

PROJECT REPORT SUBMISSION FOR ANITA TAFF-RICE
KEWALO BASIN MARINE MAMMAL LABORATORY

Study of language comprehension and competency
in Atlantic bottlenosed dolphins

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KEWALO BASIN MARINE MAMMAL LABORATORY
Language Research with Atlantic Bottlenosed Dolphins

Kewalo Basin Marine Mammal Laboratory (KBMML) was established in 1977 to study language comprehension and competency in dolphins. Current research is done with two female Atlantic bottlenosed dolphins, Phoenix and Akeakamai. Phoenix has been trained in a language composed of computer-generated sound signals similar to the natural dolphin whistle. Akeakamai's language is composed of hand signals similar to American sign language. The research has two primary objectives: to demonstrate the ability of dolphins to process, store and understand linguistic information, and to establish productive communication with the dolphins.

It is already known that dolphins have highly developed social systems and large brains. The research at KBMML and other research facilities has shown dolphins to have a well-developed memory system, a good representational ability (symbolizing one thing by another), and the ability to learn rules for solving sets of related problems (Wolz and Herman, 1982). Dolphins, therefore, seem to have the necessary characteristics for language comprehension. It is the hope of many researchers to not only demonstrate language ability in dolphins, but to eventually establish productive communication with them. Data already collected at KBMML indicates that two-way communication with the dolphin is a realistic, though long-term possibility.

Conclusive proof of the dolphin's ability to understand and use language would have many far-reaching implications. Some scientists believe that only human beings, and possibly the higher

primates, possess the capacity for language (Hewes, 1975; Wolz, personal communication). One reason that has been given for the small number of mammals capable of language is the evolutionary development of these species. The use of language is thought to have occurred because of the need to communicate within complex social structures. The first signals were probably gestural, then were coupled with vocal meanings (Whitney, 1971). Dolphins developed along an entirely different evolutionary line than primates, however, and language ability in a marine mammal species would call into question many of the theories of language thus far developed.

Research from KBMML indicates that dolphins are very intelligent and possess highly developed cognitive abilities. It is thought that memory processing mechanisms in the dolphin are similar to those in humans (Wolz and Herman, 1982). Perhaps findings such as this will influence public opinion enough to bring about greater efforts to protect the dolphin. Despite the Marine Mammal Protection Act of 1976, which prohibits dolphin fisheries, dolphins are still being killed by man. Studies indicate that some dolphin species are already below maximum sustainable yield levels (Marine Fishery Service Report, 1978).
Currently, one of the major causes of dolphin mortality is the tuna industry. Tuna tend to congregate under dolphins in the ocean, so the tuna nets surround the dolphins as well as the tuna. The dolphins either suffocate or are injured so severely that they die. Dolphins reproduce at a rate of only 10% per year (Marine Fishery Service Report, 1978), so any great reduction in the standing population could have disastrous results. Evidence for the potential danger of killing great numbers of a slowly

reproducing species can be drawn from the case of whales. Most whales have a reproduction rate of approximately 25% per year (Marine Fishery Service Report, 1978). Even with a higher rate of reproduction than dolphins and a complete ban on the killing of most whales, the recovery of whales to pre-fishery levels is expected to take many years. Protective action for the dolphins must take place now, before their numbers are irreversibly diminished.

SECTION II
CURRENT RESEARCH

There are two daily training sessions at KBMML and every session has a specific goal. Many times the session consists of a general review of previously demonstrated tasks. The dolphin is given a command in her language. The command is a sentence of up to five words, consisting of nouns, verbs and modifiers. The nouns in their language are the floating and stationary objects in the tank. The dolphins know the verbs fetch, in/on and erase. Akeakamai has learned the modifiers left and right, and Phoenix has learned the modifiers bottom and surface.

Dolphin commands instruct them to take one object and do something with it in relation to another object. A typical sentence might be: Phoenix, surface pipe, fetch, hoop. This sentence tells Phoenix to take the surface pipe to the hoop. Akeakamai's word order is reversed. The sentence: surface pipe, fetch, hoop, tells her to take the hoop to the pipe. The reason for this reversal is to show that the syntax of the sentence is an arbitrary element and either word order is equally understandable to the dolphin. This part of the research is considered to be very important because syntax is a key element of language.

Since each dolphin has approximately fourteen nouns which can be paired with different verbs and modifiers, there is a great variety of sentences which may be produced. As a consequence, there are some sentences which have never been given to the dolphins. These sentences are called novel sentences

and are usually filmed on their initial trial. The dolphins respond to these sentences with an accuracy of approximately 90%. This is a significant level of accuracy because the dolphins are responding to a word order they have never heard before, yet they are able to understand the meaning of the sentence. The ability to understand words in novel arrangements is considered to be another key element of language usage (Wolz, personal communication).

There are currently two other types of training sessions besides general review at KBMML. These sessions have a more specific objective than general review. The first type is displacement. In this training session, all objects are taken out of the tank (the objects float in the tank during general review). A sentence is then given and the objects are thrown in on a timed delay signal of 0, 3, 6 or 12 seconds. The dolphin, therefore, must form some type of mental representation of the sentence since the objects are not immediately in sight. Displacement trials have just recently been initiated, so there are no conclusive data yet. However, the performance of both dolphins has improved with time. Researchers at KBMML hope to eventually design experiments which will enable them to determine how the dolphins remember the command during the delay period. It is not known whether the dolphins form a visual image of the command, or perhaps rehearse an auditory signal in order to remember the sentence.

Training has also recently begun on teaching the dolphins the concept of yes and no. Two portable paddles are hung over

the side of the tank. The "yes" paddle is a flat white paddle. The "no" paddle is a round black ball-shaped paddle. These colors were chosen because dolphins perceive black and white more distinctly than colors (Wolz, personal communication). The dolphins were first taught to press the paddles when the appropriate sign was given. Then, the concept of "no" was taught by giving a non-sensical sentence to the dolphin. A sentence such as basket, ball, fetch would be given when there was no ball in the tank. Another type of nonsensical statement was to give the dolphin an impossible task such as fetching the window in the tank. The dolphins learned very quickly that the correct response in either of these situations was to press the "no" paddle. The concept of "yes" was taught by taking all of the objects from the tank except one. The sign of the object was given followed by the sign for yes. (This sentence is more of a question format than a general command sentence). The object was either removed or replaced in the tank according to a command from the trainer. If the object was present, the correct response for the dolphin was to press the "yes" paddle. At first the paddles were put in the tank separately, but as the training progressed, both the "yes" and the "no" paddles were placed in the tank side by side. The dolphin then had to choose the correct paddle as well as making the correct conceptual response.

SECTION III
WORK EXPERIENCE

My work at KBMML involved all aspects of dolphin training. The actual training sessions with the dolphins comprise only a small portion of the overall training program. There are many other areas which require careful attention to ensure a smooth training session and healthy dolphins.

One of the most important areas is husbandry. This area covers everything concerning the dolphin's diet and health. Each morning the dolphins are given vitamin supplements. These are given to ensure the general good health of the dolphins. The dolphin's diet is composed of smelt. The smelt is delivered to KBMML frozen. Ten pounds of fish are thawed for each dolphin at each training session. There are two daily sessions (10 a.m. and 2 p.m.), so 20 pounds of fish per day are thawed for each dolphin. Many of the fish are damaged (torn skin, punctured intestines, cuts, etc.) and must be discarded. Dolphins are very susceptible to viral diseases, and the damaged fish could be contaminated, so they are rejected during the sorting process. The remaining fish are weighed and divided between the two dolphins. Until the training session begins, the fish are stored in buckets in a small refrigerator to comply with state health regulations. The sinks and counters in the fish room must be scrubbed with Ajax after each sorting session. The most important element of husbandry is keeping everything as clean as possible.

During the training session, there are several jobs which

must be done besides the actual training. Object monitors must watch the floating objects in the tank during the session. Each monitor has a boat hook for use in removing and repositioning the objects.

Another job which is extremely important to the project is data recording. A data recorder is positioned on an observation deck over the tank. The command that was given to the dolphin and her response are recorded. These data are logged into a computer so that a statistical profile of each dolphin's performance over a given period of time can be determined. The data recorder is also responsible for logging each sentence that was given during the session into a sentence generation log book. The date and time (a.m. or p.m.) the sentence was used is recorded. This procedure prevents any one sentence from being used too often. The keyboard operator, who is responsible for running the session refers to the log book when making up the next day's training schedule.

The most exciting and challenging area is working with the dolphins. Students are first taught to do "locals," an informal training session. Locals are done with one dolphin while the other dolphin goes through a formal training session. The dolphins are trained on opposite sides of the tank to minimize interference with one another. The local trials are done with gestural signals for both dolphins. Examples of local commands are fetches, jumps, over, under and hugs. Usually the only objects used in local trials are a ball or a frisbee. During locals, trainers are able to have a great deal of physical contact with the dolphin because the dolphin should be kept near station (the

formal training is in progress on the other side of the tank). Therefore, the local session provides a good opportunity for the trainers and dolphins to get to know one another. Locals are free from the pressures of formal trials, so it is a time when both trainer and dolphin can play and enjoy themselves.

While local sessions are very similar for both dolphins, formal training is different for each dolphin because of the difference in their languages. Students begin formal training with Phoenix because she uses the easier of the two languages. Since Phoenix's commands are given to her in a language of computer sounds, the trainer doesn't have to give any signals to the dolphin. When the command "ready" is given by the keyboard operator, who enters the commands on the computer keyboard, the trainer stands in a neutral position and the sentence is played by the computer. If the dolphin's response is correct, the trainer gives praise and a fish.

Formals for Akeakamai are more difficult because her commands are given with hand signals. The keyboard operator, who has a pre-determined schedule of sentences tells the trainer what sentence to give. The trainer must be able to remember and accurately communicate all of the signals contained in Akeakamai's language. Because Akeakamai's training is more difficult than Phoenix's, students do formal sessions with Phoenix and locals with Akeakamai for several months before moving to formals with Akeakamai.

Formal trials are conducted according to a very structured set of guidelines in order to obtain the most accurate data

possible. The trainers wear goggles to prevent cueing an object with their eyes (a problem in many chimpanzee studies). Everyone helping during a session must stay away from the sides of the tank so that the dolphins are not confused or distracted. Trainers cannot pet or talk to the dolphin after an error because these actions are seen as rewards by the dolphin and will reinforce the mistake. If the dolphin makes a correct response, she is given a fish, which must be fed head first. These are only a few of the many things a trainer must remember during formal trials. The goal for the trainer in formal sessions is to have enough experience to handle problem situations immediately and effectively.

Because of the strict nature of formal trials, this can be a stressful time for the dolphins, especially if they make incorrect responses. Sometimes the dolphins will display aggressive behaviors, such as tossing objects out of the tank, after an error. If this happens, a "time out" is given and the trainer turns his or her back to the tank. In extreme cases, the trainer may step down from the platform and take the fish bucket away. The time out lasts for varying periods of time, depending on the severity of the aggressive behavior. This time gives the dolphin a chance to calm down and be able to continue with the rest of the session. Time outs are the only form of punishment given to the dolphins.

SECTION IV

ADDITIONAL PARTICIPATION

In addition to the areas already mentioned, I was asked to put my journalism background to use in the project. Dr. Herman is preparing a brochure about KBML that will be sent out with a letter asking for contributions from the private sector. Contributions for the project are now greatly needed because of the recent federal funding cutbacks. I helped edit the letter and gave suggestions about the brochure.

Videotapes that explain current research at KBML are used in presentations at various conferences and meetings. These videotapes, therefore, must be kept up to date. I reviewed several of these tapes and combined the information in them. I then wrote a shooting script with camera shots and editing techniques to be used while filming a new videotape. This new videotape will be presented at several conferences which Dr. Herman will attend this summer.

EVALUATION

I joined the Marine Option Program to strengthen my background in environmental sciences because I want to develop a science writing career. I feel that the more specialized my background, the better able I will be to ask challenging questions and interpret the answers. Although a strong academic background is essential to a writer, it is not enough. Journalists must have some first-hand experience to add depth to their reporting. Much more can be learned in a laboratory situation than in three semesters of classes. My objective for the M.O.P. project was to learn from experience, the things I couldn't learn from a book. Although participation in only one project is not adequate to teach one everything there is to learn, it does provide experience in basic areas which can be applied to other projects.

This project was very exciting because it dealt with living, emotional creatures. Sometimes the experiment is more difficult to design for dolphins because there is always an element of unpredictability. Some days the dolphins just don't perform as well as others. They may be tired or not feeling well, or may be easily distracted. All of these factors must be taken into account when designing an experiment. Experiments involving live animals are more challenging than other types of experiments, in my opinion, because rocks or chemicals hardly ever have a bad day.

The relationship I developed with the dolphins went through several stages. When I first started getting acquainted with the dolphins, I wanted to be accepted by them. As I began to train,

I had to let the dolphins know that during the session, I was in command. The dolphins test every new trainer. Sometimes they will wander away from station (directly in front of the training platform) or will ignore a command. If the dolphin refuses to do a command, the trainer must let her know that she won't get away with it. The trainer keeps giving the command until the dolphin responds. I think the most important thing I learned in training was to understand and respect the dolphins. Some days they might not feel like doing a certain command during locals. For example, some days Akeakamai didn't want to play ball. The dolphins will let you know that they are unhappy with a certain command by being very lethargic while performing the command or by squawking. On these occasions, during locals, the dolphin's wish should be respected. The dolphins generally do the commands during formal training without any problems. The trainers must be firm during sessions, but the objective is not to prove who is "boss," but rather to develop a mutual sense of trust and respect.

Besides learning about the dolphins themselves, I think the most valuable thing I learned was experimental design. Since I had not had a lot of laboratory experience, this was an important skill to develop. In science it is not enough to ask good questions, one must be able to set up experiments that will provide the answers. I gained a lot of knowledge about experiments by being able to see the information that they wanted to get, and then seeing how they developed an experiment.

The main areas in which I developed skills during this

project were experimental design, data compilation, and animal training. However, I gained experience in many areas of scientific research. For example, whenever a new command was taught, a new hand signal had to be designed. It was very interesting to see how the sign was developed and how well the dolphins responded. I also think I have gained a lot of knowledge about how to organize a research project so that everyone contributes to its overall objectives. Sometimes it is hard to see these goals on a day-to-day basis, but when the data are compiled and reviewed, everyone has a better understanding of where the research is going.

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