ENVIRONMENTAL ENRICHMENT FOR DOLPHINS AND SEALS

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Master of Arts
in
Biology: Marine Biology

by

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CERTIFICATION OF APPROVAL

I certify that I have read *Environmental Enrichment for Dolphins and Seals* by Cheryl Renée Aday, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirements for the degree: Master of Arts in Biology: Marine Biology at San Francisco State University.

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ENVIRONMENTAL ENRICHMENT FOR DOLPHINS AND SEALS

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An environmental enrichment study involving two Pacific white-sided dolphins (Lagenorhynchus obliquidens) and three Pacific harbor seals (Phoca vitulina richardsi) was conducted at the Steinhart Aquarium in San Francisco. An electromechanical apparatus, known as the "xylophone" because it resembles a xylophone and consists of eight movable "keys" of graduated lengths, was used to give the animals the opportunity to request fish, tactile stimulation by humans (petting), a water jet, a ring, a ball, dolphin sounds, classical music, or popular music.

Use of the xylophone, as measured by number of key presses, did not decrease significantly over time. As a group, the animals pressed Key 1, fish, more often than all other keys combined. A significant increase in key presses per session was seen when Key 1 was one of the active keys in the xylophone setup for that session. Two animals, one dolphin and one seal, accounted for 80% of the key presses.

Significant increases in three behavioral measures indicated increased well-being of the dolphins during experimental sessions. In both of the studies reported, the duration of active behaviors exhibited by the dolphins increased during experimental sessions. The frequency of agonistic behaviors in dolphins was seen to be lower in experimental sessions in both studies, although only statistically significant in the second study. In both studies, the mean frequency of a stereotypic behavior, wall-touching, by dolphins was found to be significantly lower during experimental sessions than during baseline sessions.

The two behavioral indicators used to assess well-being of the harbor seals did not show any measurable increase during experimental sessions. There was no significant change in duration of active behavior of the seals in either study. The frequency of agonistic behaviors of seals was not seen to change significantly in either study; however, the frequency of agonistic behaviors in the seals was extremely low in both baseline and experimental sessions.

I certify that the Abstract is a correct representation of the content of this thesis.

Hal Markowitz
Chair, Thesis Committee

6/21/93
Date

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The enrichment project described herein is based upon preliminary work done by Vicki Case-Ferrari and Eric Carlson and Hal Markowitz, who were involved both with training the animals to use the apparatus and in programming the original Atari and Tandy software for this project. All data for this project was collected by volunteers under student supervision. These supervisors, Peter Mangold, Karen Proehl and Cara Gubbins contributed many hours of their time to this project, and were integral to its accomplishment. In addition, Peter Mangold was responsible for much of the documentation used in day to day operation of the project.

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INTRODUCTION

Behavioral Studies of Animals in Captivity

Behavioral studies of captive animals have often been criticized as having little relevance to the behavior of animals in the wild. However, especially with animals that are difficult to observe in the wild, research in captivity is very useful in providing behavioral information that would otherwise be impossible or prohibitively expensive to obtain. While unnatural groupings, restrictions on group size, and other features of the captive setting may affect the comparability of one captive group to another captive group, or of a captive group with a wild group, the restriction of variables within a captive setting makes it appealing for the study of behavior in detail. Gubbins (1993) refers to this as the "high internal validity and low external validity" of captive studies, contrasted to the "high external validity and low internal validity" of field studies. This is especially true in cases where, a species cannot be observed for a significant part of its activities. For example, in marine mammal studies, due to physical and cost constraints of studying animals underwater in the open ocean, much of the available field behavioral data is based on either surface behaviors or, in the case of pinnipeds, behaviors when the animal is hauled out on land. In such cases, behavioral data from captive animals are necessary to complement information obtained through field research.

This is not to say that the captive environment does not significantly change the behavior of (formerly) wild animals. Hediger (1964) pointed out that many items found in the natural environment of animals were lacking in captivity. The lack of environmental features such as sufficient space, escape routes or hiding places, opportunities for foraging, and opportunities to interact with other animals is often correlated with changes in the behavior of captive animals (Meyer-Holzapfel 1968). As compared with behavior of animals in the wild, some behaviors will increase in frequency, others will decrease. Stereotypic behaviors, behaviors such as pacing or head bobbing that have no apparent functional significance for the animal, will often increase (Fox 1968). Certain species-specific behaviors may cease altogether, or appear rarely (Markowitz 1982). Increased aberrant behaviors, including behaviors never seen in the wild, may appear. The amount of time an animal spends in certain behaviors such as foraging or grooming may decrease (as compared to time budgets of wild animals of that species), and amount of time an animal spends in agonistic behavior may increase or decrease significantly, depending on the features of the environment, social grouping and amount of space available. In summary, animals in captivity behave significantly different from those in the wild, making the external validity of captive research suspect. Do the behavioral changes observed indicate "suffering" in these animals? Are there any ways to reduce or ameliorate the many behavioral changes seen in the captive environment?

Environmental Enrichment

Moran (1987) states that the choice to keep animals in captivity, whether for research, agriculture, or education must involve a cost/benefit analysis. Benefits to humans could include food, knowledge of biological processes, enhanced medical procedures, and public education. Benefits to the animal might include knowledge to be applied to conservation and land management, as well as better veterinary procedures. The costs of captivity would be felt mainly by the animal, ranging from simple restriction of territory to more serious costs such as suffering and death (Dawkins 1988). Moran goes on to suggest that evaluation of the ethical costs of keeping animals must be based on a systematic knowledge of behavior and evaluation of their condition. Environmental enrichment studies are studies in which changes are made to the environment of captive animals, then analyzed to see if the condition of the animals can actually be said to be improved.

The accurate assessment of well-being in animals is integral to determining if environmental enrichment has been successful. Approaches to well-being assessment can be divided into two major categories: physical and behavioral.

For both the physical and behavioral methods of measuring an animal's condition, it is typically assumed that the more closely a captive animal's measurements match those seen in the wild the greater the well-being of that animal. Novak and Suomi (1988) list a number of ways to assess an animal's well-being physically and physiologically: external appearance (of skin, eyes, coat); rate of growth and aging; neurological and morphometric studies; and chemical analyses of physiological variables, such as blood profiles and urine analysis.

Well-being can also be defined as the absence of stress or of suffering. Dawkins (1988) lists a number of behaviors that, when seen in captive animals, can be considered indicative of "suffering" due to behavioral deprivation. These include what she terms conflict, frustration and stereotypic behaviors. Stereotypies are fixed sequences of behavior that occur repetitively with no obvious biological function. In some animals, this takes the form of pacing a fixed pattern within their enclosure; in pigs, for instance, stereotypies, such as continually biting the metal bars that are part of their cage enclosure, may be exhibited.

Abnormal behavior is often seen as a result of captivity. Abnormal behavior includes not only behavior that is never seen in the wild (qualitatively abnormal behavior), but also quantitatively abnormal behavior, significant changes in the frequency of a behavior from the level at which it normally occurs in the wild (Erwin & Deni 1979). So, in assessing the well-being of a captive animal, it is important to take into consideration not only the presence or absence of behaviors seen in the wild, but also the amount of time an animal spends in general behavioral categories as compared to individuals in the wild (Dawkins 1988; Markowitz and Spinelli 1985).

Which environmental elements most strongly influence the well-being of a captive animal? While intuitively one might guess that lack of space is a large factor in animal well-being, some studies have shown otherwise. For example, in Wilson's 1982 studies of environmental influences on the activity levels of gorillas (Gorilla gorilla) and orangutans (Pongo pygmaeus), she found that group size and number of objects within the cage were a much stronger predictor of activity levels than enclosure size, usable surface area, or feeding frequency. Objects were classed as stationary, movable and temporary. While both species showed correlation of group size to behavior, activity levels in gorillas were more strongly correlated to stationary and temporary objects than to movable objects, while the orangutan activity levels exhibited strong correlations to stationary and movable objects, but not as much to temporary objects. So, at least for these species, variations between zoos in enclosure size (volume) and usable surface area were not seen to have a significant effect, negative or positive, on the activity levels of the animals. Presence of objects within the captive environment did appear to increase the activity levels of these animals, a positive change for these animals, since inactivity in apes has often been associated with poor breeding, lethargy and obesity (Wilson 1982).

Markowitz (1982) has proposed "behavioral enrichment," a type of environmental enrichment based on changing the contingencies in the captive environment in such a way that animals are provided with motivation to perform behaviors. Rather than focusing on making the environment more naturalistic-appearing, he proposes focusing on the behaviors lacking in the captive animals that are often seen in the same species in the wild. Lindburg aptly demonstrates the deprivation of feeding behaviors in captive felines in his 1988 review, "Improving the feeding of captive felines through application of field data." He points out that in the wild four phases of "food-getting" must be practiced by predators: (1) locating; (2) capturing; (3) killing; and (4) processing (this includes consuming). Only the last of these four food-getting tasks is necessary or even possible for felines to practice in a "conventional" captive environment. The felines in captivity are thus deprived of much of the stimulation and motivation for exercise that they would receive in the wild environment.

To stimulate foraging behavior, Markowitz has often used electromechanical devices, similar to those used in "preference testing," to dispense food when an animal "hunts." Obviously, electromechanical devices are not a normal part of the natural environment -- but the behavior of foraging is, and in those cases where introduction of live prey is not an option, this may be the only way to give the animal an opportunity to display this behavior.

In a more complicated setup, animals may be able to choose between a number of different reinforcers, both food and non-food. In domestic animal research, this "preference testing" is often used to determine which kind of food or which kind of substrate an animal prefers (Dawkins 1988). However, in contrast to preference studies using domestic animals, the goal of this type of environmental enrichment is not to find what an animal likes best, then make it permanent, but rather to allow an animal to perform behaviors to select what it wants when it wants it. Markowitz and LaForse (1987) term this giving "power" to the animal.

Environmental enrichment, and specifically the behavioural enrichment approach, can contribute to the well-being of animals not only in terms of fewer aberrant behaviors and more "naturalistic" time budgets, but in addition, unusual differences or changes in apparatus use can be applied as an aid in the early detection of illness (Markowitz 1990). If one animal never uses the apparatus, or if an animal has been using the apparatus regularly, then stops suddenly, this can cue further investigation into the general health in that animal. For example, one serval (Felis serval) involved in a behavioural enrichment study suddenly stopped pursuing artificial prey -- medical investigation revealed a hernia in the animal which could have easily gone unnoticed under less active conditions (Markowitz et al. 1978).

Since foraging often takes up a significant amount of an animal's time in the wild but practially no time at all with conventional feeding procedures, the focus of many behavioral enrichment studies has been to provide opportunities for foraging. One of the easiest ways to do this is to present live prey items. For example, Foster-Turley and Markowitz (1982) introduced live crickets into an Asian small-clawed river otter (display). The otters were seen to show a strong preference for live prey over other foods, by the increased number of forages seen when live crickets were available. Markowitz and LaForse (1987) describe the use of artificial prey to increase foraging behavior in tigers (Panthera tigris) and servals (Felis serval). These studies showed a significant increase in "arousal" (non-stationary behavior) time as a result of the enrichment. Were the animals in these studies foraging using artifical devices simply because they would have gone hungry otherwise? In a number of studies, such diverse animals as ostriches, pigeons and rats (Markowitz 1982; Neuringer 1969; Carder & Berkowitz 1970) were seen to continue performing a behavior to "order" food, even in the presence of free food. In most "behavioral enrichment" studies where foraging is encouraged, food is also available to the animals on an ad lib basis as per the regular institutional feeding schedule.

Environmental Enrichment for Marine Mammals

While the environments of most captive marine mammals are enriched by the addition of toys and constant interactions with humans, studies involving more complex environmental enrichment of marine mammals have been surprisingly few. Mackay (1981) described an interesting experiment in which he provided bottlenose dolphins (Tursiops truncatus) with equipment that allowed them to control a number of items in their environment including an electrical fish feeder, an underwater water jet, a plastic bottle (which could be lowered into or raised from the pool), pool lights, and a small submarine. The dolphins could manipulate these items by emitting "steady tones of fixed frequency." Availability of the feeder was not signalled in any way to these dolphins, so to find out if it was working, they had to emit a test whistle every so often. A two-minute dead time was started each time a fish was ordered. Until the dead time had elapsed, correct whistles would elicit a "correct" response tone, but no fish would be delivered. The ratio of correct responses required was as high as five per fish for some tests. Mackay reported that the dolphins appeared interested in ordering all available items, but found none as interesting as the fish feeder.

Myers (1978) mentions enrichment as his primary purpose in pursuing discrimination and sonar demonstration tasks with a captive river dolphin (Inia geoffrensis). Unfortunately, no behavioral data on the effects of the research tasks on the behavior of the dolphin are reported in the study.

Basolo (1984) compared the behavior of two Pacific white-sided dolphins (Lagenorhynchus obliquidens) before and after a visual discrimination study was begun. Her approach in this discrimination study was not only to investigate one of the dolphin's learning capabilities, but also to increase behavioral complexity of the environment for all the animals in the same tank. While Basolo did not report numerical data, she anecdotally reported that during experimental sessions there appeared to be a decrease in a number of behaviors, including rapid swimming, avoidance of novel toys, avoidance of humans, and in behaviors she defined as stereotypic, such as resting on the bottom.

In an attempt to quantify the well-being of captive belugas, Thomas et al. (1990) applied both physiological and behavioral techniques, however, this was not an enrichment study. The purpose of the study was to assess the possibly adverse effects of oil drilling noise on the well-being of belugas. Swim patterns, social groups and respiration/dive rates were observed both before and during playback of noise recorded from an oil drilling platform to four captive belugas (Delphinapterus leucas). No significant changes were seen in the behavioral parameters reported. In addition, no significant changes were seen in levels of blood epinephrine and norepinephrine levels measured before and immediately after the noise was played.

Seals and Dolphins in the Wild

In order both to envision a possible venue for enriching the environment of a captive animal, and to be able to measure its effects, one must have some knowledge of the behavior of that species in the wild.

Harbor Seals. Pacific harbor seals, Phoca vitulina richardsi, are a subspecies of harbor seal found only along the west coast of North America, from Baja California to about 65°N latitude (Reeves et al. 1992). In the wild, harbor seals are known to feed on fish, cephalopods, and other invertebrates (Scheffer & Slipp 1944). Pacific harbor seals have also been seen to eat birds, though this is probably not a regular part of their diet (Reidman 1990). The behavior of harbor seals appears to be greatly influenced by their geographical location and habitat (Stirling 1983 in Reidman 1990). For example, in the northern part of their range, where Pacific harbor seals sometimes breed on glacial ice, they tend to form triads (Hoover 1983 in Reidman 1990). When Pacific harbor seals breed on land, they usually form large polygynous groups (Reidman 1990). Life expectancy for harbor seals is about 30 years, although at least one harbor seal lived to 33 years of age (Jeffries & Newby 1986).

Pacific White-sided Dolphins. Pacific white-sided dolphins, Lagenorhynchus obliquidens, have been seen in the wild from as far north as Amchitka Island in the Aleutians, south to Baja California and west to the Pacific coast of Japan (Leatherwood et al. 1988; Leatherwood & Reeves 1983; Aurioles et al. 1989). Although groups of one thousand or more have been sighted, these dolphins are most often seen in groups of about one hundred individuals (Evans 1987), and are most often sighted in deep water, between the seaward edge of the continental slope and the 100 fathom mark (Leatherwood & Reeves 1983). In the wild, Pacific white-sided dolphins, or "lags", feed on many different species of fishes and squids, with squid, anchovies and hake comprising the majority of their diet (Leatherwood et al. 1988; Leatherwood & Reeves 1983). Pacific white-sided dolphins have been known to reach lengths of at least 2.3m and weights of 150kg (Leatherwood & Reeves 1983).

The average life span for L. obliquidens in the wild has not been reported -- it probably falls somewhere between those of the intermediate sized odontocetes Stenella longirostris (17-22 years) and Stenella attenuata (30-40 years) (Gaskin 1982). Webber (1987) argues convincingly that Lagenorhynchus obliquidens and Lagenorhynchus obscurus (the dusky dolphin) may actually be the same species, although they are geographically isolated, since L. obscurus is found only south of the equator. Although there is some discussion as to what constitutes an annual layer, the number of annual dentinal growth layers is commonly used as an estimate of the age of cetaceans (Bryden 1986). Age data on L. obscurus gathered by Sergeant et al. (1980) from dentinal growth layers in teeth of stranded animals show one dusky dolphin that stranded at approximately 22 years of age, so an estimated life-span range of 17-40 years for Pacific white-sided dolphins is not unlikely. The greatest age reported for a Pacific white-sided dolphin, as evidenced by dentinal growth layers, is 46 years (Klinowska 1991).

Objectives of the Study

This project was designed with two major objectives. The first was to provide environmental enrichment for two Pacific white-sided dolphins and three harbor seals at the Steinhart Aquarium in the California Academy of Science. The second goal was to assess the feasibility of using a simple interface that would allow marine mammals to select differentially from a variety of available reinforcers. This study uses changes in behavior to assess effectiveness of an enrichment apparatus in improving the overall condition of five captive marine mammals. Rather than separate the individual animals, access to the enrichment apparatus during a session was available to all animals in the tank, which provided a challenge for both investigators and marine mammals, but also allowed richer information about social interactions, both inter and intra-specific, to be gathered (Markowitz & Woodworth 1978).

METHODS

Subjects

The project involved five animals, two female Pacific white-sided dolphins and three female harbor seals. The prior history of these subjects is detailed in Tables 1 and 2. The two dolphins involved in this study had a variety of past experience including learning to discriminate between objects (e.g., Basolo 1985) and prelimary enrichment studies (Markowitz, unpublished study). They had also been exposed to a number of floating toys and occasional interaction with humans providing them with food and other treats, sometimes accompanied by vocal encouragement for responding to these offerings.

Facilities

All five animals were housed in a 235,000 liter saltwater tank at the Steinhart Aquarium in San Francisco, California. This 9.2m x 6m tank was open to the air above, and had a depth of 3m at one end of the pool, graduated to 4.6m at the other end. As shown in Figure 1, the tank had six glass observation windows on one side, for public viewing from inside the aquarium building. The aquarium was open daily from 9:00 to 17:00 hours.

Husbandry

The mammals were normally fed by aquarium staff four times daily, at 10:30, 12:30, 14:30 and 16:30. Each of the dolphins received a measured amount, approximately 1.4-1.8 kg of smelt, herring (Clupea harengus), or squid per feeding, with the food species depending both upon availability and husbandry recommendations. The tank also contained toys, including rings, balls and buoys.

Table 1. Histories of Individual Dolphins.

Subject	Amphi	Thetis
Sex	F	F
Length	2 meters (6' 6")	2.1 meters (7')
Weight	109 kg (240 lbs)	118 kg (260 lbs)
Date of Capture	1975	1978
Capture Location	32 km (15 mi.) SW of Santa Cruz, CA	Off Point Loma, CA
Age at Capture (Est.)	4 years	10 years
Age at Onset of Study 1 (Est.)	20 years	23 years
Previous Research	• Music and tactile preference study (Markowitz, pers. comm.)	
	• Subject of visual discrimination study (Basolo 1984).	• Stationed in tank during visual discrimination study (Basolo 1984)
Identifying Marks	• Notch, leading edge dorsal fin • White mark, front lower left jaw • Smaller of two dolphins.	• Hole in dorsal fin • Small piece missing from right fluke • Larger of two dolphins.

Table 2. Histories of Individual Seals.

Subject	Missy	Gerry	Reno
Sex	F	F	F
Date of Capture	July 15, 1970	July 15, 1970	April 1976*
Capture Location	Ocean Beach, San Francisco, CA	Ocean Beach, San Francisco, CA	Marin County, CA
Age at Capture (Est.)	6 mos.	6 mos.	1 year
Previous Research Experience	• Music and tactile preference study (Markowitz, pers. comm.) • Stationed in tank during visual discrimination study (Basolo 1984)		
Age at Onset of Study 1 (Est.)	21 years	21 years	16 years
Identifying Marks	• Main colors black & white • Ventrum white with many black spots • Blind in one eye	• Main colors black & beige • Ventrum beige with more black spots than Reno	• Main colors black and beige • Ventrum beige with few black spots

*Reno was confiscated by the National Marine Fisheries Service from private citizens on April 17, 1976.

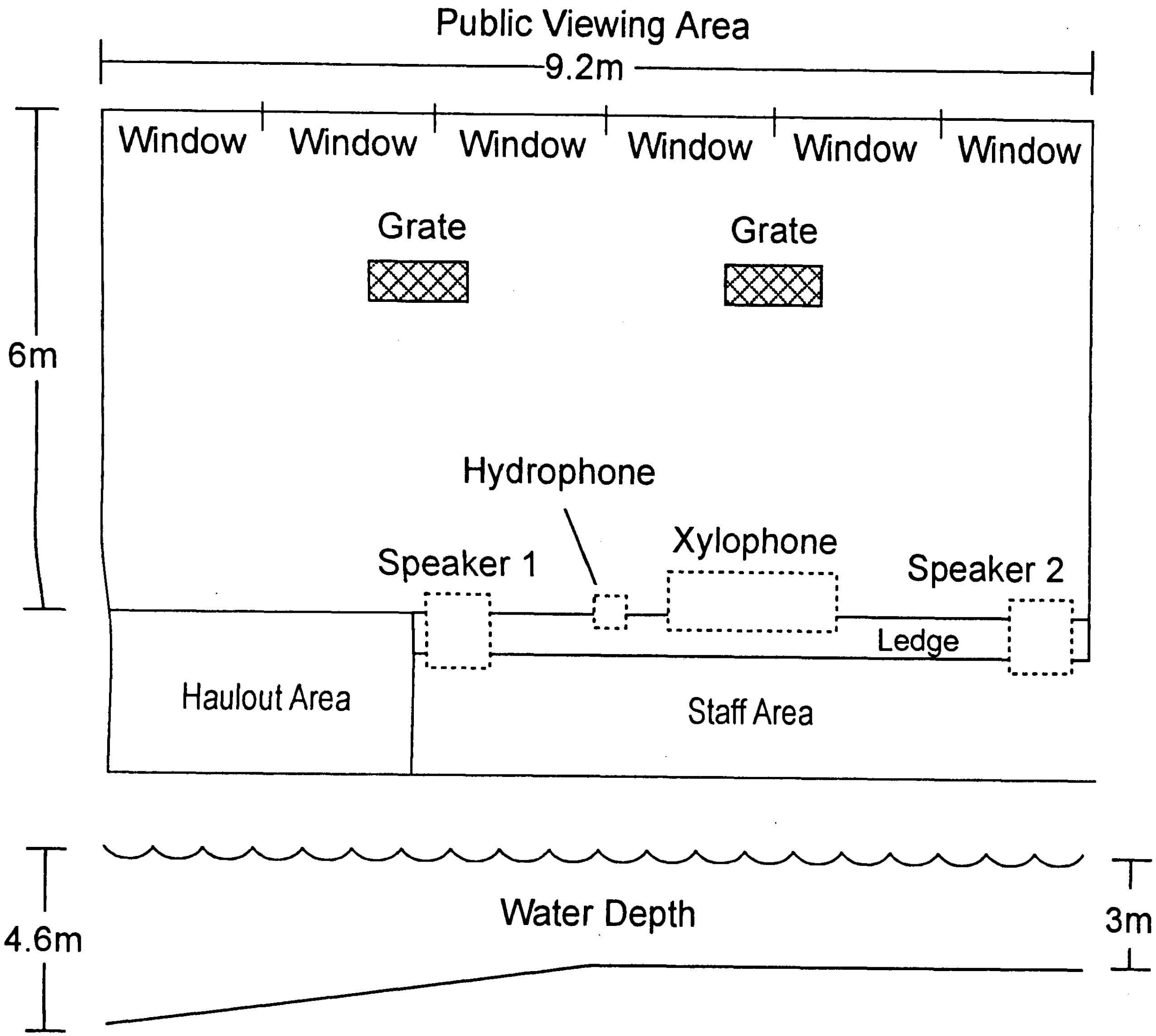

Figure 1. Tank Layout.

Daily Schedule

For both baseline and experimental observations, two sessions were run each day on Mondays, Wednesdays and Fridays. Baseline behavioral observations were made during the first part of each of the studies. This was done to establish a baseline of the captive animals' behavior for comparison with the mammals' behavior during experimental sessions (i.e., when the enrichment apparatus was in the tank). The first baseline session would start at approximately 13:45, so that the observations would be over before the scheduled 14:30 feeding began. The second baseline session would begin after the feeding session was over.

The first daily experimental session started at approximately 13:55, with a 10 minute break after the first session was completed before the second session was started. It should be noted that these sessions were started at a slightly later time than the baseline, to ensure that the second session would run during the posted time (14:30) for marine mammal feedings, to avoid disappointing aquarium visitors. Following the second session, each animal was fed the rest of its food on an ad lib basis.

Enrichment Apparatus - The Xylophone

The environmental enrichment device used in this research (shown in Figure 2) resembled a xylophone: it consisted of eight pieces of 3 in. diameter PVC pipes (keys) of different lengths, mounted vertically. The keys were linked together in pairs (e.g., 1&2, 3&4); both keys in the pair were connected to the same horizontal connector, with each pipe able to swing back and forth independently. Swinging one of the pipes moved a magnet which operated a reed relay, sending a signal to an Atari computer that the pipe (or "key") had

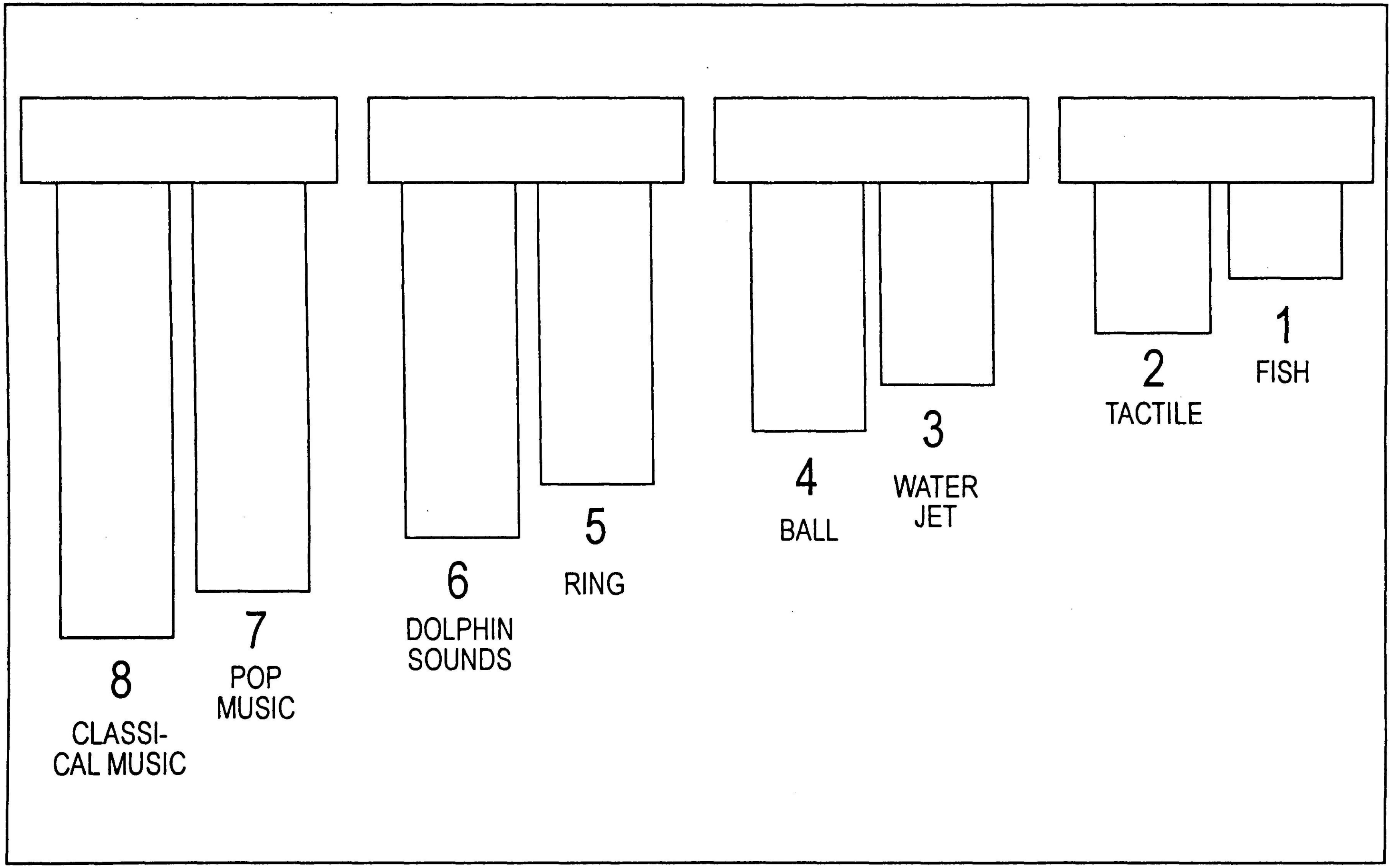

Figure 2. Xylophone Keys and Corresponding Reinforcers. Keys are shown as they appear from inside the tank.

been "pressed." Any of the four pairs of keys, or up to all four pairs could be in the tank at one time.

Xylophone Key Assignments

Overview. Each of the keys on the xylophone corresponded to a different reinforcer. In the final arrangement, eight reinforcers were available for the animals to choose from: fish, tactile stimulation, water jet, ball, ring, dolphin sounds, popular music and classical music. These are shown, with their corresponding keys, in Figure 2.

Not all keys were in the water at all times. If a key was in the water, the presence of the corresponder on the edge of the pool signified its availability -- this was called an "active" key. When a dolphin or seal successfully pressed an active key, a tone would sound both above and below the water, and the appropriate reinforcer would be delivered. If the key was in the water, but the reinforcer was not present, that key was inactive. When an inactive key was pressed, no tone sounded, and no reinforcer was delivered. Due to the difficulty of placing a sound on the edge of the pool, once the sound keys had been added as possible selections (Study 2), keys 6, 7 and 8 were always active when they were in the water. With the exception of the sound keys, any combination of reinforcers (if requested) could be in the tank at the same time. Pressing any sound key stopped any sound currently playing and started the most recently selected one.

Fish (or sometimes both fish and squid) were supplied by the aquarium, in suggested amounts for that scheduled feeding. All seals were fed from the same bucket; individual buckets were used for the two dolphins. If Key 1 was both active and available, after a Key 1 press fish were delivered (one each) to any animal within 3m of the fish buckets within the 5 seconds following the tone. Later in the study, to prevent delivery of fish to animals clearly not interested in feeding, this rule was amended in that only those animals that moved in the direction of the researcher and indicated readiness to eat (for dolphins, opening their mouths) would get fed.

Tactile stimulation availability was signified by gently waving one hand, palm down, about 12 inches above the surface of the water.

The water jet was supplied by a standard spray nozzle attached to an artificial seawater supply. During the reinforcement time, the operator used the nozzle to spray water anywhere in 1/3 of the tank (the right-hand 1/3, as marked off by the windows, as shown in Figure 1).

The ball was a white, heavy-duty plastic volleyball, and was available to the animals only during experimental sessions.

The ring was white and made of plastic, with a diameter of approximately 30cm. It was one of the toys regularly available to the animals in the tank.

Dolphin sounds were played back from tapes of captive Pacific white-sided dolphins provided by Long Marine Lab, University of California at Santa Cruz.

The popular music played in response to a choice of Key 7 included selections from Carly Simon and James Taylor albums.

Classical music was represented by selections from Mozart and Vivaldi.

Other than fish, the rest of the reinforcers, including the sounds played through underwater speakers, were delivered to the animals for 45 seconds. When reinforcement time was up, delivery of the reinforcer was stopped (in the case of tactile stimulation, water jet, or sounds), or the reinforcer (ball or ring) was removed from the tank via a long-handled net. If recovery was temporarily impossible (prevented by the animal), recovery attempts were discontinued until later on in the session or after the session, when removal was possible without upsetting the animals in the tank. Uneaten fish were not removed from the tank until the end of the second session. If a key was pressed for a reinforcer that was still being delivered (45 seconds not expired), the 45 second clock for that reinforcer was restarted.

Xylophone Key Availability

Not all reinforcers were available all the time. When a reinforcer was available, it was visible on the edge of the pool (except for sounds) at the beginning of the session. If a key was pressed that corresponded to an unavailable reinforcer, the "key pressed" tone did not sound.

In Study 1, only keys 1-5 were available, although key 6 was in the pool whenever key 5 was. No reinforcer was assigned to key 6; no tone sounded when it was pressed. In Study 2, keys, 6-8, were made available in addition to keys 1-5.

Baseline Setup

Volunteer researchers were needed for each session to record behavioral observations. In Study 1, two observers were used. Three observers were present for Study 2 sessions. For baseline sessions in Study 1, all toys were removed from the tank. For Study 2 baseline sessions toys were not removed from the tank.

Experimental Setup

Overview. Experimental sessions required the same number of behavioral observers as in baseline sessions (two observers for Study 1, three for Study 2). In addition, other volunteers were required to run the xylophone apparatus and deliver and retrieve reinforcers. Before sessions started, the tank was cleared of all toys. Two underwater speakers (which played back the "key pressed" tone, as well as sounds selected by dolphins) and the xylophone keys for that session were placed in the tank (see Figure 1 for placement) and attached to the edge before the first session began. At the beginning of each session, three tones in a row were used to signal to the animals that the xylophone was "active" (the experimental session had begun). The same three tones were used at the end of each session to signal that the xylophone was now inactive.

Study 1. Three researchers were used in connection with running the xylophone. One researcher was stationed at poolside to deliver reinforcers, and one was stationed above to retrieve the play items (ball or ring) after the 45-second reinforcement time had expired. A third researcher was stationed at the Atari computer. When a tone sounded, indicating an available key had been pressed, the researcher stationed at the Atari computer called out the reinforcer associated with that key, so that the poolside volunteer would deliver it to the animals.

Study 2. In Study 2, two poolside volunteers were used to deliver reinforcements at poolside. This was done to facilitate overlapping the delivery of different reinforcers. For example, with two poolside people, it was much easier to deliver fish that were requested while the water jet delivery had not yet been finished. In addition, tactile stimulation was now available for two animals at once. The poolside volunteers were also required to wear mirrored sunglasses and to orient their heads toward the opposite side of the tank, to decrease the possibility of their cueing the animals, by eye or head movements, to select a certain xylophone key.

Teaching Animals to Use the Xylophone

Shaping and demonstrating were used to teach the mammals to use the xylophone, i.e., an investigator leaned over poolside with one of the reinforcers and touched the appropriate key. On successive trials, the marine mammal was assisted in pressing the key all the way. Finally, full-action responses by the marine mammal were required.

Experimental Sessions

Study 1. Following introduction of the first five key options for the mammals, and their demonstrated use of each of these reinforcers, sessions where only two keys were available were alternated with cafeteria style sessions.

In the cafeteria sessions, reinforcers for all active keys were available to the dolphins and seals and, except for fish, they could order them in any sequence. Once the Key 1(Fish) had been pressed, another key had to be pressed before Key 1 became active again. In later trials, a 15 second delay was added to availability of the fish key. After this contingency was added, if the fish key (Key 1) were pressed within 15 seconds after a previous successful selection of that key, no tone sounded - no fish were delivered.

The discrimination trials were run first using pairs of available reinforcers and then trios. In order to measure the animals' ability to connect keys with appropriate reinforcers, two of the five possible items were shown to the mammals. For example, if human tactile reinforcement and a ball were to be available to the animals, a researcher stood by the side of the pool and leaned over making stroking motions in the area where tactile reinforcement was given and the ball was displayed on the edge of the pool. Only key presses of those keys which corresponded to these items (in this case, Key 2 and Key 4) were reinforced. If the animal selected one of the other key (e.g., Key 3), a "time out" of 30 seconds began, during which even key presses for available items did not sound a tone, and no reinforcers were delivered.

Study 2. In Study 2, all keys were available (cafeteria-style) during every session, except those sessions when not enough researchers were available to staff both tankside positions.

Collection of Data on Apparatus Use

The xylophone apparatus was connected to an Atari computer which recorded information each time a key was pressed - the number of the key, the time it was pressed, and whether the reinforcer was available at that time. This included key 1 presses that took place before the 15 second unavailability period had expired.

Collection of Behavioral Data

Overview. The data collection method described in Altmann (1974) for sampling all occurrences of some behaviors was used to record observations of both state and event behaviors. The behaviors to be sampled were chosen both for importance and ease of spotting. Scanning of current state behaviors proceeded sequentially, while event behaviors for any animal were recorded instantaneously. Definitions of those behaviors analysed in this paper are shown in Table 3.

These observations were recorded using portable Tandy computers, bar code wands, and computer-generated bar code data sheets(Markowitz, et al. submitted). Both baseline and experimental behavioral data were gathered. On a rotating schedule, researchers and volunteers were assigned to duties

Table 3. Behavioral Definitions

Activity Levels	
Active	Animal swims at fast, slow or normal speed. Includes swimming inverted.
Inactive	Animal is stationary, moving no more than .3m per 10 second period. Also includes seals hauled out of water.
Agonistic Behavior	
Chase	Two animals swim fast, with one animal (the chaser) closely following the other animal.
Bite	One animal takes a body part of another animal into its mouth.
Clasp	One animal puts its pecs around a body part of another animal.
Lunge	One animal makes a lunging motion towards another animal.
Stereotypic Behavior	
Wall-touching	Dolphins only: Animal contacts wall, or pipes attached to wall, with any part of its body.

including running the Atari computer, recording behaviors, delivering reinforcers at poolside, and retrieving reinforcers.

Study 1 Observation Procedures. In Study 1, focal group sampling (Altmann 1974) was used for observing behaviors. The focal group for observer 1 was comprised of the three seals, while the two dolphins were the focal group for a second observer. As part of the procedure, observers were confined to coding no more than three behaviors in a row for one animal before moving on to the next animal. The bar code sheet used in Study 1 can be found in Appendix A.

Study 2 Observation Procedures. In Study 2, three observers were used. Two of them were involved in recording behaviors seen in focal animals (one of each species), and the third observer focused on any interactions with the xylophone or related reinforcers (e.g., ball, ring, etc.). This necessitated the use of two different bar code sheets in Study 2. These are included in this report as Appendices B and C.

Data Analysis

Behavioral data files were downloaded from the Tandy portable computers to a IBM-compatible personal computer. Programs written in Microsoft's QBasic (1992) were used to summarize the raw data. The summary data files were then imported into Microsoft Excel (1993) for further data manipulation and analysis.

Although two sessions per day were always scheduled, a number of mishaps could cause only one or neither to be a "valid" session. If the dolphins or seals used up all available fish before the 25 minute session was over, the session was stopped immediately. Behavioral data files where less than 25 minutes of behavior was recorded were not used in this analysis. If something occurred that might significantly change the behavior of the animals (e.g. nearby drilling, etc.), then that session was also discarded. In Study 1, to ensure optimal comparability, all sessions where only one valid session was available for that day were discarded. A breakdown of the numbers of sessions used in analysis of state and event behaviors for animals in both studies is shown in Table 4. Distribution of the study sessions by month is shown in Table 5.

GBStat (Dynamic Microsystems 1991) was used to perform both t-tests and Mann-Whitney U tests. The two sample T-test was used to determine significance of differences between state (activity) behavior means. The Mann-Whitney U test was used to determine if differences between event behavior (agonistic and stereotypic) means were significant. Confidence levels used for one-tailed tests are stated in the text. GBStat was also used for Spearman's Rho rank correlation.

Table 4. Sessions Used for Analysis (by Animal).

Study	Session Type	Session	Missy	Gerry	Reno	Thetus	Amphi	Seals	Dolphins
1	Baseline	Total*	34	34	34	36	36	102	72
	Experimental	Total*	64	64	64	84	84	192	168
2	Baseline	1	2	2	3	5	5	7	10
		2	0	2	2	2	2	4	4
		Total	2	4	5	7	7	11	14
	Experimental	1	4	2	3	6	9	9	15
		2	4	5	2	6	10	11	16
		Total	8	7	5	12	19	20	31

* In Study 1, the number of Session 1 observations and Session 2 observations is equal.

Table 5. Distribution of Study Sessions over Time

			3/91	4/91	5/91	6/91	7/91	8/91	9/91	10/91	11/91	12/91	1/92	2/92	3/92	4/92	5/92
Study 1	Seals	Baseline	30	18	36	0	0	18	0	0	0	0	0	0	--	--	--
		Experimental	0	0	0	42	48	18	0	6	36	18	12	12	--	--	--
	Dolphins	Baseline	8	8	32	0	0	20	4	0	0	0	0	0	--	--	--
		Experimental	0	0	0	40	40	24	0	4	24	16	12	8	--	--	--
Study 2	Seals	Baseline	--	--	--	--	--	--	--	--	--	--	--	--	2	6	2
		Experimental	--	--	--	--	--	--	--	--	--	--	--	--	2	12	6
	Dolphins	Baseline	--	--	--	--	--	--	--	--	--	--	--	--	8	5	1
		Experimental	--	--	--	--	--	--	--	--	--	--	--	--	4	13	14

RESULTS

Discrimination Trials

The seals and dolphins successfully reached a criterion of 90 percent appropriate responses within sessions with the reinforcers (1-5) displayed in pairs and then in trios. No discrimination trials were run with the reinforcers for keys 6-8, the sound keys. However, it is significant to note that once these keys were introduced, they were consistently selected. The first session in which these keys were available, the dolphins demonstrated highly animated responses to the sounds.

Xylophone Use

Monthly means of key presses per session are shown in Table 6. As illustrated in Figure 3, the mean number of key presses did not decrease significantly over time (Spearman Rank Correlation, $t= 0.94$, $DF=9$, $P>0.05$). Active and inactive key presses by animal for Study 1 are shown in Figure 4.

Xylophone Key Preferences

Among the available keys, Key 1(Fish) was chosen most often ($x=21.2$ key presses per session). The next most often chosen key ($x=5.0$ key presses per session) was Key 3(Water Jet). All other items were selected from time to time, but much less often than those two keys.

Changes in Xylophone Use as a Function of Key Setup

Key presses for different key setups are shown in Table 7. The mean number of key presses per session when the Key 1(Fish) was active (35.5) was significantly higher ($z = 3.30$, $P<0.01$) than the mean number of key presses when Key 1 was not active (19.0).

Table 6. Xylophone Use (Key Presses) over Time

	Active Keys	Inactive Keys	All Keys
	MEAN (S.D.)	MEAN (S.D.)	MEAN (S.D.)
6/91	23.2 (14.0)	5.0 (5.1)	28.3 (15.2)
7/91	20.1 (10.4)	5.7 (9.3)	25.7 (14.6)
8/91	27.5 (17.8)	5.0 (8.0)	32.5 (22.7)
9/91	-- --	-- --	-- --
10/91	14.0 (5.6)	9.2 (9.0)	23.2 (12.9)
11/91	29.8 (13.5)	10.4 (8.0)	40.2 (14.4)
12/91	28.2 (16.4)	3.5 (5.2)	31.7 (17.8)
1/92	26.0 (24.6)	7.3 (9.2)	33.3 (33.5)
2/92	16.2 (7.4)	2.0 (2.9)	18.2 (9.3)
3/92	20.7 (11.6)	0.7 (1.2)	21.3 (11.0)
4/92	38.9 (14.9)	7.7 (10.0)	46.6 (19.3)
5/92	37.6 (16.9)	6.6 (4.8)	44.2 (18.6)

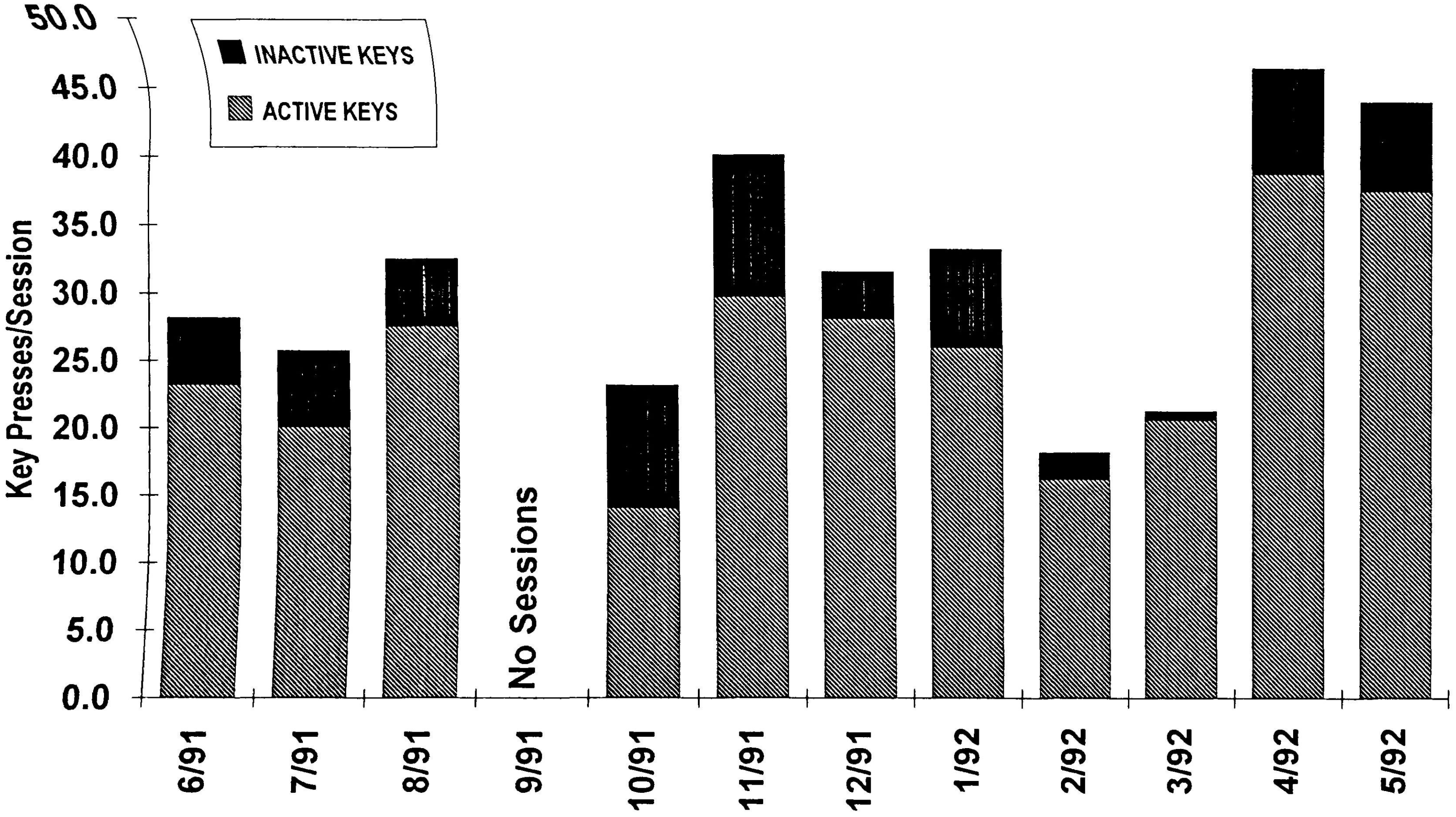

Figure 3. Mean Key Presses (All Animals Combined) per Session by Month

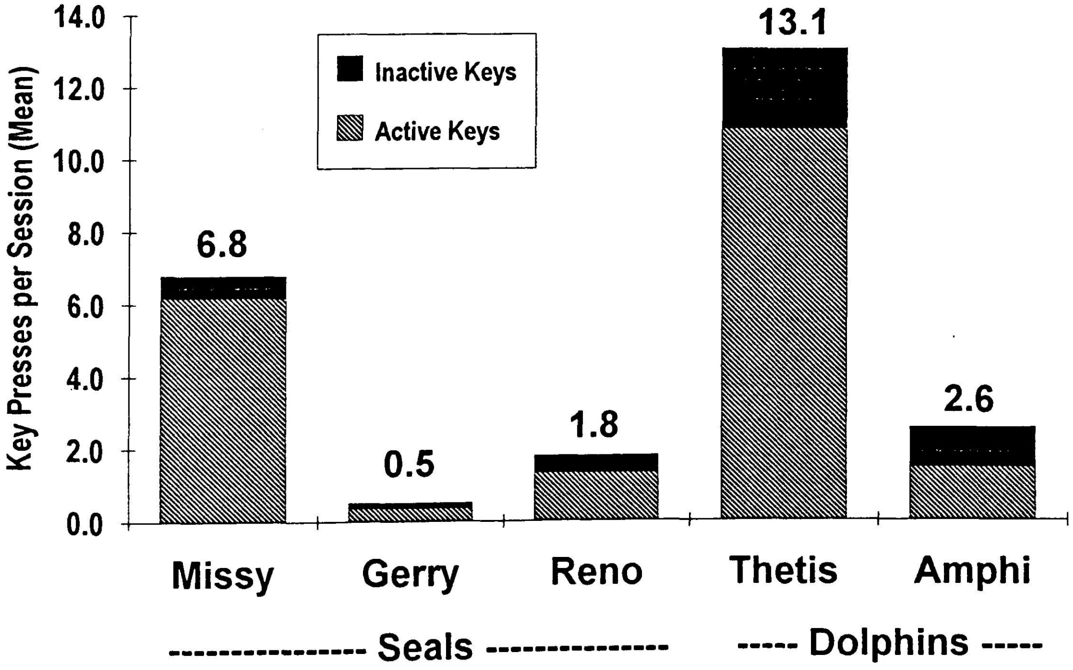

Figure 4. Mean Key Presses per Session by Animal
Data presented are from Study 1 observations only.

Table 7. Key Presses for Different Key Setups

		ACTIVE KEYS									INACTIVE KEYS									COMBINED
ACTIVE/INACTIVE	n	1	2	3	4	5	6	7	8	TOTAL	1	2	3	4	5	6	7	8	TOTAL	TOTAL
12	16	21.5	11.5	--	--	--	--	--	--	33.0	6.0	--	--	--	--	--	--	--	6.0	39.0
34	4	--	--	11.3	4.0	--	--	--	--	15.3	--	--	--	--	--	--	--	--	--	15.3
5 / 6	2	--	--	--	--	13.5	--	--	--	13.5	--	--	--	--	--	0.5	--	--	0.5	14.0
5 / 678	2	--	--	--	--	--	6.0	4.0	5.0	15.0	--	--	--	--	19.5	--	--	--	19.5	34.5
12345 / 6	43	9.7	2.4	2.8	2.0	6.7	--	--	--	23.6	1.3	--	--	--	--	4.4	--	--	5.7	29.3
12345 / 678	7	15.9	3.1	3.4	0.6	4.6	--	--	--	27.6	1.7	--	--	--	--	2.0	3.9	4.6	12.1	39.7
12345678	22	21.2	3.0	5.0	1.0	3.2	2.5	1.8	1.7	39.4	5.2	--	--	--	--	--	--	--	5.2	44.6

Differential Responses to Reinforcers

Fish. The original paradigm, in which Key 1(Fish) was inactive until another key was pressed, was was included because in training sessions the dolphins would order all of the allotted food (even though they might not consume it all) before they made significant use of the other opportunities. They often signalled their disinterest in eating the fish by closing their mouths and turning their heads away from the researcher when the fish was offered to them. This happened with both preferred and less "appreciated" food items. The dolphins appeared in general to prefer herring over squid or smelt, and once given herring during a session would often ignore any other kind of food that was tossed to them. They would wait the 15 seconds for the fish key to reactivate, then press Key 1 again. Seals did not appear to have any food preferences among those items offered.

Tactile Stimulation. The aquarium staff and common sense both warned us not to attempt petting the seals -- fortunately they did not seem interesting in receiving tactile stimulation. In the first study, where only one trainer was available at poolside to give tactile stimulation, Thetis either intereacted with the trainer for tactile stimulation or kept Amphi from doing so. In study 2, with a second trainer at poolside, many times both dolphins moved to poolside to receive tactile stimulation.

Water Jet. Dolphins and seals responded differently to the spray of water on the surface of the pool. Seals treated it like a shower and moved to float on the surface right under the jet of water. Dolphins, on the other hand, moved beneath the water jet but stayed about 0.5m under the pool's surface. When the water jet was moved in random patterns on the surface of the water, a watching dolphin would often move its head to keep the point where the water jet contacted the water directly in front of its rostrum.

Ball and Ring. After a while, the dolphins developed some patterns in dealing with these reinforcers. After they had ordered one of these toys, the dolphins would often ignore it until it was almost time for the reinforcer to be removed from the tank. At about 40 seconds, one of the dolphins would move to the toy and as much as possible keep it from being removed. In the case of the ring, they would usually place their pectoral fin through it and swim to the bottom of the tank. In the case of the ball, they would move it to the farthest end of the tank from where the person with the removal net was standing. Any attempt to remove the ball was met with moving the ball to another part of the tank. When the ball was finally recaptured by the researchers, the dolphins would often release bubble bursts to the surface. Once airborne whistle vocalizations were heard as the ball was being removed.

Sounds. The first few times any of the sound keys (6, 7, 8) were played, the dolphins approached the speakers and appeared to examine them carefully. An unusual behavior was seen from time to time when the classical and popular music selections were played: one or both of the dolphins would move their bodies from side to side in a fast rhythm, in a motion that might be described as "dancing."

Activity Level Differences due to Time of Observation (Study 1 Only)

Baseline Sessions. When baseline data from the observation sessions before (first) and after eating (second) are compared, animals are seen to spend different amounts of time in active behavior, as shown in Figure 5.

The difference between the mean seconds of active behavior seen in seals in the first sessions (x=834.5, S.D.=467.4) and second sessions (x=713.2, S.D.=504.1) is not statistically significant (t=1.26, DF=292, $P > 0.05$).

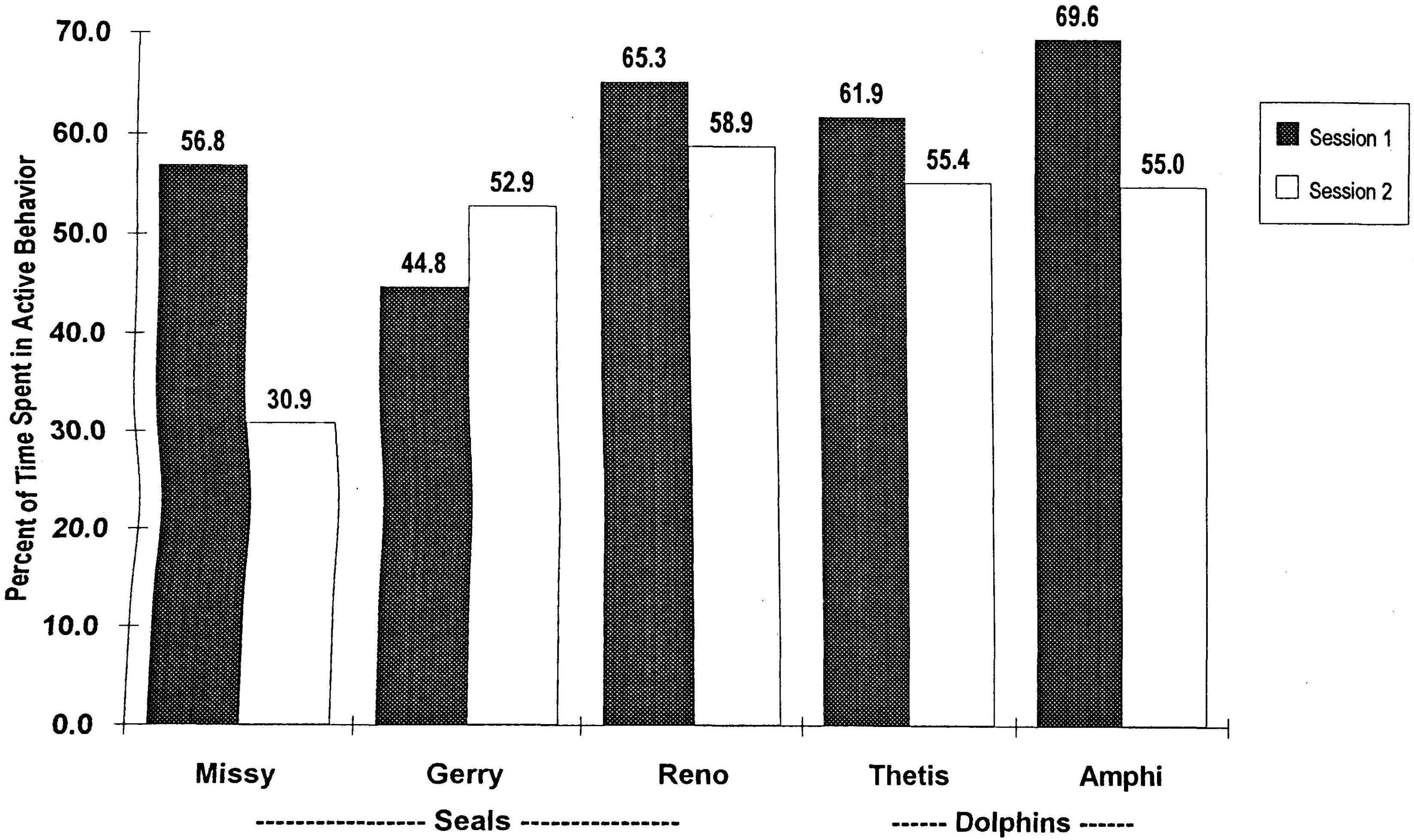

Figure 5. Duration of Active Behavior -- Study 1 Baseline (Session 1 vs. Session 2)

In baseline sessions, the mean seconds of active behavior exhibited by dolphins between first (x=986.1, S.D.=214.3) and second sessions (x=828.1, S.D.=233.7) is significantly higher in the first session (t=2.99, DF=166, P<.01).

Experimental Sessions. During experimental sessions, the mean seconds of activity seen for dolphins in the first session was 1012.8 (S.D.=267.3) and in the second session 1017.3 seconds (S.D.=246.5). These two means were not found to differ significantly (t= -0.11, DF=70, P>0.05).

The mean seconds of activity seen for seals in the first of the two experimental sessions per day was 541.2 (S.D.=622.0) and in the second experimental session 570.9 seconds (S.D.=646.2). These two means were not found to differ significantly (t= -0.20, DF=68, P>0.05).

Changes in Total Time Spent in Active Behavior, Baseline vs. Experimental

Study 1. Seals spent an average of 773.8 seconds (S.D.=487.5) in active behavior during baseline sessions, and an average of 787.5 seconds (S.D.=448.6) in active behavior during experimental sessions. These means were not significantly different (t= -0.24, DF=292, P>0.05). Dolphins spent an average of 907.1 seconds (S.D.=236.4) in active behavior during baseline sessions, and an average of 1015.0 seconds (S.D.=256.3) in active behavior during experimental sessions. The mean amount of time spent in active behavior during experimental sessions was significantly higher than that seen in baseline sessions (t=-3.05, DF=238, P<0.01).

Study 2. Seals spent an average of 1146.7 seconds (S.D.=383.6) in active behavior during baseline sessions, and an average of 1032.7 seconds (S.D.=405.7) in active behavior during experimental sessions. These means did not differ significantly (t= 0.763, DF=29, P>0.05).

Dolphins spent an average of 977.8 seconds (S.D.=218.5) in active behavior during baseline sessions, and an average of 1115.7 seconds (S.D.=231.2) in active behavior during experimental sessions. The mean for experimental sessions was significantly higher (t= -1.88, DF=29, P<0.05).

Changes in Frequency of Agonistic Behaviors

Table 8 provides information on frequency of agonistic behavior for all individuals in the study.

Study 1. In both baseline and experimental sessions, agonistic behaviors recorded for this study were seen very rarely (x = 0.04 agonistic behaviors per session) in seals. Agonistic behaviors were seen to occur in seals with a mean frequency of 0.06 (S.D.=0.37) in baseline sessions and 0.03 (S.D.=0.27) in experimental sessions. Although the mean frequency of agonistic behaviors is lower for the experimental sessions, the difference in the baseline and experimental means was not statistically significant (z =0.196, P>0.05).

Agonistic behaviors by dolphins were found to be relatively rare as well, with a mean frequency of 0.10 (S.D.=0.59) in baseline sessions and 0.02 (S.D.=0.13) in experimental sessions. Although agonistic behaviors apparently occurred less frequently in experimental sessions, the difference in means was not found to be statistically significant according to the Mann-Whitney U test (z =0.13 , P>0.05).

Study 2. Agonistic behaviors were seen to occur in seals with a mean frequency of 0.09 (S.D.=0.30) in baseline sessions and no agonistic behaviors were seen in experimental sessions. However, the Mann-Whitney U test did not show these two means to differ significantly (z =0.4541, P>0.05).

Table 8. Mean Frequency of Agonistic Behavior (Events per Session)

		Study 1		Study 2	
		Baseline	Experimental	Baseline	Experimental
		Average (S.D.)	Average (S.D.)	Average (S.D.)	Average (S.D.)
Seals	Missy	0.09 (0.38)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Gerry	0.00 (0.00)	0.02 (0.13)	0.00 (0.00)	0.00 (0.00)
	Reno	0.09 (0.51)	0.08 (0.45)	0.20 (0.45)	0.00 (0.00)
	Combined	**0.06 (0.37)**	**0.03 (0.27)**	**0.09 (0.30)**	**0.00 (0.00)**
Dolphins	Thetis	0.11 (0.67)	0.01 (0.11)	2.14 (2.19)	0.33 (1.15)
	Amphi	0.08 (0.50)	0.02 (0.15)	5.57 (11.07)	0.05 (0.23)
	Combined	**0.10 (0.59)**	**0.02 (0.13)**	**3.86 (7.87)**	**0.16 (0.73)**

Table 9. Mean Frequency of Wall-Touching by Dolphins (Events per Session)

		Study 1		Study 2	
		Baseline	Experimental	Baseline	Experimental
		Average (S.D.)	Average (S.D.)	Average (S.D.)	Average (S.D.)
Dolphins	Thetis	4.5 (6.5)	0.3 (0.9)	3.6 (3.6)	0.7 (2.0)
	Amphi	11.5 (10.0)	0.5 (1.2)	9.7 (7.1)	1.4 (2.9)
	Combined	**8.0 (9.1)**	**0.4 (1.1)**	**6.6 (6.3)**	**1.1 (2.6)**

Agonistic behaviors were seen to occur in dolphins with a mean frequency of 3.86 (S.D.=7.87) in baseline sessions and 0.16 (S.D.=0.73) in experimental sessions. Agonistic behaviors occurred more frequently in baseline sessions, according to the Mann-Whitney U test (z =2.79 , P<0.01).

Changes in Frequency of Stereotypic Behavior (Wall-Touching)

Table 9, found on the previous page, provides information on wall-touching behavior for all individuals in the study. Since wall-touching is considered a stereotypic behavior for the dolphins only, only those means are compared.

Study 1. Dolphins were seen to touch the wall with a mean frequency of 8.0 (S.D.=9.1) in baseline sessions and 0.4 (S.D.=1.1) in experimental sessions. Wall touching occurred significantly less frequently in experimental sessions, according to the Mann-Whitney U test (z = 3.53, P<0.01).

Study 2. Dolphins touched the wall an average of of 6.6 times per session (S.D.=6.3) in baseline sessions and 1.1 (S.D.=2.6) times per session in experimental sessions. The mean frequency of wall touching is significantly lower in the experimental sessions, according to the Mann-Whitney U test (z = 10.25, P<0.01).

Differences in Time Spent Hauled Out, Baseline vs. Experimental (Seals only)

Differences in mean haulout time for seals in Study 1 are shown in Table 10. Application of the t-test indicated a significant difference (t = 2.08, DF=131 (adjusted), P<0.05) in haul out time between the mean haulout times observed in seals during the baseline (x=99.6, S.D.=317.3) and experimental (x=29.7,S.D.=164.2) sessions. In contrast, the Mann-Whitney U test revealed no significant difference (z-0.76, P>0.05). In Study 2, seals were not observed to haulout during any of the sessions.

Table 10. Study 1: Mean Duration of Seal Haul Outs (Seconds per Session)

	Baseline	Experimental
	Average (S.D.)	Average (S.D.)
Missy	49.7 (236.2)	26.8 (150.7)
Gerry	147.0 (390.9)	40.8 (230.3)
Reno	102.0 (307.7)	21.4 (76.1)
Combined	**99.6 (317.3)**	**29.7 (164.2)**

DISCUSSION

All animals used the xylophone, as shown previously in Figure 4, although two of the animals, Thetis and Missy accounted for 80% of the key presses. It should be mentioned anecdotally that in early discrimination trials one of the seals, Missy, learned to use the xylophone before any of the other animals, and dominated its use. This was very frustrating to some of the researchers, who expected the larger-brained dolphins to take more readily to this equipment. However, in later cafeteria-style sessions (many keys available), the balance of key presses was tilted to the dolphin side by Thetis' consistent xylophone use. Little competition was seen between species for use of the xylophone, even though one of the seals, Missy, might hang on the keys or float behind the keys in such a way that no other animal could successfully press a key. However, the dolphins did not obviously behave in an aggressive manner toward the interfering seal, but either ignored the apparatus entirely or tried to work around her.

In contrast, there was apparently strong competition between the dolphins for use of the xylophone. The trainer (Smith, pers. comm.) often remarked on the dominance struggles between these two animals. We saw evidence of this dominance relationship in that Thetis would prevent Amphi from pressing keys on the xylophone. Amphi often floated nearby, oriented toward the xylophone, apparently watching Thetis or Missy press keys, and in a good position to move forward and get fish when they were dispensed. When no other animal was pressing keys, Amphi would sometimes approach the xylophone, swimming very slowly. When Amphi got close to the xylophone, Thetis would usually swim between Amphi and the xylophone, cutting off access to the xylophone. There were also times when Thetis ordered one of the toys (the ring or the ball) but ignored it, until Amphi started to play with it. Then Thetis would steal the toy away, keeping her body between Amphi and the toy.

Hutchins (1978, 1979 in Kleiman 1992) predicted that captive animals would rapidly become bored with electronic enrichment apparatus. In this study, there was no evidence of "boredom," that is, over a one-year period there was no measurable decrease in the mean number of times animals pressed the xylophone keys. Can this be interpreted to mean that this apparatus is complex enough to merit the animals' continued interest? The fact that the xylophone was not available to the animals 24 hours a day may have been a factor that kept the animals' interest in the apparatus high. Interaction with humans may have been a significant factor in the complexity of this paradigm as perceived by the animals: not only did the dolphins appear to take a perverse pleasure in keeping researchers from removing reinforcers from the pool, they also interacted with the researchers in other ways that could be considered to add complexity. Tactile stimulation provided direct interaction with humans, and the dolphins, by their proximity, could control if they were stroked at all, who stroked them and how long they were stroked. When Key 3, water jet, was selected, the researcher controlling it was to spray it on the surface of the water, but could also move it in patterns on the surface -- sometimes the dolphins appeared very interested in this, and would move quickly to keep up with the water jet's movement. In addition, at the beginning of each session, the dolphins would spyhop near the poolside volunteers, seemingly trying to elicit visual contact from the humans. Research on comparing the effects of a similar, but completely automated apparatus could allow evaluation of the importance of the human interaction component in producing measurable effects contributing to the mammals' well-being.

The animals' continued selection of Key 1, fish, even though they were consistently fed ad lib at the end of the daily experimental sessions, may add two more species to the list of those that will work for food despite free availability of food. However, it must be mentioned that for this to be strictly interpreted, the food should have been present at another site in the pool during the experimental sessions. Saying that these animals were working despite the fact that they "knew" they would be fed at the end of the sessions presupposes that they not only remembered being fed at the end of previous sessions, but could anticipate the feeding to come.

While it is not surprising that the animals appeared focused on Key 1, fish, and pressed it twice as many times as the rest of the keys combined, it will be surprising to some that these animals pressed any of the other keys consistently. Why did they press the other keys at all? The reinforcers delivered when these other keys were pressed, with the exception of Key 6, dolphin sounds, were not items usually found in the animals' wild environment, and thus could have little adaptive significance for these animals. Did they press these other keys by mistake, or did the animals "hope" that pressing the other keys might possibly pay off with fish or some other kind of food? Successful identification of the keys corresponding to available reinforcers, occurred in the discrimination trials that were part of these sessions, so it may be assumed that the animals had some idea of the reinforcer associated with a given key.

The dolphins did appear to anticipate the results of their key presses, with the animal that pressed Key 3, water jet, sometimes moving into the area of the tank where the water jet was available, and seldom moving back with mouth agape to accept fish, except when an animal had operated the fish key. The seals, on the other hand, appeared to be more fixated on fish, and sometimes lacked the precision that the dolphins showed in key pressing. Missy would sometimes pull rather than push on the keys, or hang on the keys (which not only did not activate them, but kept other animals from activating them) and look up expectantly at the researcher with the fish. Sometimes the seals ordered tactile stimulation, but they never moved in to receive the reinforcer. Perhaps the animals' ordering of the non-fish and non-dolphin sound reinforcers cannot be explained in terms of adaptiveness, but only in terms of individual preference. Although these animals did have limited experience in the wild, much of their current repertoires was undoubtedly a function of their past history of reinforcement in captivity.

As shown in Figure 6, an unusually high percentage of incorrect key presses was recorded for the setup where Keys 6, 7 and 8 were available, and Key 5 was in the water, but inactive (no reinforcing tone would sound for a Key 5 press, no reinforcer would be delivered). This may have been due to the fact that Key 5 was the shortest key, and its relative length and location were very similar to that of Key 1 when Keys 1-5 or 1-8 were in the water. Indeed, in all setups, whichever key was the shortest was pressed close to twice as often as the other keys. Transposition, of the sort described as a possible reason for the high number of presses for the shortest key available, has been the focus of many discrimination studies (Osgood 1953; Deese 1958; Candland 1968).

The phenomenon mentioned earlier in which dolphins pressed Key 1 (fish) then refused to eat them, was also seen in Mackay's (1981) research with bottlenose dolphins. Although lack of complete documentation of their complex history made it impossible to identify the exact reason for this behavior, it was generally believed that the preference for ordering food, even when not hungry, was a function of their having been differentially reinforced for this behavior for

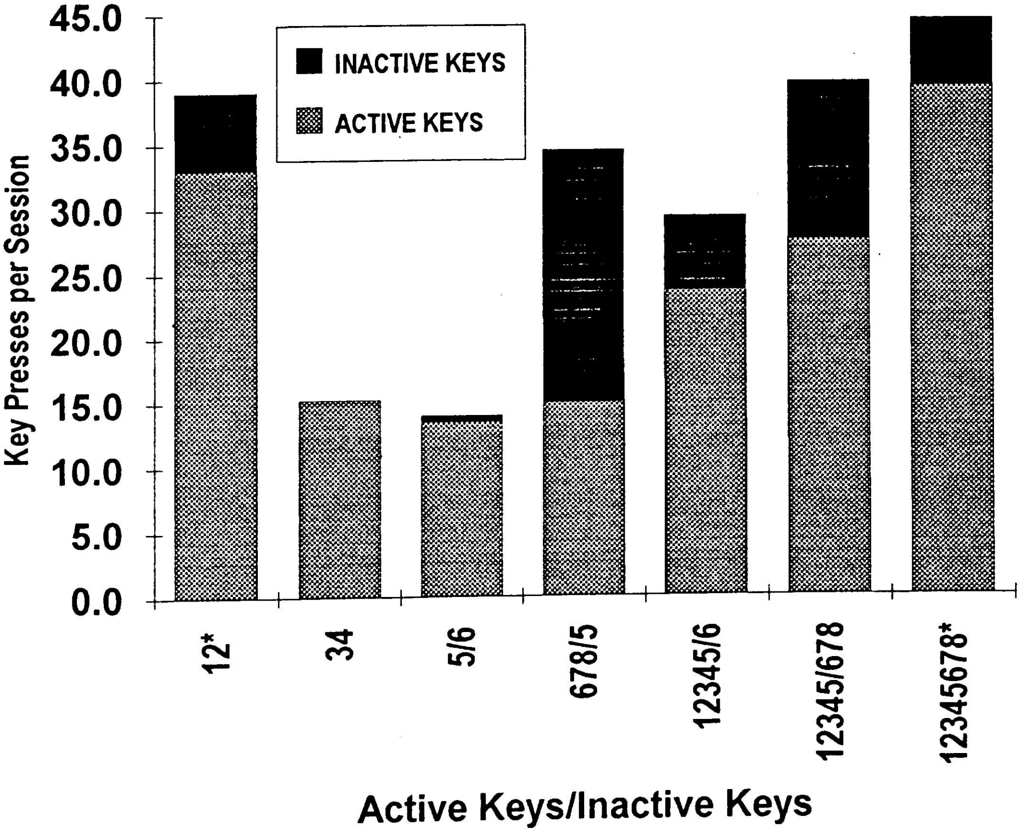

Figure 6. Xylophone Use by Key Setup

many years. It should be noted that this is not an unusual behavior among carnivores in general. This phenomenon seems to lend credence to the idea that the animals may enjoy not only earning their own food, but more simply the controlling something in their environment (making a fish be thrown to them). However the dolphins' continuing to order food when they did not eat it, can also be considered in light of Pryor's (1981) report of research situations in which dolphins were seen to intentionally (apparently) give a number of totally wrong responses when the fish reward supplied did not meet their standards.

While in this study the dolphins seemed to prefer herring over smelt, as detailed above, in Basolo's (1984) research, she mentions night smelt (Spirinchus sp.) as one of these same lags' favorite foods.

As shown in Figure 7, tactile stimulation was selected a mean of three times per session, making it fourth in the ranking of key item preferences. The seals did not attempt to participate in being "petted" during times when tactile stimulation was available, which is not really surprising. Sullivan (1982) reports that harbor seals cannot be called a "contact species," that is, when two conspecifics come within a threshold distance, contact inevitably leads to aggression by the individual being touched. Harbor seals do not appear to seek out prolonged physical contact with each other (except for breeding purposes) or with humans. So, one would not expect tactile stimulation to be an attractive reinforcer to seals.

The dolphins, on the other hand, often participated in tactile stimulation. Attractiveness of tactile stimulation seemed dependent on a number of variables, including familiarity of the researcher at poolside and temperature and salinity of the water. Changes in temperature and salinity have been reported to have

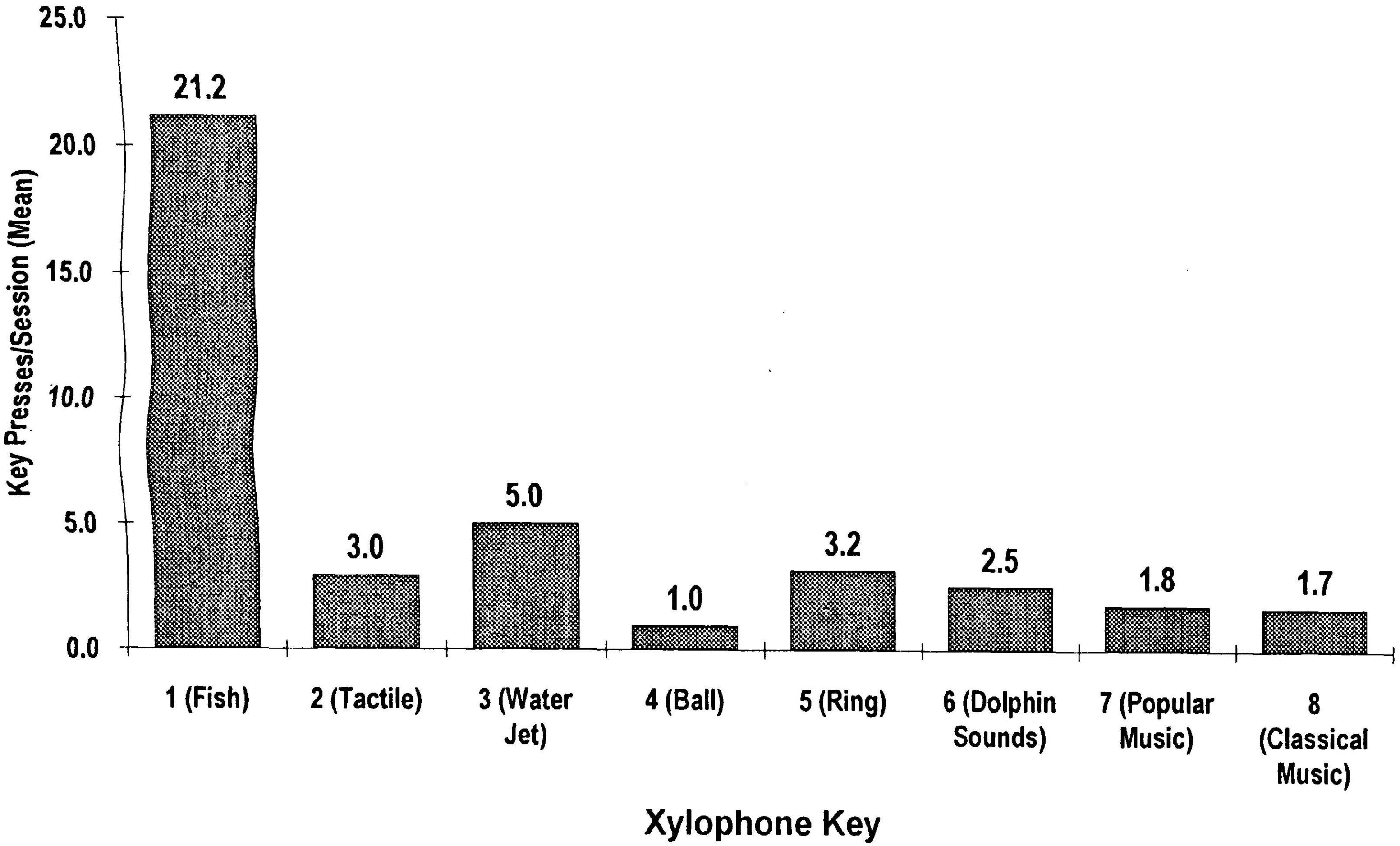

Figure 7. Key Preferences with All Eight Keys Available

significant effects on both the skin condition and the activity level of dolphins (Manton 1986).

In interactions with the water jet, the seals would often move to the surface where the water jet would be in direct contact with their skin, while the dolphins, in contrast, never moved into a position where they would be in direct contact with the water jet. Yet they did interact with it. Perhaps they avoided direct contact with the water jet due to general skin sensitivity, or due to the sensitivity of the blowhole region, which would necessarily be exposed when they surfaced. In Mackay's research, he allowed bottlenose dolphins to order both a surface water jet and an underwater jet. For the surface jet, his findings were similar to the present ones, in that he said "the dolphins seemed interested," while he reported the dolphins would swim through the underwater jet. In a completely automated system, where the surface jet would not be moved, perhaps dolphins would eventually become bored with it, or perhaps they would use it more frequently, since the predictability of the water jet angle would allow them to avoid the inflow of water to their blowholes. In an automated system, an underwater jet could provide an efficient way of automating a substitute for human tactile stimulation.

Although the frequency of key presses for Key 5 was relatively low during the 22 sessions where all keys were available, balls were one of the dolphins' favorite items during baseline sessions. Since the ball used in the xylophone sessions was a different one than that regularly available to the dolphins, the low interest in the "ball" key could be explained by the confinement of the dolphins' interest to the particular balls they had available during the baseline sessions. With both the ball and the ring, the dolphins often showed little interest in the reinforcer until the 45 second time limit had almost expired. They would then approach the item and take it to the farther part of the tank possible to keep it from being retrieved. For the ball, this was merely a far corner, from which they would move it quickly if the researcher with the retrieval net approached. If the reinforcer was the ring, the dolphins often took it deep underwater, where retrieval was not possible. Eventually, the dolphins would allow the reinforcer to be retrieved, sometimes showing evidence of excitement in the form of bubble bursts, and once with in-air vocalizations.

Key 4, ring, was selected third most often of any of the reinforcers. This amount of interest is consistent with the strong interest in the ring mentioned by Basolo (1984) in a research report involving these same dolphins (some 6 years earlier). During Basolo's study, however, the ring was the only toy in the tank.

Of the three sound keys, dolphin sounds were selected most often (2.5 key presses session). The keys for popular and classical music were pressed less frequently than any of the other keys, except Key 4, ball. While it was expected that the dolphins would be most interested in hearing sounds of conspecifics, we were surprised that the overall selection of any of the sound keys was so low; since dolphins are such aurally-oriented animals, we expected audio stimulation to be especially attractive to them. Perhaps different samples of these sounds, with recordings of wild L. obliquidens and different artists for the classical and popular music selections would produce a higher level of interest in these keys.

In this study, we used behavioral changes as indications of changes in the animals' conditions. Few data on activity budgets in the wild are available for these animals, due to the previously mentioned constraints of studying animals when they are underwater in the open ocean. In consequence, we chose three behavioral measures: activity levels, as indicated by time spent in active behaviors; occurrences of agonistic behavior; and occurrences of stereotypic behavior.

In a zoo setting, it has been noted that many animals, especially predators, have little reason to exercise, since the opportunity to forage is denied to them (Hediger 1964, Lindburg 1988). An increase in activity levels in captive predators would lead to increased energy expenditure and an increase in both health and well-being. While the levels of activity in dolphins were seen to increase significantly during the experimental sessions, the activity levels for seals remained about the same, increasingly slightly in Study 1 and decreasing slightly in Study 2 (see Figure 8). If we assume that the increased time spent in active behavior seen in the dolphins indicates increased well-being, must we also assume that the well-being of the seals did not increase? This could mean that the seals as a group were little affected by the presence of the xylophone, or it could be that a seasonal reduction in activity levels occurred at the time when experimental sessions were being run. This is consistent with research mentioned by Thompson et al. (1989) where feeding activities of harbor seals were seen to be reduced during the time of the summer moult; in the two present studies, a good portion (Study 1) or all (Study 2) of the experimental sessions took place during the summer months, with most baseline sessions in spring (see Table 5).

Perhaps activity levels did not increase in seals because their activity levels were already unusually high. While this information is not readily available from field data, field data on the amount of time harbor seals spend hauled out, does suggest an unusual activity budget for these animals. The amount of time these seals spent in the water is much higher than that reported by Sullivan (1981) for wild harbor seals at Abalone Beach in Humboldt County, California. While the

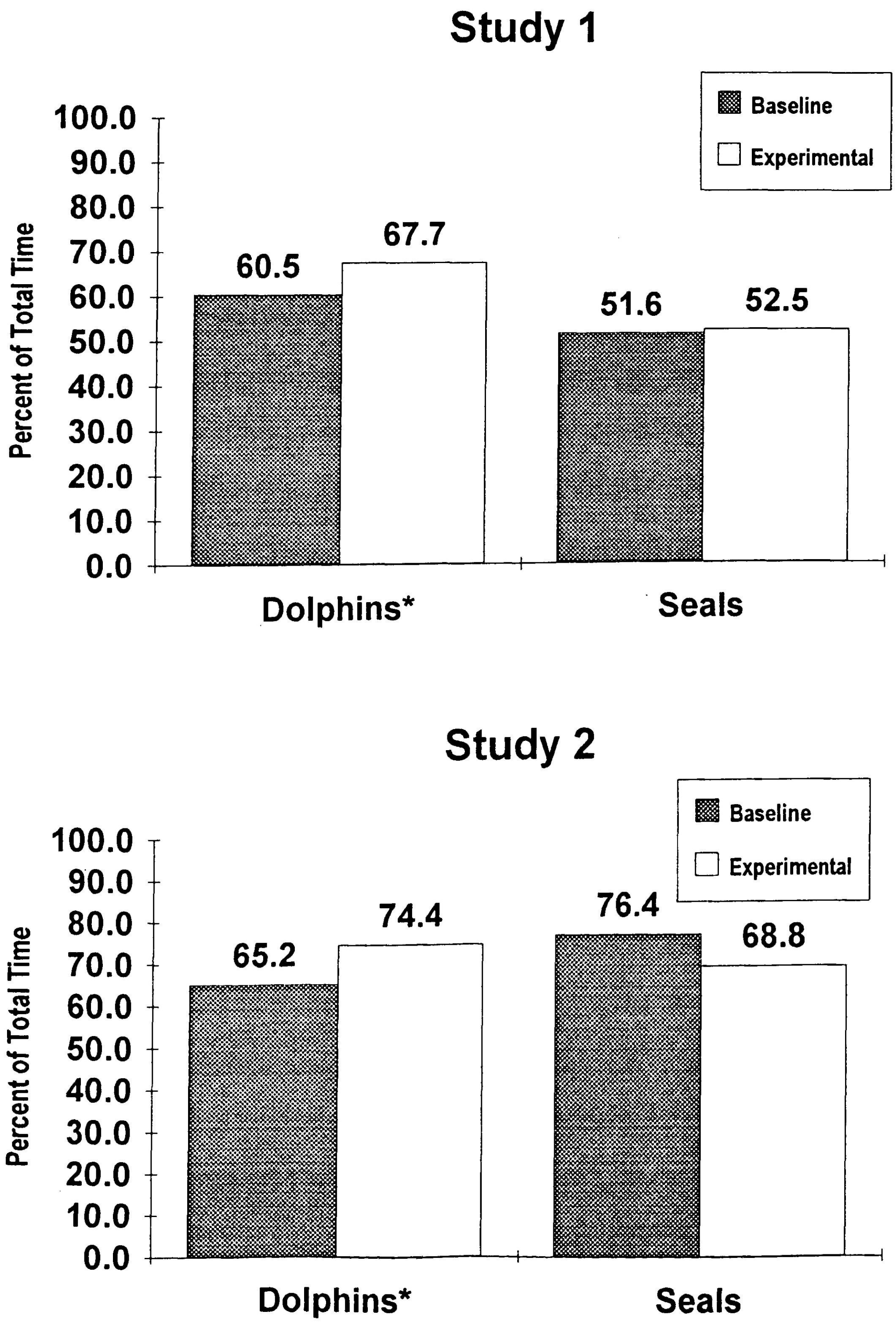

Figure 8. Percent of Time Spent in Active Behavior

*P <0.01

seals in this study spent an average of 6.6% (Baseline Sessions - Study 1) of the time hauled out, the seals in the wild observed by Sullivan spent an average of 43.6% of the time hauled out. Since all of the current research sessions took place during the same daily time period (between 13:45 to 15:00), the comparatively low haul-out times could be due to the seals' diurnal activity schedule. However, in Thompson's 1989 study of haul out patterns of harbor seals in Scotland, the haul out time of female seals was found to peak in summer, with a diurnal peak between 13:00 and 17:00 hours. This suggests that the haul out pattern of these seals requires further study, to determine whether they haul out significantly less often than other seals, either in the wild or in captivity. The reduced haul out time seen in this particular captive situation might indicate a need for changes in the size, ease of access, or in the substrate of the haul out area for these seals, or it could represent the effects of human observers on the haul out behavior of seals. It should be noted that there were three observers in Study 2 baseline sessions, where the seals were never seen to haul out, as compared to the two observers used in Study 1 baseline sessions, in which the seals were observed to haul out,

Duration of haul out time for seals was significantly reduced during the experimental sessions in Study 1; however, this is not necessarily an effect of availability of the apparatus. Since field studies (e.g., Slater & Markowitz 1983; Heinonen 1985) have correlated reduced haul out times with presence of humans in the vicinity, the presence of poolside researchers during the experimental sessions and researchers at the top of the walls surrounding the pool during both baseline and experimental sessions must be considered a confounding variable. Further research, with one group of observers recording haul out time as observed from above and beside the tank and another group of observers watching from the public viewing windows, could help to clarify the effects of observers on this behavior in harbor seals.

Times of haul out and re-entry of wild harbor seals have also been tentatively linked to food availability patterns: the haul outs of harbor seals may occur when food is least available (Watts 1993; Scheffer & Slipp 1944). While food was available after and before the baseline sessions, it was not available <u>during</u> the baseline sessions as it was during the experimental sessions. So, the lowered haul out times seen during experimental sessions could in fact be a response of the seals to the availability of food during these sessions. However, this does not account for the fact that no haul outs were seen during any of the Study 2 sessions.

In addition, in contrast to the dolphins, the seals' reactions to receiving fish usually involved very little movement. Once an experimental session had started, the seals interested in receiving fish would often float near the equipment or hang on the wall. To eat a fish, the seals stayed at the surface, often working to get one end of the fish firmly between their teeth, then flipping their heads back to orient the fish vertically before opening their mouths and allowing it to slide down their throats. This type of behavior was not counted as active in the behavioral definitions used for this study.

Therefore, for the seals, the insignificance of the changes observed in time spent in active behavior may be a factor of anyone of the following: (1) the well-being of the seals was not increased by presence of the enrichment apparatus; (2) the presence of humans disturbed the seals, negating the effects of the enrichment apparatus; (3) seals exhibit less of what we termed "active" behavior during feeding periods, because the behaviors connected with swallowing a fish require increased time spent in inactive behavior (according to the definition in these studies).

Elevated frequencies of agonistic behavior within animal groups are usually assumed to be indicative of stress (Craig 1981). The frequency of agonistic behaviors in the dolphins was seen to decrease in both studies, though significantly only in Study 2. In Study 1, the insignificance of the observed decrease in agonistic behavior may be attributable to the low starting frequency of 0.10 agonistic behaviors per dolphin per session (see Figure 9). In Study 2, the baseline frequency of agonistic behaviors performed by Thetis, the dolphin that pressed the xylophone keys the most, was much lower than that seen in Amphi, the more subordinate dolphin. While the behaviors chosen in these studies to represent agonistic behavior (chase, bite, clasp, lunge) are easily identified by volunteer observers, other, more subtle agonistic behaviors were not included in the ethogram, since they were not easily visible from the observer's vantage point. Accuracy in observation of these behaviors would have been strongly influenced both by the observer's visual acuity and by their familiarity with these particular animals, leading to increased levels of inter-observer error. The behaviors used most often by Thetis to keep Amphi subordinate may have been these more subtle behaviors. For example, the dolphins' trainer reported that in his training sessions, he has observed immediate changes in Amphi's behavior in response to "eye flashes" by Thetis (Smith, pers. comm.).

Probably because the original incidence of agonistic behaviors exhibited by the seals was quite low, no significant change in frequency of agonistic behavior was seen in either of the two studies. The low incidence of agonistic behaviors in seals is consistent with the data reported by Sullivan (1982) in a field study

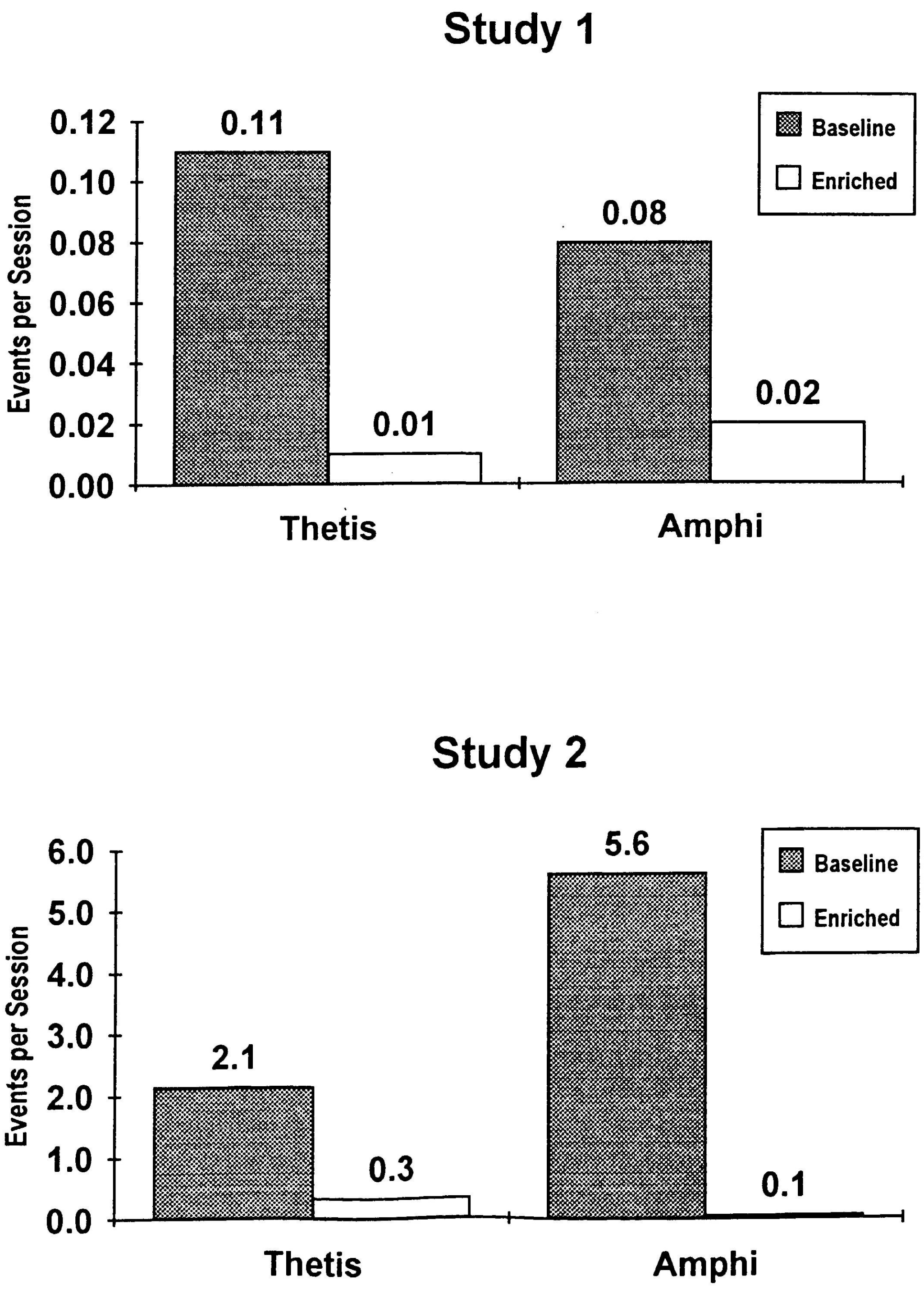

Figure 9. Mean Frequency of Agonistic Behavior

that included seals of all ages and sexes. In his time-based study, he found that seals on land exhibited agonistic behaviors only 2% of the time, with pups most likely to engage in agonistic behavior (about 3% of the time). In addition, he lists a number of agonistic behaviors specific to seals that were not a part of the original list of agonistic behaviors for this study. In addition, it should be pointed out that the original behavior list for this study was adapted from an ethogram for dolphin behavior (Östman 1985). As a result, the agonistic behaviors for seals are based on aggressive behaviors seen in the water (see Sullivan 1981 for examples). The agonistic behaviors exhibited by hauled out harbor seals, as reported by Sullivan (1982) for example, head-up stare, extended foreflipper, foreflipper wave, growling, and foreflipper scratch were not in the ethogram for this study. It is therefore a distinct possibility that the frequency of agonistic behaviors in these seals may have changed but our behavioral observations were not seal-specific enough to pick up those changes. Or, if most agonistic behavior in harbor seals occurs during haul out periods, the low levels of hauling out in these animals during both the baseline and experimental sessions may have artificially lowered the frequency of agonistic behaviors observed in both baseline and experimental sessions. In addition, in all in-water interactions of more than one minute in duration where Sullivan (1981) was able to identify the sex of the participants (54.7% of all interactions), only male-male (48%) or male-female pairs (6.7%) could be identified. Do female harbor seals ever engage in aquatic agonistic behavior with female conspecifics? If not, since all the animals in this study were female, this could contribute to the low levels of agonistic behavior observed in this study.

The third method of assessing well-being reported in this study is frequency of stereotypic behaviors. While the causal basis of stereotypies is still unclear, it is widely accepted that they are indicative of behavioral deprivation, and in high frequency can be considered an indication of decreased well-being (Erwin & Deni 1979). Wall-touching in dolphins was selected as a representative stereotypic behavior for these animals. No stereotypic behaviors were measured for the seals. As shown in Figure 10, the frequency of wall-touching behavior decreased for both dolphins, but most dramatically for Amphi. In Study 1, the mean frequency of wall-touching for Amphi decreased from 12.2 to 0.7 per session, while in Study 2, it decreased from 9.7 to 1.4 per session. In interactions between the dolphins, Thetis appeared to dominate Amphi, which is supported by Thetis' dominance of use of the apparatus (13.1 times per session, compared to Amphi's 2.6 times per session). However, this does not directly explain why, in light of the fact that Thetis used the apparatus most often, Amphi's frequency of wall-touching decreased. Was this apparent increase in Amphi's well-being due to the increased complexity of the tank environment because reinforcers were being constantly taken in and out, turned off and on? Was the availability of food throughout the session, even though it was most often ordered by other mammals, a component in the reduced frequency of aggression and stereotypy exhibited by Amphi in experimental sessions? Or could the frequency of stereotypic behavior be a direct response of Amphi to Thetis' frequency of aggressive behavior, which was perhaps redirected away from Amphi and toward the xylophone (or humans) during experimental sessions? Whether directly or indirectly, it is apparent that the well-being of this dolphin, although it used (i.e., pressed the keys) the xylophone at a very low frequency, was still enhanced as measured by both frequency of agonistic behavior and frequency of stereotypic behavior.

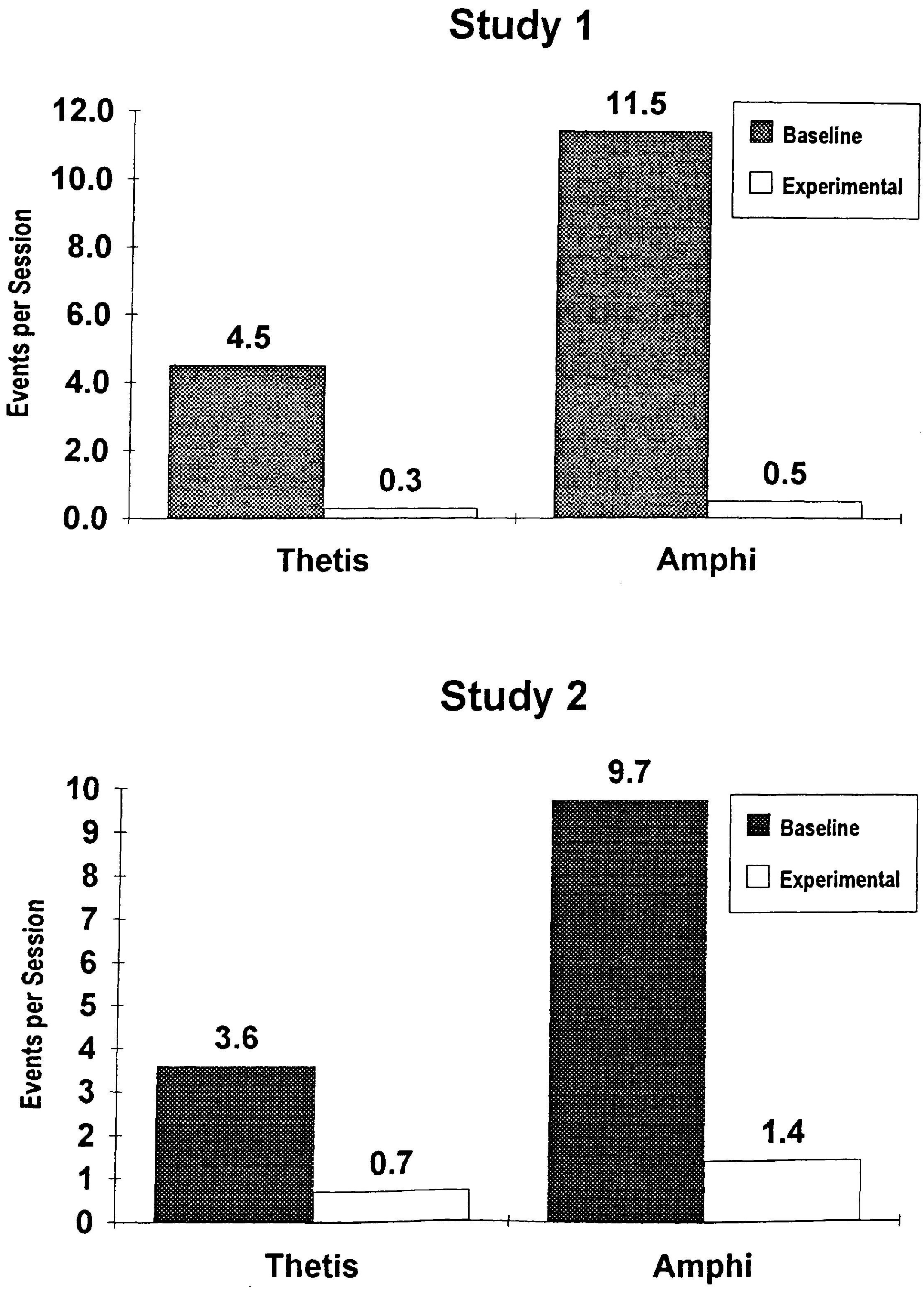

Figure 10. Frequency of Wall-Touching by Dolphins.

Analysis of behavior changes indicates that the condition of the dolphins improved when the apparatus was available in the tank; the lack of significant observable changes in the seals' behavior during experimental sessions may be taken to indicate that this particular device is not "enriching" for harbor seals. This conclusion is supported by the fact that the harbor seals did not respond strongly to most of the reinforcers, with the exception of fish and water jet. The ring, the ball, the sounds, and tactile stimulation did not appear to be positive reinforcers for these animals. Perhaps another pinniped species such as California sea lions (Zalophus californianus californianus) might be more "interested" in these reinforcers. Language research (Schusterman & Krieger 1984, 1986; Schusterman & Gisiner 1988) has reflected positively on the intelligence of these animals as comparable in some ways to that of bottlenose dolphins -- would a similar environmental enrichment project with sea lions as subjects find behavioral changes indicative of increased well-being?

Other suggestions for future research include not only attempting this same type of enrichment with other marine mammal species, but also the use of different reinforcers. For example, different sounds could be made available to the animals, such as sounds of other marine mammals, sounds of the open ocean, different types of music, or even human speech. The animals could be given a way to adjust the light levels in their habitat, to change the light levels in the public viewing area (within reason), perhaps even a way to turn on and off at two-way intercom between the public and mammal areas, so the animals could choose to listen to human sounds (or not). One of the most exciting concepts in term of furthering enrichment would be to allow the mammals to press a key that would deliver live fish or squid into the tank. In addition to increasing the activity level of the marine mammals, introduction of live prey could also increase the public's enjoyment in viewing these animals, although sentiment against prey being eaten may make this type of enrichment impossible in a public setting. Full automation of a xylophone-type enrichment device and associated reinforcers would open up the possibility of round-the-clock observations of apparatus use, which could make possible analysis of peak use periods. Perhaps these peak use periods would correspond with peak feeding or other activities in wild individuals of the same species. Lastly, physiological measures could be used as additional indicators to assess the effects on well-being in animals when this type of enrichment device is made available to them.

None of the animals in this study was particularly young. Amphi, the younger of the two dolphins, was 20 years old at the onset of the study, and Reno, the youngest of the three seals, was 16 years old. Enrichment studies in the past have sometimes found that older animals respond less strongly than younger animals to enrichment (Markowitz and Line 1989). A second factor, however, is the level of environmental complexity that an animal has been exposed to during its developmental period. Animals born and raised in a stark environment have been seen to react more favorably to a stark environment, in contrast to the reactions of animals born and raised in the wild (Price 1985). All of the animals in this study were wild-caught, with the seals captured at 6 months to 1 year of age, while the dolphins, Thetis and Amphi, were caught at 10 and 4 years of age respectively. Therefore, the amount of behavioral change indicating increased welfare that was seen in the dolphins during experimental sessions would likely have been less if they had been captive born and had been raised in a stark environment.

Summary

1. The dolphins and seals, as a group, were able to master the concept of the xylophone enrichment apparatus.

2. Use of the xylophone, as measured by mean key presses per session, did not decrease significantly over time.

3. The animals as a group pressed the Key 1(fish) more often than all other keys combined. A significant increase in key presses per session was seen when Key 1 was one of the active keys in the xylophone setup for that session.

4. Two animals, one dolphin and one seal, accounted for 80% of the key presses.

5. In both Study 1 and Study 2, the duration of active behaviors exhibited by the dolphins increased during experimental sessions. There was no significant change in duration of active behavior of the seals in either study.

6. The frequency of agonistic behaviors in dolphins was seen to be lower in experimental sessions in both studies, although this was only statistically significant in Study 2. The frequency of agonistic behaviors of seals was not seen to change significantly in either study; however, the frequency of agonistic behaviors in the seals was extremely low in all sessions.

7. The mean frequency of a stereotypic behavior, wall-touching, by dolphins was found to be significantly lower during experimental sessions than during baseline sessions in both Study 1 and Study 2.

CONCLUSIONS

Both Pacific white-sided dolphins and harbor seals can learn to use this type of enrichment apparatus. Within the study group, two of the five animals, one dolphin and one seal, accounted for 80% of all key presses. The welfare (condition) of the two Pacific white-sided dolphins, as measured by three behavioral comparisons, improved when the enrichment apparatus was available within the tank. The well-being of the three harbor seals, as measured in this study, did not appear significantly changed by availability of the apparatus. Further research, in the form of complete automation of a similar enrichment apparatus, is strongly suggested, as a means of assessing the importance of the human interaction component in enrichment of the captive environment for these marine mammals.

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Appendix A.
Study 1: Bar Code Sheet for Recording Focal Group Behavior

Animals

- Missy
- Gerry
- Reno
- Thetus
- Amphi
- Trainer
- Wave

Objects/Reinforcers

- Water Play
- Water Attn
- B Ring Rub
- B Ring Bite
- B Ring Attn
- Tactile Part
- Tactile Attn
- Fish
- Ball Play
- Ball Attn
- Rope Chew
- Rope Attn
- W Ring Bite
- W Ring Carry

Movements

- Breach
- Inv Breach
- Haul Out
- Porpoise

Directed

- Spy Hop
- Tail Stand
- Circle Fast
- Chase
- Bite
- Clasp
- Lunge
- Touch

DEL

Tones

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- Reinf Off
- Key Attn

Keys

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- Time Out

Vocalizations / Noises, etc.

- Cry
- Click
- Raspberry
- Bub. Strm
- Bub. Brst
- Fluke Slap
- Pec Slap
- Chuff

1

- Dorsal Down
- Swim Slow
- Swim Normal
- Swim Fast
- Surface Lay
- Stat Bottom

2

- Dorsal Down
- Swim Slow
- Swim Normal
- Swim Fast
- Surface Lay
- Stat Bottom

3

- Dorsal Down
- Swim Slow
- Swim Normal
- Swim Fast
- Surface Lay
- Stat Bottom

4

- Dorsal Down
- Swim Slow
- Swim Normal
- Swim Fast
- Surface Lay
- Stat Bottom

5

- Dorsal Down
- Swim Slow
- Swim Normal
- Swim Fast
- Surface Lay
- Stat Bottom

6

- Dorsal Down
- Swim Slow
- Swim Normal
- Swim Fast
- Surface Lay
- Stat Bottom

Spkr 2 Grate Wall Wndw Hydro. Spkr 1

Appendix B.
Study 2: Bar Code Sheet for Recording Focal Animal Behavior

Focal*

ANIMALS

Missy
Gerry
Reno
Thetus
Amphi
Trainer

TOUCH

Grate
Wall
Window
Hydro

DEL

SWIM

Swim Slow
Swim Normal
Swim Fast
Dorsal Down
Static

VERTICAL POSITION

Surface
Under-water
Bottom

TANK POSITION

1	2	3
4	5	6

Version 5A

MOVEMENTS

Breach
Leap
Haul Out
Spy Hop
Head Stand
Circle Fast

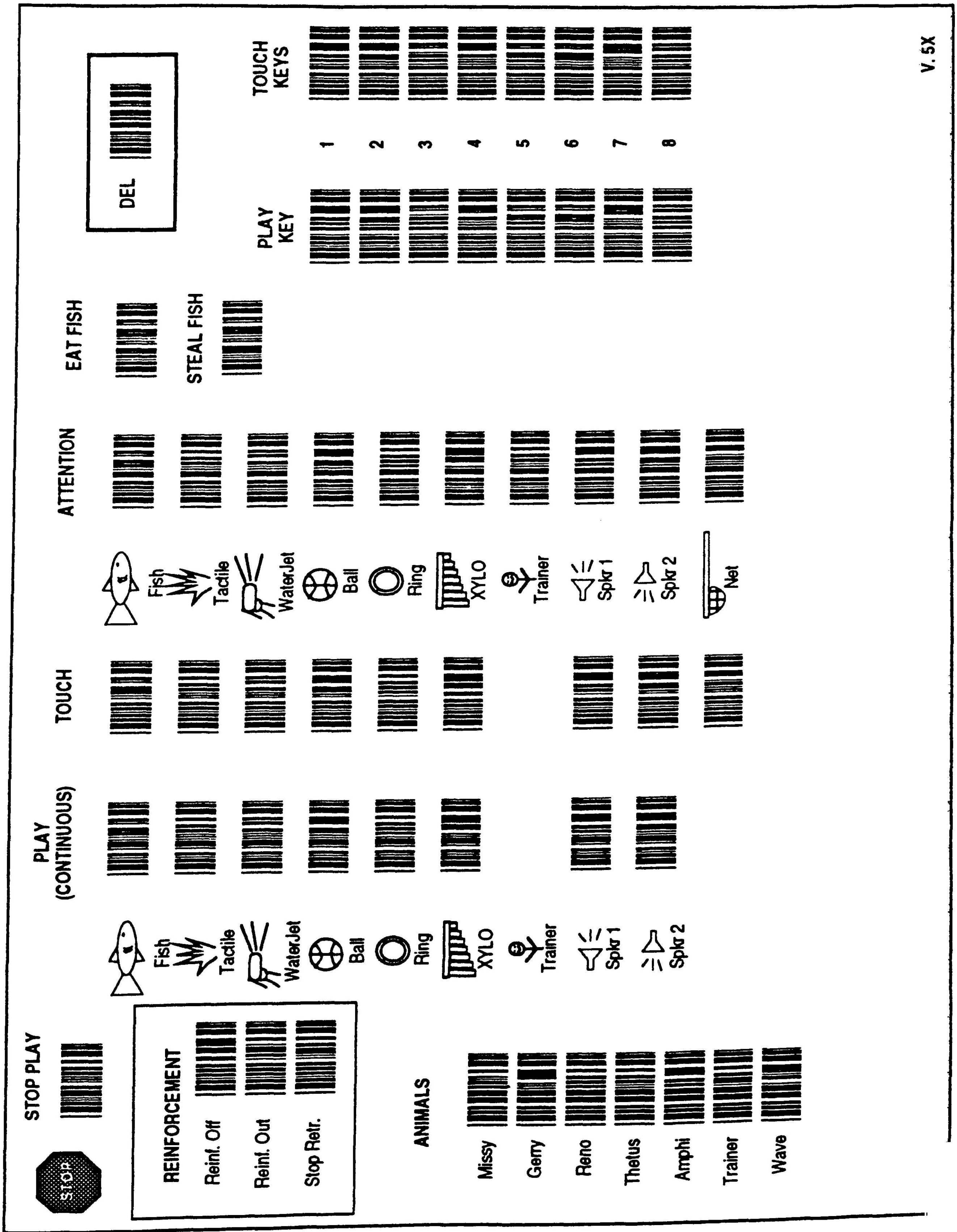
DIRECTED BEHAVIORS

Touch*
Chase*
Bite*
Lunge*
Jawclap*

SECONDARY BEHAVIORS/ SOUNDS

Tail Slap
Pec Slap
Bbl Brst
Whistle
Click
Raspberry
Chuff

Appendix C.
Study 2: Bar Code Sheet for Recording Xylophone-Related Behaviors



STOP

STOP PLAY

REINFORCEMENT
Reinf. Off
Reinf. Out
Stop Retr.

ANIMALS
Missy
Gerry
Reno
Thelus
Amphi
Trainer
Wave

PLAY (CONTINUOUS)

TOUCH

ATTENTION

EAT FISH

STEAL FISH

DEL

PLAY KEY

1
2
3
4
5
6
7
8

TOUCH KEYS

V. 5X