes of South Carolina, groups of bottlenose dolphins intentionally rush the shoreline, propelling both themselves and the fish onto the muddy shores, where they are able to feed freely on the stranded fish before sliding back into the water (Duffy-Echevarria, Connor, & St. Aubin, 2008; Hoese, 1971).

Dolphins will also cooperate with other species. Cooperative foraging encounters between bottlenose dolphins and false killer whales (*Pseudorca crassidens*) retain a degree of segregation between the species during the event, though both groups benefit from the interaction (Zaeschmar, Dwyer, & Stockin, 2013). In some locations, dolphins coordinate fishing activities with humans. For example, a group of bottlenose dolphins in Southern Brazil (Daura-Jorge, Cantor, Ingram, Lusseau, & Simões-Lopes, 2012) and a

group of Irrawaddy dolphins (*Orcaella brevirostris*) in the Ayeyarwady River (Smith, Tun, Chit, Win, & Moe, 2009) both participate in cooperative hunting efforts with local fishermen. However, many variables are unaccounted for in wild instances of cooperation. To better understand the mechanisms that underlie these behaviors, experimental investigations of cooperative behavior have been conducted.

Chalmeau and Gallo (1996a) argue that true cooperative behavior requires that the cooperating individuals understand both the situation and their relative social relationships. Experimental investigations are designed to explore the animals' awareness of their partner's behavior and their ability to make adjustments to their own behavior based on their partner's behavior. Such experiments also allow for control of external variables that are impossible to manipulate in wild observations, such as animal pairings and task difficulty. It is possible that some observed cooperative behaviors happen by chance, thus are not truly cooperative (Chalmeau & Gallo, 1995a), so the designed tasks must appropriately test the behavior within the physical limitations of the target species.

The most common design to test cooperation is an apparatus in which two animals must synchronize their actions in order to receive a food reward. One of the first tests of cooperative behavior in non-human animals involved pairings of two young chimpanzees that had been trained to pull ropes simultaneously to obtain a food reward (Crawford, 1937). The chimpanzees would even encourage help from unwilling partners. However, changes in the pulling technique (from horizontal to vertical) in later trials resulted in failure, demonstrating a lack of understanding of the task. Hirata and Fuwa (2007) adapted this task to explore if the chimpanzees would cooperate without behavioral shaping, but eventual training was required. Chalmeau (1994) created a fruit distributor setup that the animals learned through trial and error to operate. The alpha

male chimpanzee worked together with an infant chimpanzee to access the fruit, which the alpha male then monopolized.

In a cooperative tool-exchange task, a female Hamadryas Baboon (*Papio hamadryas*) cooperated with a male, but no communication between the animals was noted (Beck, 1973). Povinelli, Nelson, and Boysen (1992) successfully trained chimpanzees to cooperate with human partners in a task that required either gesturing toward a box with a reward in it or responding to a human's gesturing toward a box. Three of the four chimpanzees were easily able to undertake the opposite role in subsequent trials. However, rhesus monkeys exposed to this test could not immediately comprehend a role reversal (Povinelli et al., 1992).

Preferences toward cooperative interactions have also been examined in primates. When presented with an uninterested adult human partner in a cooperative task, young children attempted to reengage the partner while young chimpanzees did not (Warneken, Chen, & Tomasello, 2006). Similar findings of cooperative inclination were discovered when children and chimpanzees were asked to complete a rope-pulling task: the children preferred to cooperate while chimpanzees did not (Rekers, Haun, & Tomasello, 2011). Chimpanzees have demonstrated greater proficiency in cognitive tasks that are competitive in nature, as opposed to tasks that require cooperation (Hare & Tomasello, 2004). Melis, Hare, and Tomasello (2006b) showed that when collaboration is necessary, chimpanzees seek out a collaborator and attempt to recruit them based on their previous experiences working together. Chimpanzees also prefer to work individually rather than collaborate when the payoff is the same, and only prefer collaboration if the reward for that option is greater (Bullinger, Melis, & Tomasello 2011).

Melis, Hare, and Tomasello (2006b) found that chimpanzees spontaneously cooperate to perform a task when partners have a high tolerance level, which is measured by the willingness of an animal to share food. If one animal was less tolerant, even previously successful animals did not cooperate with that chimpanzee. Bonobos (*Pan paniscus*) have shown their ability to outperform chimpanzees in tasks that require cooperation, which has been attributed to their higher tolerance level (Hare, Melis, Woods, Hastings, & Wrangham, 2007). Bonobos showed more tolerance than chimpanzees when cofeeding, cooperated as well as chimpanzees when there was shareable food, and were more successful at cooperating than chimpanzees when the food was easily monopolizable (Hare et al., 2007). This suggested that though the animals might understand the need for coordinated behavior, social tolerance is crucial in cooperation. Early experiments with capuchins, which have also shown a high tolerance level (de Waal, Luttrell, & Canfield, 1993; de Waal, 1997), suggested they cooperate without understanding and adjusting to their partner's behavior (Chalmeau, Visalberghi, & Gallo, 1997; Visalberghi, Quarantotti, & Tranchida, 2000). Later studies suggested that the capuchins might not have fully understood the apparatus of Chalmeau et al. (1997) with its mechanical design, as an adjustment to the task rendered the capuchins significantly less successful when their abilities to observe and coordinate with their partner's behavior were blocked (Mendres & de Waal, 2000).

Individual capuchins trained to participate in a sequence task cooperated when the opportunity was given, though there was no explicit communicative behavior (Hattori, Kuroshima, & Fujita, 2005). In handle-pulling tasks with untrained chimpanzees (Chalmeau & Gallo, 1996b) and orangutans (Chalmeau, Lardeux, Brandibas, & Gallo, 1997), the animals coordinated their behaviors with their partners

more successfully than the same task administered to trained capuchins (Chalmeau et al., 1997). The results suggested that the cognitive processes of chimpanzees and orangutans are similar, though the latter have not been observed cooperatively hunting in the wild. Cottontop tamarins (*Sanguinus oedipus*) successfully cooperated to pull a tray handle for food, but required behavioral shaping in order to become proficient (Cronin, Kurian, & Snowdon, 2005). The tamarins pulled on the apparatus significantly more when a partner was present, suggesting they understood a partner was necessary. While various primate species have undergone cooperative tests, the cooperative abilities of other organisms have also been tested.

Rooks (*Corvus frugilugus*) coordinated, but did not delay their actions in response to their partner in a string-pulling task (Seed, Clayton, & Emery, 2008). The temperament of the rooks was an indicator of their performance on cooperative tasks: bold rooks were more willing to participate, while shy rooks were easily influenced by their partner's behavior (Scheid & Noë, 2010). African grey parrots (*Psittacus erithacus*) were also able to coordinate string-pulling behavior; however only one altered its actions in response to its partner (Péron, Rat-Fischer, Lalot, Nagle, & Bovet, 2011). Keas (*Nestor notabilis*) participated in a seesaw task in which the dominant birds forced cooperation and monopolized the food (Tebbich, Taborsky, & Winkler, 1996).

Drea and Carter (2009) constructed a rope-pulling task for spotted hyaenas (*Crocuta crocuta*), a species that naturally engages in cooperative hunting behaviors that can include pulling motions. The animals in this study were not trained, but were acquainted with a similar solo task. The animals were successful, and those experienced with the testing procedure modified their behavior in order to cooperate successfully with naïve animals (Drea & Carter, 2009).



Domestic dogs (*Canis familiaris*), which fail to show understanding of means-end connections (Osthaus, Lea, & Slater, 2005), coordinated their behavior to receive a reward in a sliding-door task (Bräuer, Bös, Call, & Tomasello, 2013). Although the dog pairs were successful, they showed no communicative behaviors to coordinate or motivate their partners and it was unclear whether the animals were conscious of their partner's behavior or if they had just learned appropriate timing (Bräuer et al., 2013). Dominant animals received most of the food reward, and the amount of food the dominant animal received was positively correlated with the speed at which the dogs solved the problem.

Asian Elephants (*Elephas maximus*) were provided with a large version of the rope-pulling task and cooperated successfully at the same level as chimpanzees (Plotnik, Lair, Suphachoksakun, & de Waal, 2011). The elephants learned to wait for their partner in a delayed release trial, and one even stepped on the rope, forcing the partner to pull in the cart alone.

A summary of the species that performed in an explicitly cooperative task demonstrating their cooperative capabilities is shown in Table 1, below.

Table 1

*Summary of Cooperative Task Research*

Species	Study	Task Type	Training	Result	Notes
Chimpanzees ( <i>Pan troglodytes</i> )	Crawford, 1937	RP	Yes	S	Required much training
	Povinelli et al., 1992	RG	Yes	S	Worked with human partner, able to reverse roles

Table 1 (continued).

Species	Study	Task Type	Training	Result	Notes
Chimpanzees ( <i>Pan troglodytes</i> )	Chalmeau, 1994; Chalmeau & Gallo, 1996a; 1996b	HP	Yes	S	Alpha male monopolized the reward
	Hirata & Fuwa, 2007	HP	No	F	Training necessary for success Employed alternate strategies for success
Elephants ( <i>Elephas maximus</i> )	Plotnik et al., 2011	RP	Yes	S	No communication between animals
Hamadryas Baboons ( <i>Papio hamadryas</i> )	Beck, 1973	TE	No	S	Could not comprehend a role reversal
Rhesus monkeys ( <i>Macaca mulatta</i> )	Povinelli et al., 1992	RG	Yes	S	Did not modify pulling behavior
Capuchin monkeys ( <i>Cebus apella</i> )	Chalmeau et al., 1997	HP	Yes	F	Did not modify pulling behavior
	Visalberghi et al., 2000	HP	Yes	F	Modified pulling behavior
	Mendres & de Waal, 2000	BP	Yes	S	No communication between animals
	Hattori et al., 2005	ST	Yes	S	
Orangutans ( <i>Pongo pygmaeus</i> )	Chalmeau et al., 1997	HP	No	S	Did not modify pulling behavior
Rooks ( <i>Corvus frugilegus</i> )	Seed et al., 2008	RP	No	F	Could not comprehend a role reversal
African Grey Parrots ( <i>Psittacus erithacus</i> )	Péron et al., 2011	RP	Yes	S	

Table 1 (continued).

Species	Study	Task Type	Training	Result	Notes
Cottontop tamarins ( <i>Sanguinus oedipus</i> )	Cronin et al., 2005	HP	Yes	S	
Keas ( <i>Nestor notabilis</i> )	Tebbich et al., 1996	LP	No	S	Dominant individuals forced cooperation
Spotted Hyenas ( <i>Crocuta crocuta</i> )	Drea & Carter, 2009	RP	No	S	
Domestic dogs ( <i>Canis familiaris</i> )	Bräuer et al., 2013	SD	No	S	Unclear if dogs were conscious of partners' behavior
Timber wolves ( <i>Canis lupis</i> )	Möslinger, Kotschal, Huber, Range, & Virányi, 2009	SP	Yes	S	Dominant animal did not force cooperation

Note. Only studies that specifically looked at cooperation (not tolerance or cooperative preference) are listed in this table. Task Type: RP = rope pulling, HP= handle pulling, SP = string pulling, TE= tool exchange, LP = lever pushing, BP= bar pulling, ST= sequence task, RG= response to gesture, SD = sliding door. Result: S= success, F = failure

While wild dolphins cooperate to assist injured companions, secure a breeding partner, play, and forage, it has proven difficult to determine the origin of these behaviors, as well as demonstrate cooperation when dolphins are exposed to a novel problem. This task was the first to explore cooperative problem solving abilities in bottlenose dolphins when given a novel device.

## CHAPTER II

## METHODS

Dolphins Plus and Dolphin Cove are both interaction and research facilities located on the coast of Key Largo, in Southern Florida. Island Dolphin Care is a not-for-profit facility that provides therapeutic services to children and adults. All three facilities house Atlantic Bottlenose Dolphins (*Tursiops truncatus*) in natural seawater enclosures. The housing enclosure at Dolphin Cove consists of a 20,000-ft<sup>2</sup> area with an approximate, mean depth of 18 ft ( $\pm 4$  ft). The two housing enclosures at Dolphins Plus (hereon referred to as the “North Side”) and at Island Dolphin Care (hereon referred to as the “South Side”) include a total area of 18,000 ft<sup>2</sup> and a mean depth of 12 ft ( $\pm 4$  ft). All locations continued normal training sessions during trials, and had a range of ages (Table 2) and varying combinations of mother-calf and gender groupings.

Table 2

*Study Population Demographics*

Dolphin Cove	Age	Sex	Captive Born
Alfonz	20	M	Yes
Kimbit	20	M	Yes
Samantha	~ 29	F	No
Isaac	2	M	Yes
Nica	9	F	Yes
Julie	6	F	Yes
Elvis*	9	M	Yes
Leo*	10	M	Yes
The North Side	Age	Sex	Captive Born
Ding	~ 36	F	No
Baby-Bit (BB)	2	F	Yes
Sarah	~ 29	F	No
Grace	5	F	Yes
Jessica	~ 29	F	No

Table 2 (continued).

The North Side	Age	Sex	Captive Born
Zoe	3	F	Yes
Fiji	9	M	Yes
The South Side	Age	Sex	Captive Born
Squirt	~ 31	F	No
Lotus	5	F	Yes
Tashi	1	M	Yes
Bob	19	M	Yes
Bella	13	F	Yes

Note: \*Elvis and Leo were both moved prior to the start of free-floating trials.

### Apparatus and Materials

Conrad Eskelinen, Stan Kuczaj, and Holli Eskelinen designed and constructed the testing apparatuses (Figure 1). Each device consisted of a 17” long hollow PVC cylinder of 4 ½” diameter and two nylon ropes extending from either side, with two GoPro Hero3 cameras mounted near the ends to collect additional video footage. The additional ropes on either side allowed for more than 2 animals to pull on the ropes at any time. Later modifications to the apparatus for safety purposes modified the four ropes to two loops, one extending from either side (Figure 1a & 1b).



*Figure 1.* The apparatus and training device. Photos a) and b) depict the device, while photo c) shows the training device.

The apparatus was filled with approximately 1.5 lbs. of fish, gelatin, and ice as reinforcement for success for each trial. The trials were recorded using multiple cameras:

a Canon Powershot S100 12.1MP digital camera, a Canon Powershot G12 10.0MP digital camera with Canon WP-DC34 underwater housing, and two GoPro Hero3's in GoPro Hero3 housings that were attached to each apparatus using tripod mounts.

### Preliminary Training and General Procedure

The dolphins at Dolphins Plus, Island Dolphin Care, and Dolphin Cove were not accustomed to pulling a rope. Because of this, it was necessary for a few individuals to be trained to pull a rope so that they had the requisite skill to open the test apparatus when it was introduced into their exhibit. The animals selected were as follows: Dolphin Cove, Elvis and Leo; North Side, Ding, Sarah, Grace, and Fiji; South Side, Squirt and Lotus. The animals were all trained to bite down on the rope and pull. To fit criteria, the animals were asked to pull a jolly-ball toy with a rope attached (Figure 1c) across their enclosure three times. The dolphins on the North and South Sides were eventually trained using the apparatus due to failure in the first set of trials. Sessions occurred at varying times of the day, depending on the facility schedule.

### The Conditions

#### *Testing Set-Up*

For Condition 1 and the first 7 trials of Condition 2, the trainer walked down on the dock, opened the apparatus in front of the dolphins, filled it with 1.5 lbs. of fish, and emphasized the motion of pulling the rope and placing the fish inside. The trainer then emptied the apparatus and allowed the dolphins to feed before refilling the apparatus and leaving the area. For the sessions following Trial 7 of Condition 2, the apparatus was filled out of sight and tossed into the lagoon.

*Condition 1*

This condition allowed the dolphins the opportunity to understand the mechanics of operating the apparatus. During this condition, dolphins were exposed to the device while it was tied to a portion of their enclosure. Thus, the non-opening end was tied to a handle on a dock while the other end was free floating.

*Condition 2*

The apparatus was allowed to free float in the enclosure, providing the true cooperative test. The easiest way for the apparatus to open was for two animals to each grasp the ropes on one side and pull.

*Condition 3*

In this condition, the number of apparatuses placed in the lagoon was randomly varied between one or two apparatuses. This condition served to evaluate whether the animals preferred to work together on one apparatus or to each go to their own in the two apparatus trials. The implementation of a second apparatus also allowed other animals the opportunity to potentially interact.

*Condition 4*

The opening cap was replaced with a black cap, while the closed end remained white, to explore the role that dominance might have played in interacting with the apparatus, as it provided a stark contrast between the two ends.

*Condition 5*

This condition, only occurring at Dolphin Cove, consisted of the two adult males being held at station for the duration of the trial while one all-white apparatus was released into the lagoon.

## Coding and Analysis

The video footage was coded and analyzed using an all-occurrence method (Altmann, 1974) in which the animals' interaction rate per minute and type of interaction were recorded. All behaviors involving the apparatus were coded for the duration of the trial. A trial success was considered to be any instance of the apparatus opening, whether this was due to 1) simultaneous cooperation- two animals pulled on the ropes at the same time, causing the apparatus to open 2) sequential cooperation- one animal opened the apparatus after both animals have held the ropes, potentially loosening the cap or 3) solo opening- only one animal interacted with the apparatus and it opened. Cooperative behavior was constituted based on two animals interacting with the apparatus together in order to achieve the common goal of opening the apparatus, releasing fish, or transporting the apparatus (Boesch & Boesch, 1989) without visible aggression (e.g. biting, displacement). The tugging rates (tugs/minute) were also analyzed to look for differences between times when the animals were alone or in the presence of the other male (male investigating or also interacting with apparatus) as well as aggressive or synchronous behaviors.

Videos were coded using all camera angles, unless one of the GoPro cameras became dislodged from its normal position, in which case only the above-water camera was used. Inter-rater reliability for the interaction rate as well as the tugging rate of each animal was assessed at above 80% accuracy for 20% of the data.



## CHAPTER III

### RESULTS

#### North Side

This location did not show much interest in the apparatus. Four out of the seven dolphins housed on this side were eventually trained to open the apparatus during the 30 trials allotted to them for Condition 1, however there was no cooperative behavior observed between animals interacting with the apparatus. Generally, the apparatus was opening through forceful contact, and it wasn't until the implementation of extensive training that some animals began to mouth the ropes. However, there was no cooperative opening behavior. The dominant females opened the apparatus the most frequently, and the younger animals were not often granted access to interact with it. Due to the lack of cooperative opening behavior, analyses were not conducted at this location for this thesis.

#### South Side

The adult female, Squirt, was trained to open the apparatus after 20 trials of Condition 1. She continued to open the apparatus by herself for the rest of the study, alternating sides when tugging on the ropes. She also refused to let any other animals interact with the apparatus, including her also-trained daughter, Lotus. She shared food with Bob, the adult male, and her calf, Tashi. If Bob attempted to interact with the apparatus, Squirt would immediately remove it from his vicinity. Because of the lack of cooperative behavior observed on the South Side, analyses from this location were not performed for this thesis.

## Dolphin Cove

*Condition 1*

The animals successfully opened the apparatus five times within the 10 trials first established for Condition I (50%). The first success occurred during Trial 3, with success occurring again in Trials 4, 7, 9 and 10. Following the second success, the dominant males, Alfonz and Kimbit, patrolled the apparatus and kept the successful animals (Elvis and Isaac in both prior instances) from interacting with it. The two adult males successfully hit the apparatus open in Trial 7. In Trial 9, Alfonz pulled the opening end rope and opened the apparatus by himself, and in Trial 10 the males hit the apparatus with their rostrums until it was opened. It was during the post-opening time in this condition that the two males became familiar with pulling on the ropes, as they used this technique to appropriately maneuver the apparatus to feed from it.

*Condition 2*

During this condition, the apparatus was opened successfully 10 out of the 12 trials (83.33%). Alfonz opened the apparatus once by himself, and the pair opened the device 8 times using simultaneous cooperation, and once using sequential cooperation (Table 3).

Table 3

*Condition 2 Trial Results.*

Trial	Date	Opened	Time taken to open (minutes: seconds)	Simultaneous/ Sequential/ Solo
1	7/1/13	No	N/A	N/A
2	7/2/13	Yes	0:11	Simultaneous
3	7/3/13	Yes	0:20	Simultaneous
4	7/4/13	Yes	1:49	Sequential
5	7/6/13	Yes	0:11	Simultaneous
6	7/7/13	Yes	0:06	Simultaneous

Table 3 (continued).

Trial	Date	Opened	Time taken to open (minutes: seconds)	Simultaneous/ Sequential/ Solo
7	7/8/13	Yes		0:20 Solo- Alfonz
8	7/8/13	No	N/A	N/A
9	7/10/13	Yes		0:10 Simultaneous
10	7/12/13	Yes		0:44 Simultaneous
11	7/15/13	Yes		0:13 Simultaneous
12	7/15/13	Yes		0:31 Simultaneous

Alfonz was the first animal to touch the apparatus in 9 out of the 12 trials (75%), and touched simultaneously with Kimbit in two trials (16.6%) (Table 4). Kimbit only made contact with the apparatus first in one trial (8.4%). When the apparatus opened, Kimbit was on the closed end five times (50%) and Alfonz was on the closed end 4 times (40%) of the 10 successful trials. In one trial, the cap popped off due to pressure change when Kimbit released it from depth, so no animals were on the apparatus at the time of opening. When returning the apparatus unasked, Alfonz was on the opening end three times out of ten trials (30%) and on the closed end four times (40%). Kimbit returned the apparatus on the opening end four times (40%) and on the closed end five times (50%).

Table 4

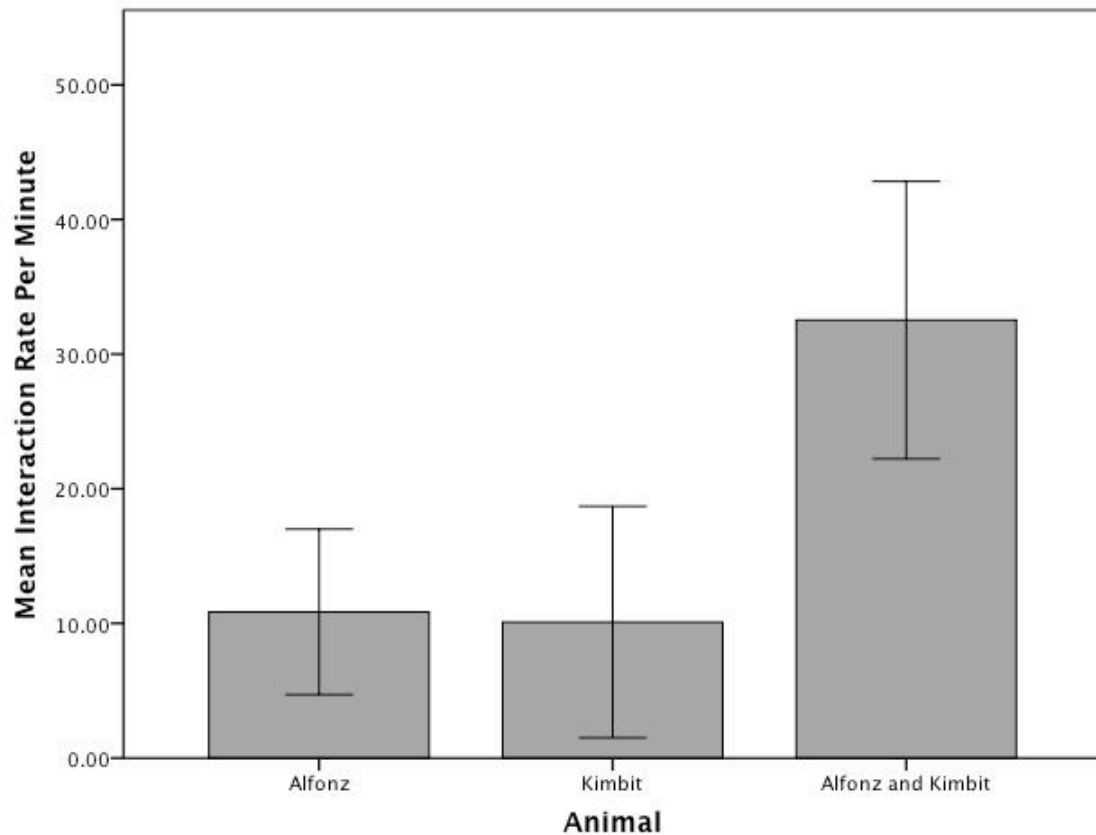
*Condition 2 Side Information*

Trial	First Animal to Touch Apparatus	At Time of Opening		Returning Apparatus	
		Opening End	Closed End	Opening End	Closed End
1	Alfonz and Kimbit		N/A		N/A
2	Alfonz and Kimbit	Kimbit	Alfonz	Alfonz asked	
3	Alfonz	Kimbit	Alfonz		Kimbit
4	Alfonz		NONE	Kimbit	Alfonz
5	Alfonz	Alfonz	Kimbit		Kimbit
6	Alfonz	Kimbit	Alfonz	Kimbit	
7	Alfonz		Alfonz	Alfonz	Kimbit
8	Kimbit		N/A		Alfonz

Table 4 (continued).

Trial	First Animal to Touch Apparatus	At Time of Opening		Returning Apparatus	
		Opening End	Closed End	Opening End	Closed End
9	Alfonz	Alfonz	Kimbit	Alfonz	Kimbit
10	Alfonz	Alfonz	Kimbit	Kimbit	Alfonz
11	Alfonz	Alfonz	Kimbit	Kimbit	Alfonz
12	Alfonz	Alfonz	Kimbit	Alfonz	Kimbit

Figure 2 shows the interaction rate per minute of each of the two males as a team, as well as individually. Both Alfonz and Kimbit's solo interaction rates were significantly different than the pair's interaction rate together ( $F(2, 33) = 8.95, p = .001$ ). Alfonz (Tukey HSD:  $p < .01$ ) and Kimbit (Tukey HSD:  $p < .01$ ) interacted alone at a significantly lower rate compared to the two males interacting together. There was no difference in the interaction rate of each individual male (Tukey HSD:  $p = .991$ ).



*Figure 2.* Condition 2 interaction rates. There was no significant difference between Alfonz and Kimbit's solo interaction rates, but a significant difference in the rate of each animal alone compared to the interaction rate together ( $p < .01$ ).

Analyses of tugging rates in this condition revealed no overall differences between Alfonz ( $M = 1.7$ ,  $SE = .56$ ) and Kimbit ( $M = .6814$ ,  $SE = .25$ ),  $t(22) = 1.667$ ,  $p = .116$ . However, both dolphins tugged at a significantly higher rate in the presence of the other animal compared to when they were alone (Alfonz,  $t(22) = 2.858$ ,  $p < .05$ ; Kimbit,  $t(22) = 2.606$ ,  $p < .05$ ).

### *Condition 3*

In this condition, the dolphins were randomly exposed to either one apparatus or two apparatuses. Trials 1, 3, 6, 8, 9 and 10 consisted of an Apparatus A and an Apparatus B, while the other 6 trials consisted of using only one apparatus (Table 5). Each apparatus was treated as a separate Trial for coding purposes. The apparatus was opened

15 out of 16 usable trials (93.75%). Trial 3 was omitted due to lack of sufficient video data. The opening strategy of 13 out of the 15 trials was confirmed. Five trials were opened by Alfonz solo, one trial was opened by Kimbit solo, five trials were opened by simultaneous cooperation, and two trials were opened by sequential cooperation.

Trial 5 experienced issues with one of the GoPro's, making it impossible to determine whether Alfonz opened the apparatus alone, or if Kimbit was able to get ahold of the other end of the apparatus prior to it opening. Both of Apparatus A's GoPro cameras became detached during Trial 8, so the nature of the opening as well as the exact time it occurred is unknown. In Trial 10, the cap on Apparatus B became cock-eyed so the apparatus was reset after 6:22 of the trial, as to not discourage the dolphins from interacting with it in the future. They opened the apparatus after 41 seconds using sequential cooperation once it was reset.

Because this condition has the addition of a second apparatus, each version of the trial-type in this condition (One-Apparatus/Two Apparatus) will be analyzed separately, followed by the comparison.

Table 5

*Condition 3 Trial Results*

Trial	Date	Apparatus	Opened	Time taken to open (minutes: seconds)	Simultaneous/ Sequential/ Solo
1	7/17/13	A	Yes	1:16	Solo- Alfonz
		B	Yes	0:45	Solo- Kimbit
2	7/18/13	--	Yes	0:14	Solo- Alfonz
3				<b>OMITTED*</b>	
4	7/21/13	--	Yes	0:27	Simultaneous

Table 5 (continued).

Trial	Date	Apparatus	Opened	Time taken to open (minutes: seconds)	Simultaneous/ Sequential/ Solo
5	7/23/13	--	Yes	0:32	Unk. (Solo-A or Simultaneous)
6	7/25/13	A	Yes	2:12	Simultaneous
		B	Yes	0:30	Simultaneous
7	7/25/13	--	Yes	0:19	Simultaneous
8	7/26/13	A	Yes	10:31-12:20	Unk. (Simultaneous or Sequential)
		B	Yes	1:32	Solo- Alfonz
9	7/28/13	A	Yes	0:54	Solo- Alfonz
		B	No	N/A	N/A
10	7/28/13	A	Yes	0:13	Solo- Alfonz
		B	Yes	App adjusted 0:41	Sequential
11	7/29/13	--	Yes	0:45	Simultaneous
12	7/30/13	--	Yes	0:33	Sequential

Note. Trial 3 was omitted due to lack of usable video footage; Trials 5 and 8 had unknown categorizations for the opening strategy due to compromised footage; Trial 8 had an unknown opening time due to both GoPro's falling off the apparatus.

### *One-Apparatus Trials*

Alfonz made contact with the apparatus first in five out of the six trials (83.3%), while Kimbit was first only once (16.7%) (Table 6). Alfonz was on the opening end at the time of opening all six of the trials (100%) and returned the apparatus on the opening end four out of six trials (66.7%). Kimbit was on the opening end twice and the closed end twice (33.3%) out of the six trials.

Table 6

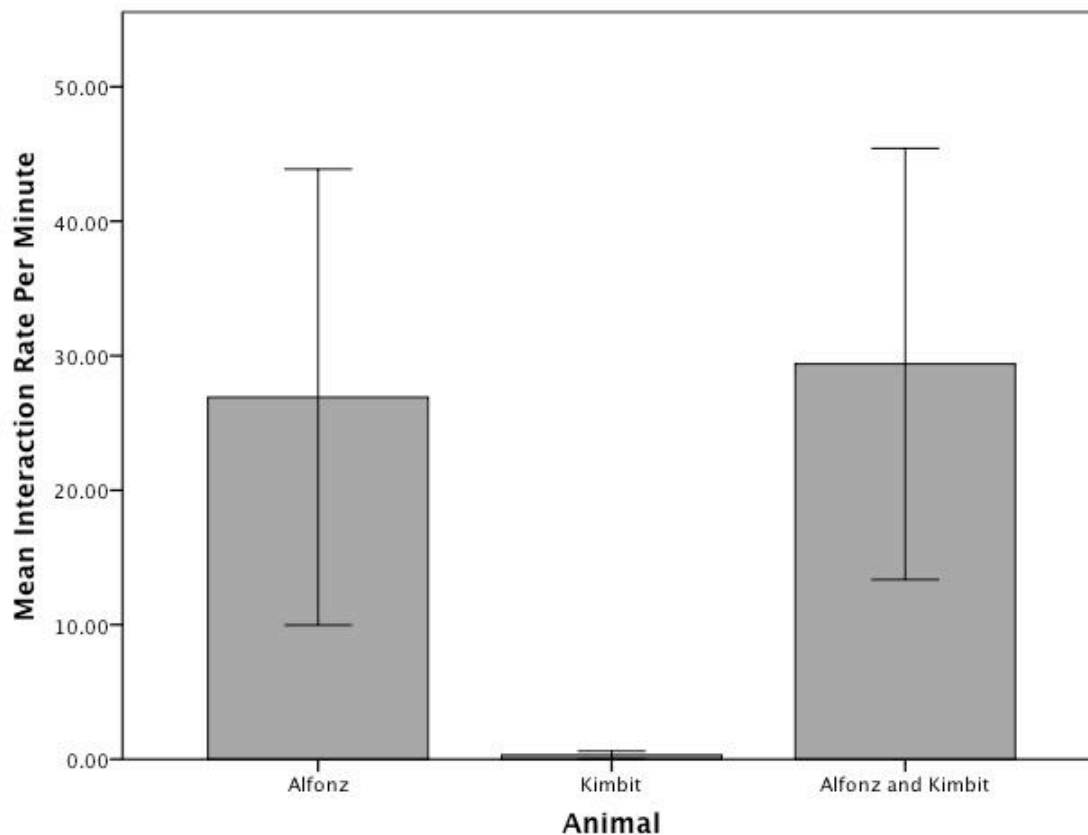
*Condition 3: One Apparatus Trials Side Information*

Trial	First Animal to Touch Apparatus	At Time of Opening		Returning Apparatus	
		Opening End	Closed End	Opening End	Closed end
2	Alfonz	Alfonz		Alfonz	Kimbit
4	Kimbit	Alfonz	Kimbit	Kimbit	Alfonz
5	Alfonz	Alfonz	Unknown	Alfonz	Kimbit
7	Alfonz	Alfonz	Kimbit	Kimbit	Alfonz
11	Alfonz	Alfonz	Kimbit	Alfonz	
12	Alfonz	Alfonz		Alfonz	

Alfonz ( $M = 2.6$ ,  $SE = .74$ ) tugged significantly more than Kimbit ( $M = .5$ ,  $SE = .19$ ) in these trials ( $t(10) = 2.73$ ,  $p < .05$ ). Alfonz tugged significantly more in the presence of Kimbit ( $M = 2.21$ ,  $SE = .77$ ) compared to when he was alone ( $M = .24$ ,  $SE = .24$ ;  $t(10) = -2.45$ ,  $p < .05$ ). Kimbit also tugged less when alone ( $M = 0$ ,  $SE = 0$ ) compared to when he was in the presence of Alfonz ( $M = .5$ ,  $SE = .19$ ;  $t(10) = -2.66$ ,  $p < .05$ ).

There was a significant difference in the interaction rate during single-apparatus trials (ANOVA:  $F(2,14) = 5.732$ ,  $p < .05$ ). Alfonz spent significantly more time interacting alone compared to the time Kimbit spent interacting with the device alone (Tukey HSD:  $p < .05$ ). There was also a significant difference between Kimbit's interaction rate alone and his interaction rate with Alfonz (Tukey HSD:  $p < .05$ ). There was no significant difference between Alfonz's solo interaction rate and his interaction rate with Kimbit (Tukey HSD:  $p = .964$ ).





*Figure 3.* Condition 3 one-apparatus interaction rates. Kimbit interacted at a significantly lower rate alone compared to Alfonz's interaction rate ( $p < .05$ ) and the interaction rate of the two males together ( $p < .05$ ).

#### *Two-Apparatuses Trials*

Table 7 shows that Alfonz was the first animal to touch the apparatus in four out of ten instances (40%) of the trials, while Kimbit was first in six out of ten instances (60%). Alfonz was on the opening end when the apparatus opened five out of the eight (62.5%) known successes and on the closed end twice (25%). Kimbit was never on the opening end at the time of the device opening, however he was on the closed end three out of the eight (37.5%) confirmable successes. When returning the apparatus, Alfonz was on the opening end six out of the ten instances (60%) and the closed end four times (40%). Kimbit was on the opening end twice (20%) and the closed end once (10%) when returning the apparatus.

Table 7

*Condition 3: Two Apparatus Trials Side Information*

Trial	First Animal to Touch Apparatus	At Time of Opening		Returning Apparatus	
		Opening End	Closed End	Opening End	Closed End
1A	Alfonz	Alfonz		Alfonz	
1B	Kimbit		Kimbit	Alfonz	Kimbit
6A	Kimbit	Alfonz	Kimbit	Kimbit	Alfonz
6B	Kimbit	Alfonz	Kimbit	Alfonz	
8A	Alfonz	Alfonz		Alfonz	
8B	Kimbit		Unknown	Kimbit	Alfonz
9A	Alfonz		Alfonz	Alfonz	
9B	Kimbit		N/A		Alfonz
10A	Alfonz		Alfonz		Alfonz
10B	Kimbit	Alfonz		Alfonz	

The average tugging rate per trial was calculated for each animal ( $[\text{Tug Rate on Apparatus A} + \text{Tug Rate on Apparatus B}] / 2$ ) for each audience scenario. Once again, Alfonz ( $M = 2.29$ ,  $SE = .53$ ) tugged significantly more than Kimbit ( $M = .55$ ,  $SE = .15$ ;  $t(8) = 3.16$ ,  $p < .05$ ). However, Alfonz tugged at a higher rate when alone ( $M = 1.36$ ,  $SE = .45$ ) than when in the presence of Kimbit ( $M = .15$ ,  $SE = .13$ ;  $t(18) = 2.6$ ,  $p < .05$ ). Kimbit also tugged at a higher rate when alone ( $M = .13$ ,  $SE = .08$ ) compared to when he was in the presence of Alfonz ( $M = .11$ ,  $SE = .09$ ), however the difference was not significant.

There was a significant difference between the average interaction rate of the animals (Brown-Forsythe:  $F(2,14) = 5.664$ ,  $p < .05$ ). However, there was no significance found between any of the groups in Games-Howell post-hoc analysis.

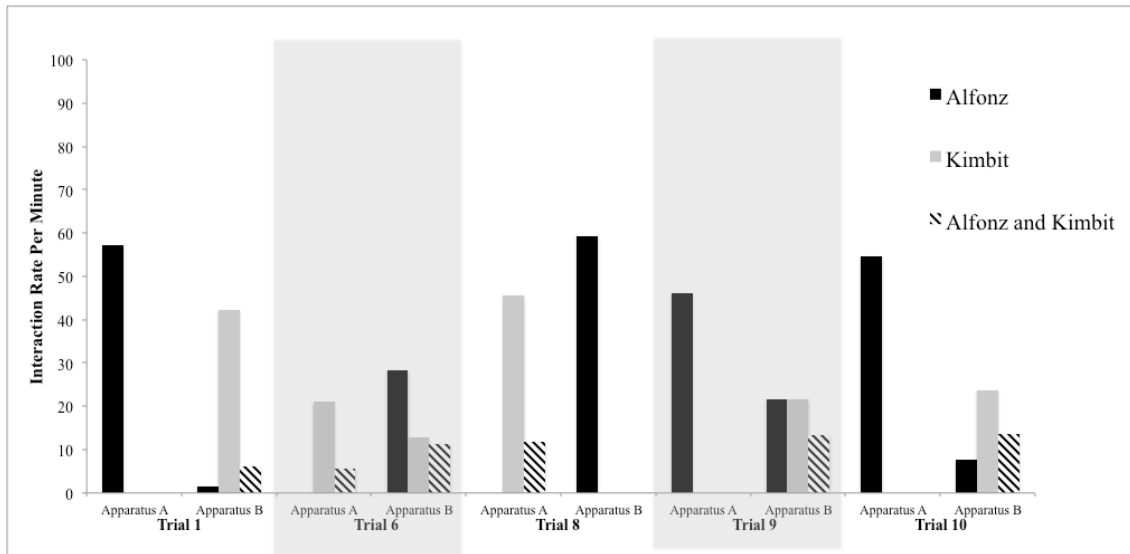


Figure 4. Condition 3 two-apparatus trials interaction rates. Each trial divided into each apparatus (A and B). Alfonz (black) had the higher interaction rate alone compared to Kimbit (gray).

#### *One Apparatus Trials Compared to Two Apparatus Trials*

Alfonz's tugging rate was slightly higher in the one apparatus trials ( $M = 2.6$ ,  $SE = .74$ ) compared to the average of the two apparatuses in each two-apparatus trial ( $M = 2.3$ ,  $SE = .53$ ), but the difference was not significant,  $t(9) = .320$ ,  $p = .756$ . Kimbit's tugging rate was slightly lower in the one apparatus trials ( $M = .502$ ,  $SE = .19$ ) compared to the average tugging rate of each two-apparatus trial ( $M = .5504$ ,  $SE = .151$ ), however the difference was also not significant,  $t(9) = -.193$ ,  $p = .852$ .

Overall, Alfonz had a higher interaction rate alone (One-Apparatus:  $M = 25.94$ ,  $SE = 6.99$ ; Two-Apparatus:  $M = 37.68$ ,  $SE = 8.62$ ) compared to Kimbit's interaction rate alone (One-Apparatus:  $M = .25$ ,  $SE = .13$ ; Two-Apparatus:  $M = 23.33$ ,  $SE = 6.35$ ). There was no significant difference between Alfonz's solo interaction rates in one apparatus trials compared to two apparatus trials ( $t(9) = -1.07$ ,  $p = .312$ ), but Kimbit interacted alone significantly less in the one apparatus trials ( $t(9) = -3.64$ ,  $p < .05$ ). The dolphins interacted together at a significantly higher rate during one apparatus trials ( $M = 30.43$ ,

SE=6.63) compared to two-apparatus trials (M= 7.93, SE=1.62) in which there were more opportunities for solo interactions ( $t(9) = 3.01, p < .05$ ; Figure 5).

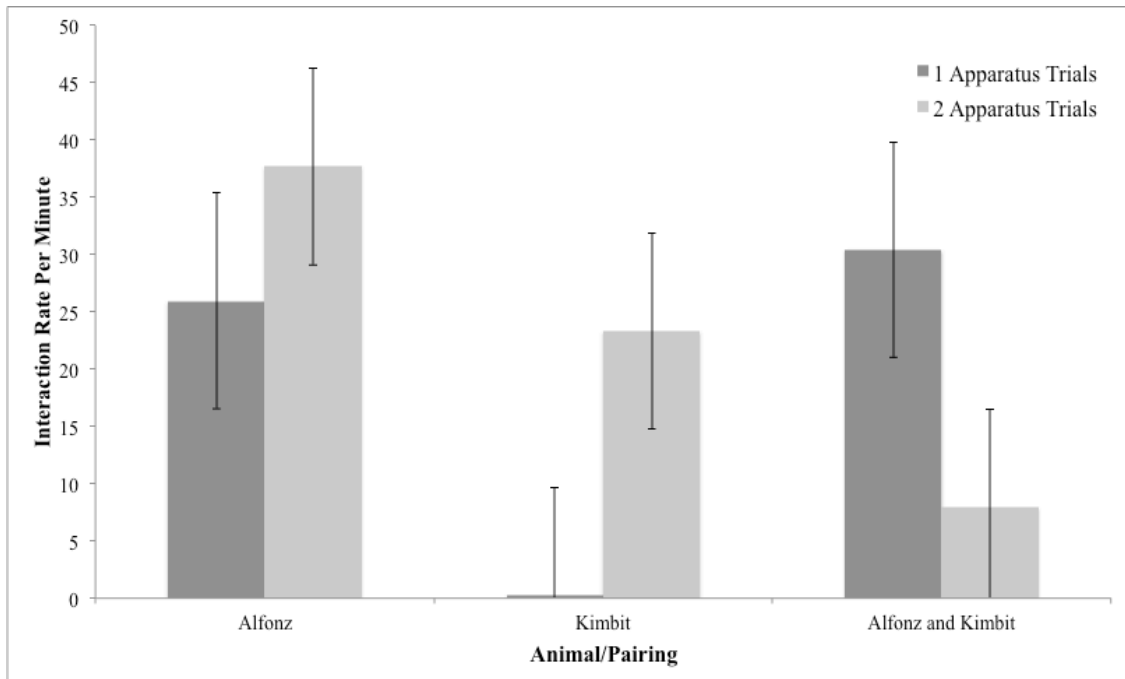


Figure 5. Comparison of one-apparatus and two-apparatus interaction rates.

During the two apparatus trials, both Alfonz and Kimbit appeared to adopt different strategies when attempting to open the apparatus alone. Alfonz began engaging in a tossing behavior, where he would tug very hard on one end of the apparatus, causing it to fly through the air. The force of this usually caused the apparatus to open, regardless of the end he tossed. He also continued tossing the apparatus after it opened, either as a method of play or as an attempt to empty the rest of the apparatus. Kimbit, however, pulled the apparatus a distance underwater and then released it. He observed the apparatus rise to the surface before pulling it again.

*Condition 4*

In Condition 4, the apparatus was opened in all 12 trials (100%). Alfonz and Kimbit each opened the apparatus individually once, and the rest was cooperative, either by simultaneous cooperation (six trials: 50%) or by sequential cooperation (four trials: 33.3%).

Table 8

*Condition 4 trial results.*

Trial	Date	Opened	Time taken to open (minutes: seconds)	Simultaneous/ Sequential/ Solo
1	8/2/13	Yes	0:20	Solo- Alfonz
2	8/2/13	Yes	0:08	Simultaneous
3	8/4/13	Yes	0:03	Simultaneous
4	8/4/14	Yes	0:02	Simultaneous
5	8/6/13	Yes	0:35	Sequential
6	8/6/13	Yes	0:33	Sequential
7	8/6/13	Yes	0:26	Simultaneous
8	8/7/13	Yes	0:12	Simultaneous
9	8/7/13	Yes	0:48	Simultaneous
10	8/8/13	Yes	0:20	Sequential
11	8/8/13	Yes	0:16	Solo- Kimbit
12	8/8/13	Yes	0:10	Sequential

Alfonz was the first animal to touch the apparatus in six out of the twelve trials (50%) and touched simultaneously with Kimbit in three trials (25%). Kimbit touched first in three trials (25%). Alfonz was on the opening end at the time of opening in five trials (41.67%) and was on the closed end six times (50%). Kimbit was on the opening end three times (25%) and the closed end five times (41.67%). When returning the apparatus, Alfonz was on the opening end eight times (66.67%) and on the closed end four times (33.33%). Kimbit was on the opening end twice (16.67%) and the closed end three times (25%).

Table 9

*Condition 4 Side Information*

Trial	First Animal to Touch Apparatus	At Time of Opening		Returning Apparatus	
		Opening End	Closed End	Opening End	Closed End
1	Alfonz		Alfonz		Alfonz
2	Alfonz	Kimbit	Alfonz	Alfonz	Kimbit
3	Alfonz and Kimbit	Kimbit	Alfonz	Alfonz	
4	Alfonz and Kimbit	Alfonz	Kimbit	Alfonz	
5	Kimbit	Alfonz		Alfonz	Kimbit
6	Kimbit		Alfonz	Kimbit	Alfonz
7	Alfonz	Alfonz	Kimbit	Alfonz	
8	Alfonz	Alfonz	Kimbit	Alfonz	
9	Alfonz	Alfonz	Kimbit	Kimbit	Alfonz
10	Alfonz		Alfonz	Alfonz	
11	Kimbit		Kimbit	Alfonz	Kimbit
12	Alfonz and Kimbit	Kimbit	Alfonz		Alfonz

During this condition, there was also a significant difference in interaction rates (Brown-Forsythe:  $F(2, 33) = 7.57; p < .01$ ). Alfonz interacted with the apparatus alone at a significantly higher rate than Kimbit (Games-Howell:  $p < .01$ ), but there was no significant difference between Alfonz's solo interaction rate and the rate he interacted with Kimbit (Games-Howell:  $p = .538$ ). Kimbit's interaction rate alone was significantly less than his interaction rate with Alfonz (Games-Howell:  $p < .05$ ).

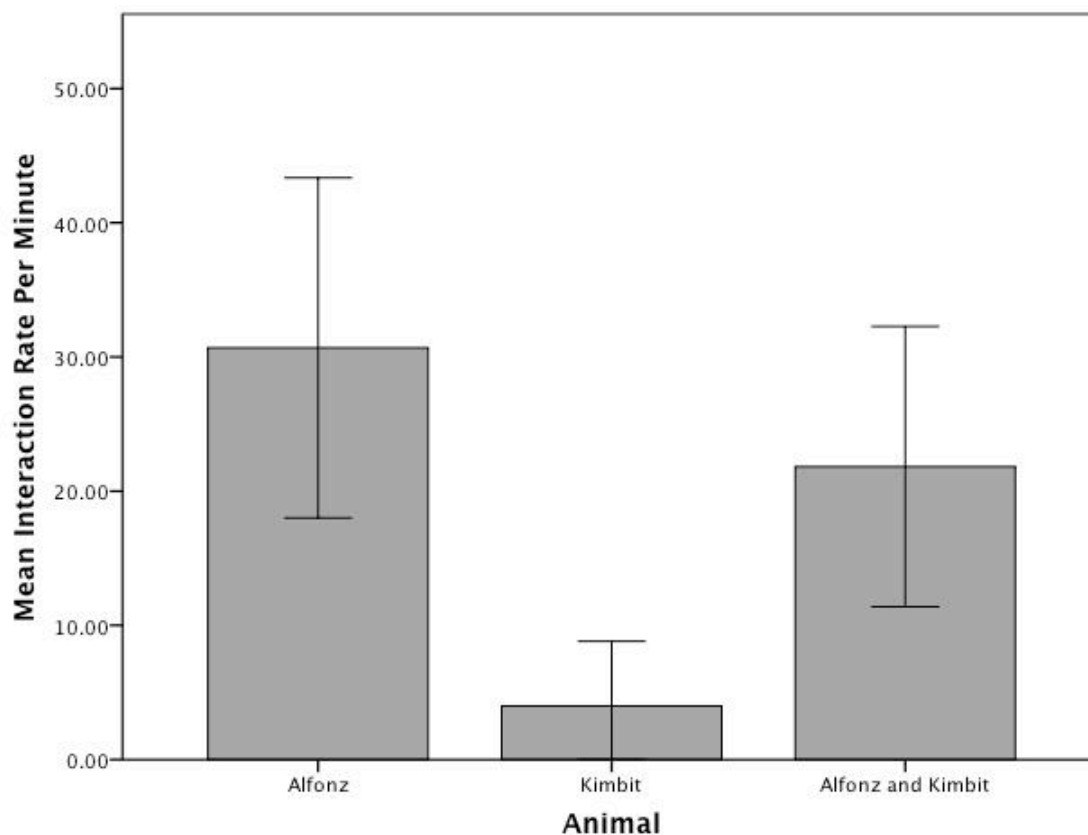


Figure 6. Condition 4 mean interaction rate. Kimbit interacted alone at a lower rate than he interacted with Alfonz ( $p < .01$ ) and compared to Alfonz's solo interaction rate ( $p < .05$ ).

Overall, Alfonz tugged significantly more ( $M = 2.25$ ,  $SE = .66$ ) than Kimbit ( $M = .53$ ,  $SE = .34$ ),  $t(22) = 2.315$ ,  $p < .05$ . Alfonz tugged significantly less when alone ( $M = .13$ ,  $SE = .09$ ) than when in the presence of Kimbit ( $M = 2.09$ ,  $SE = .64$ ),  $t(22) = -3.02$ ,  $p < .05$ . There was not a significant difference between Kimbit's tugging rate when he was alone compared to when he was in the presence of Alfonz,  $t(22) = -1.181$ ,  $p = .250$ .

There was no significant difference in Alfonz's interaction rate with the opening end ( $M = 23.93$ ,  $SE = 6.9$ ) compared to the closed end ( $M = 21.07$ ,  $SE = 6.08$ ),  $t(22) = -.066$ ,  $p = .948$ . Kimbit also showed no significant difference (Opening End:  $M = 13.5$ ,  $SE = 3.9$ ; Closed End:  $M = 15.73$ ;  $t(22) = -.842$ ,  $p = .409$ ).

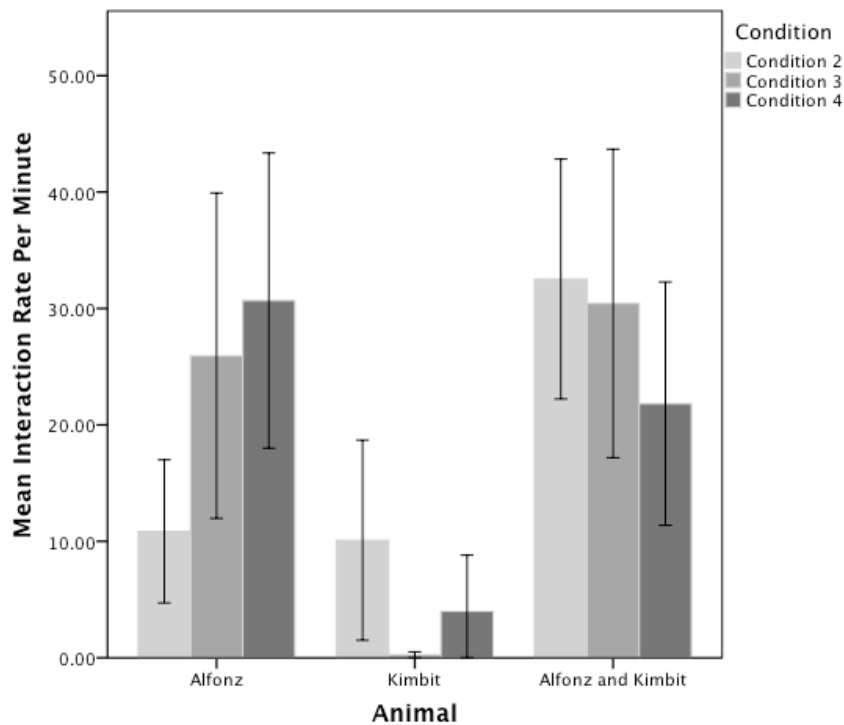
### *Condition 5*

During this two-trial condition, Alfonz and Kimbit were held at station on the opposite side of the lagoon and the apparatus was entered into the water. This allowed the other animals the opportunity to interact with the apparatus. The four animals quickly lost interest in the apparatus after pushing it toward the dock, and it was never opened. No dolphins attempted the behavior of mouthing and tugging on the ropes.

### *Comparisons Of Conditions*

In all single-apparatus trials across conditions, there was a significant difference between the types of interactions involving the apparatus (Brown-Forsythe:  $F(2,87) = 14.679, p < .001$ ). Alfonz interacted with the apparatus alone significantly more than Kimbit (Games-Howell:  $p < .01$ ). There was no significant difference between Alfonz's solo interaction rate compared to his interaction rate with Kimbit (Games-Howell:  $p = .419$ ). Kimbit interacted with the apparatus alone at a significantly lower rate than he interacted with Alfonz (Games-Howell:  $p < .001$ ). Figure 7 shows the changes of average interaction rate across the three conditions.





*Figure 7.* Interaction rates across single apparatus trials.

The types of success also varied across the conditions (Figure 8). Simultaneous cooperation was the most frequent, with 19 occurrences across 35 trials (54.3%). Alfonz's solo opening and sequential cooperation occurred at the same amount, with 7 events of each (20%). Kimbit opened the apparatus alone the least amount of times, with a total of 2 occurrences across the conditions (5.7%).

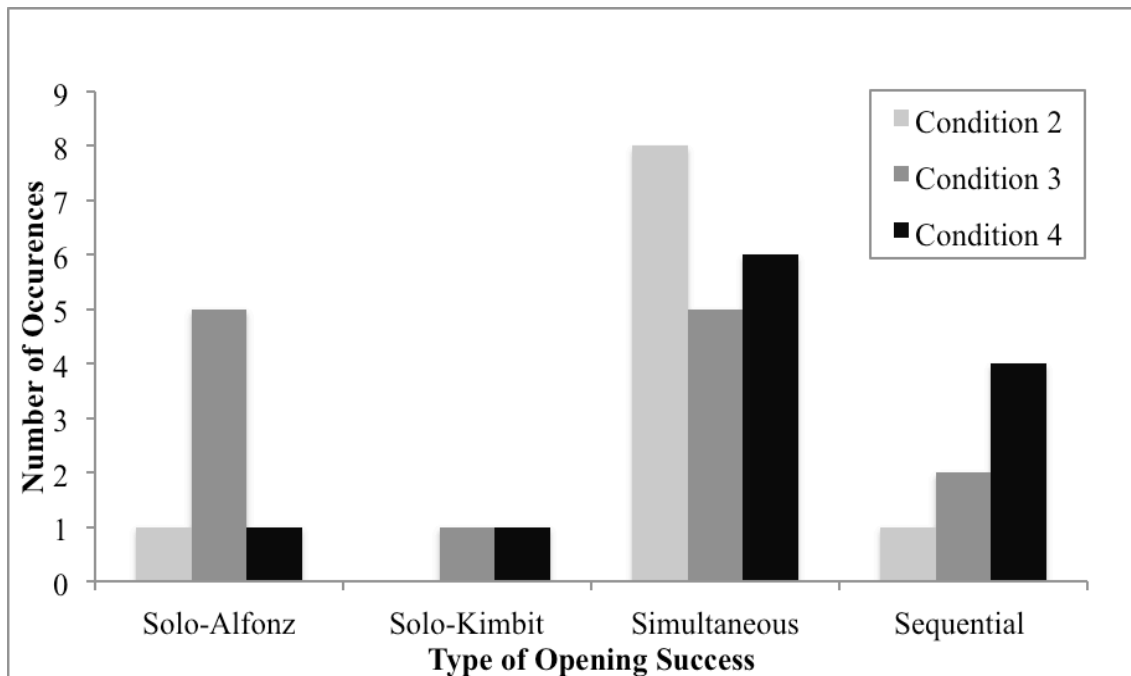


Figure 8. Success types across conditions

Alfonz interacted alone with the apparatus at a significantly higher rate in Condition 4 ( $M = 30.69$ ,  $SE = 6.34$ ) compared to Condition 2 ( $M = 10.85$ ,  $SE = 3.07$ ),  $t(22) = -2.817$ ,  $p < .05$  (Figure 8).

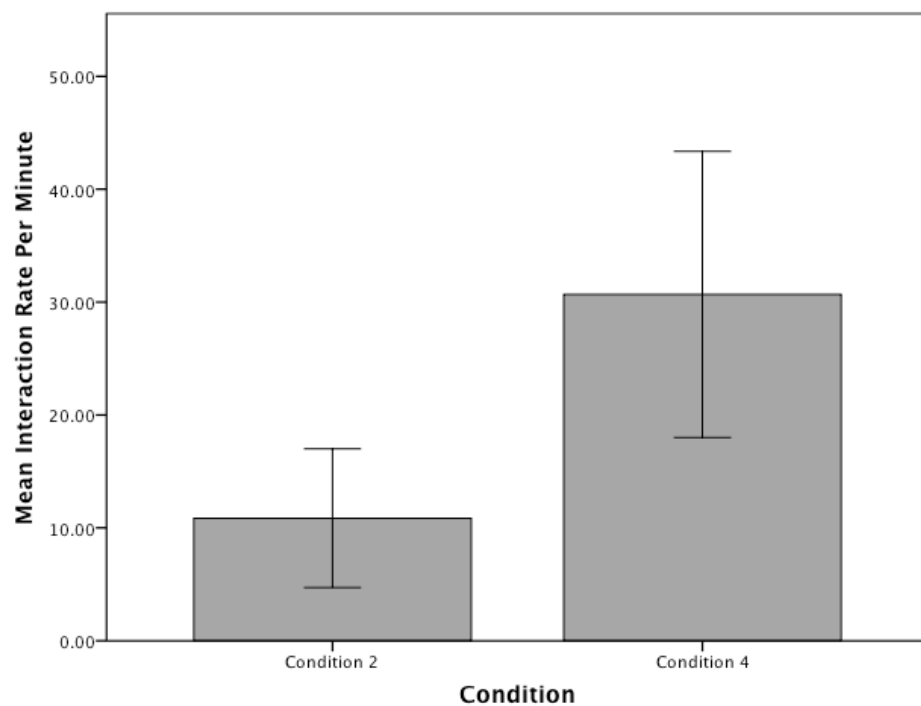


Figure 9. Alfonz's interaction rate comparison.

Across the single-apparatus trials, there was a significant difference between Alfonz and Kimbit in total tugging rate, with Alfonz tugging significantly more ( $M=2.1$ ,  $SE=.37$ ) than Kimbit ( $M = .58$ ,  $SE = .17$ ),  $t(58) = 3.735$ ,  $p < .01$ . Alfonz tugged significantly more in the presence of Kimbit ( $M = 1.93$ ,  $SE = .36$ ) than when alone ( $M=.13$ ,  $SE = .06$ ),  $t(58) = -4.913$ ,  $p < .001$ . Kimbit tugged significantly more in the presence of Alfonz ( $M=.52$ ,  $SE = .16$ ) than when alone ( $M = .03$ ,  $SE = .02$ ),  $t(58) = -2.985$ ,  $p < .01$ .

#### *Post-Opening Behavior*

After the apparatus was opened, Alfonz and Kimbit both fed from the apparatus together. On several occasions, the males would carry the apparatus around together, synchronously breathing and diving, before returning it to the trainer. The nursing adult female, Samantha, was allowed to feed from the apparatus, however her son Isaac, fathered by Kimbit, was not. While Alfonz and Kimbit swam around the lagoon displaying the apparatus, Samantha and Isaac often followed, observing the demonstration and occasionally also synchronously breathing and diving with the two males.

#### *Returning the Apparatus*

The animals were allowed access to the apparatus for as long as they wished following a successful trial. For unsuccessful trials, the apparatus was removed as soon as possible after 15 minutes had concluded. The animals were unsuccessful in the first free-floating trial, thus a trainer entered the water to remove the apparatus, the cap of which had unknowingly become cock-eyed. In future unsuccessful trials, the males brought the apparatus to wherever a trainer was standing and logged at the surface. Generally the cap had become cock-eyed, rendering the apparatus non-operational. In

Condition 2, the males first brought the apparatus back together after Trial 7, and continued to do so for the remainder of the successful trials in that condition. In the single-apparatus trials of Condition 3, they returned the apparatus together 4 out of the 6 trials (66.7%), however, in one of these trials the apparatus had come apart, so each animal brought back a different section. In the two-apparatus trials, Alfonz brought the apparatus back every time, either by himself or with Kimbit. In Condition 4, Alfonz brought the apparatus back every time, either by himself (7 times; 58.3%) or with Kimbit (5 times; 41.7%).

## CHAPTER IV

### DISCUSSION

This task showed that dolphins can engage in cooperative behavior in order to solve a novel problem. However, it is important to note that the cooperative successes only occurred at one location, and attempts at two other facilities did not result in cooperative successes. It is possible that this cooperative behavior was accidental, or it could have been due to planning on the part of the two males (see Kuczaj, Gory, & Xitco, 2009; Kuczaj & Walker, 2012 for discussions of planning behaviors in dolphins). The males exhibited competitive and cooperative behaviors while interacting with the apparatus.

In Condition 2 the two males immediately began interacting with the apparatus upon its entry into the water, a behavior which remained consistent across the conditions and trials. If one male had access to the apparatus before the other, he would rather swim off with the device immediately. The other male would attempt to grab the opposite end of the apparatus, rather than the end that the first male was carrying, which is more indicative of cooperative than competitive behavior. However, if the action was entirely competitive, it could be assumed that the male would attempt to take the apparatus away from the first animal by grabbing the same ropes, but this happened only once. The exception occurred in Trial 3 of Condition 2, in which the dolphins both went to the same side for a few seconds, each tugging on one of the ropes, before Kimbit tugged the apparatus away and Alfonz went to the other side. After this, the animals did not go to the same side again.

In the Condition 3 Two-Apparatus trials, both animals tended to go to their own apparatus for interactions, hinting at a possible preference for solo or even competitive

interactions. However, on several occasions after Alfonz opened, emptied, and returned his apparatus, he would interact with Kimbit and open the other device. Kimbit was allowed to eat from the apparatus that Alfonz opened, as was Samantha. These results suggest that future studies should look at the preferences toward cooperative vs. competitive tasks in dolphins, and individual differences in these preferences.

During Condition 4, there was no significant difference in the interaction rate of either animal with either side of the apparatus, suggesting that the dolphins overall did not interact with a particular side. This could be due to not understanding that a different colored cap indicated the opening and closed end, or that the animals did not have a preference toward interacting with one particular side. Due to the nature of the fish release, it is possible that the side did not matter when interacting with the apparatus, as they animals would receive fish regardless.

The analyses of tugging rates showed that the animals did tug more in the presence of others, and though these have been used in other studies to demonstrate that the animals understand the role of their partner (Chalmeau et al., 1997; Cronin et al., 2005), the results of this study are slightly more ambiguous. Because tugging also occurred after the apparatus had opened, it is possible that this behavior was done to either secure the apparatus for solo interaction, as a method of play, or as an attempt to release more fish.

The food sharing that occurred after successful trials was similar to what is seen in wild cooperative foraging efforts in dolphins (Benoit-Bird & Au, 2009; Duffy-Echevarria et al., 2008; Hoese, 1971; Torres & Reed, 2009; Vaughn et al., 2011; Würsig & Würsig, 1979, 1980), and suggests that this behavior was cooperative in nature. At Dolphin Cove, not all animals were allowed to share the food or even make extended

contact with the apparatus; only the nursing female was granted access. At the other two locations, some food sharing occurred. On the South Side, the adult male and the dominant female's calf were allowed some access to the food. The North Side, however, showed some aggression during post-opening feeding.

The two successful males that cooperated to open the apparatus also continued to cooperate by carrying the apparatus together, as well as synchronously breathing and diving with the device. Male bottlenose dolphins in Shark Bay, Australia have been seen to develop long-lasting alliances in order to protect themselves and to secure mating partners (Connor et al., 1992; Connor et al., 2010). Alliance membership and stability has been measured by the presence of synchronous breathing and diving (Connor, Smolker, & Bejder, 2006). This synchronous transportation of the apparatus might have been a display of their close relationship, a claim reinforced by the lack of aggressive interactions, such as chasing, biting and raking, between the two during the trials.

It is important to note that number of sequential cooperative trials increased gradually over the conditions, which could be suggestive of a more competitive interaction. While both animals were on the apparatus at some point in sequential cooperative trials, this classification indicates that the apparatus opened when only one animal was on the apparatus at the moment it opened. However, the number of simultaneous cooperative trials did not steadily decrease, as when Condition 4 was conducted with only one apparatus, the number of simultaneous cooperative successes increased from Condition 3, where the animals were each allowed to interact with their own apparatus.

Dolphins demonstrate distinct and long-lasting personalities (Highfill & Kuczaj, 2007; Kuczaj, Highfill, & Byerly, 2012), and this was evident in the behaviors exhibited

by the two males, as well as cooperative success occurring at only one location out of the three tested. Dominance, which has played a role in the successful cooperative actions of keas (Tebbich et al., 1996), domestic dogs (Bräuer et al., 2013) and chimpanzees (Chalmeau, 1994), likely played a large role in the willingness of these animals to cooperate. The two dominant males cooperated in their interactions toward the common goal of obtaining the reinforcement, rather than attempting to monopolize the apparatus and the reward. While the other two locations tested did not show successful cooperative behaviors, they did show novel problem solving skills. Although these animals did not cooperate, it is likely that their social structures and dominance hierarchy played a larger role in the lack of observed cooperation than a lack in cognitive ability. Temperament differences of the animals at the various locations likely also had an effect, as this variable has been documented as having a role in cooperative abilities in rooks (Schied & Noë, 2010) as well as chimpanzees and bonobos (Hare et al., 2007).

Individual differences in interaction rates were apparent. Alfonz interacted at a significantly higher rate in Condition 4 compared to Condition 2, and was also the most successful in opening the apparatus by himself. As his possessiveness increased, there were instances in which he would attempt to return the apparatus by himself by holding both ends of the ropes in his mouth, thus prohibiting Kimbit from assisting him. He also swam around the lagoon after positioning the apparatus between his pectoral fins and preventing Kimbit from assisting him. While this occurred, Kimbit and Isaac followed and observed. Alfonz was also the more persistent of the two males, as he never left an apparatus once he began interacting with it, even if the device had become inoperable. He also returned the apparatus every trial following Trial 7 of Condition 2, though this



behavior was likely reinforced by the apparatus being emptied for their efforts in returning it.

The results at these two locations suggest that underlying social conditions play an important role in the cooperative abilities of these animals. It is likely that the social structure and personalities of the animals at Dolphin Cove were more conducive to cooperative behaviors and tolerance compared to the other locations, where dominance and incompatible social pairs precluded any cooperative actions. Though the two dominant, adult females on the North Side were both trained to open the apparatus, they would not work together to get the apparatus open. If a more subordinate animal opened the apparatus on the North Side, the dominant females would displace that animal in order to gain access to the reinforcement. At Island Dolphin Care, the dominant female would not allow any other animal to touch the apparatus. When the adult male attempted to interact with an apparatus, even when still closed and she was not interacting with it, the female would take it away from him, pulling away on the side he had been interacting with. If other animals were asked to retrieve it following the conclusion of a trial, subordinate animals would not do so. Future investigations in which the social pairings are changed and how the resulting differences affect the presence of cooperative behavior can confirm the importance of dominance and social structure in the utilization of cooperative behaviors.

Due to the changes in types of success across the conditions, it is possible that the animals might have preferences for engaging in cooperative or competitive interactions. Chimpanzees prefer to work individually rather than cooperatively (Bullinger et al., 2011), and excel at competitive tasks, as opposed to cooperative ones (Rekers et al., 2011). Such preferences have not been tested in dolphins, however such behavior was

seen as the dominant female at one location preferred to work alone. The role of tolerance levels in successful dolphin cooperation warrants future investigation, as it has dictated the behavior in other species such as rooks (Seed et al., 2008), bonobos (Hare et al., 2007), capuchins (Mendres & de Waal, 2000), and chimpanzees (Melis, Hare, & Tomasello, 2006a).

This task showed that dolphins can cooperate to solve a novel problem, and do so when both animals are rewarded for their efforts. Future research should explore the extent to which these animals will cooperate, the level of cooperation present (Boesch & Boesch, 1989), the effect that personality has on cooperation, preference of cooperative vs. competitive behaviors, cooperation with animals naïve to the task, as well as the level of reinforcement necessary for animals to continue to cooperate.

## APPENDIX A



THE UNIVERSITY OF SOUTHERN MISSISSIPPI

*Institutional Animal Care and Use Committee*

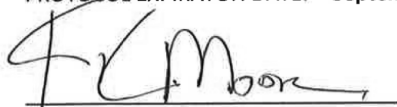
118 College Drive #5147  
Hattiesburg, MS 39406-0001  
Phone: 601.266.4063  
Fax: 601.266.4377

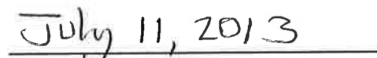
INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE NOTICE OF COMMITTEE ACTION

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 three year 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 (see attached) 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: **13071101**  
PROJECT TITLE: **Can Dolphins Cooperate to Solve a Novel Task?**  
PROPOSED PROJECT DATES: **July, 2013 – September, 2015**  
PROJECT TYPE: **New**  
PRINCIPAL INVESTIGATOR(S): **Stan Kuczaj**  
DEPARTMENT: **Psychology**  
FUNDING AGENCY/SPONSOR: **N/A**  
IACUC COMMITTEE ACTION: **Full Committee Approval**  
PROTOCOL EXPIRATION DATE: **September 30, 2015**

  
\_\_\_\_\_  
Frank Moore, Ph.D.  
IACUC Chair

  
\_\_\_\_\_  
Date

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