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COMMUNICATION RESEARCH INSTITUTE  
3908 Main Highway  
Miami 33, Florida

N 64 22791

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(9 January 1963)

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TITLE: A study of the feasibility and methodology  
for establishing communication between man  
and other species

PRINCIPAL INVESTIGATOR: John C. Lilly, M. D.

PAST HISTORY

This grant was made to the Communication Research Institute on the 25th of August, 1962. The first check was received on the 25th of September, 1962. This interim report covers the period from 1 July, 1962 when the work was actually initiated to 1 January 1963.

The past history and the reasons for the development of this program are given in John C. Lilly's book MAN AND DOLPHIN, Doubleday 1961, and Victor Gollancz, London 1962. A copy of the paperback edition published in the World's of Science Series by Pyramid Books, October 1962 is included as part of this report. In the preface of MAN AND DOLPHIN the following prediction is made... "Within the next decade or two the human species will establish communication with another species; non human, alien, possibly extraterrestrial, more probably marine; but definitely highly intelligent, perhaps even intellectual. ...If no one among us pursues the matter before interspecies communication is forced upon Homo sapiens by an alien species, this book will have failed in its purpose. But if this account sparks public and private interest in time for us to make some preparation before we encounter such beings, I shall feel my time was well spent in the research here described...

"If and when interspecies contact is made, it may be used as a force for peace or as further aid to warfare. It may be that we shall encounter ideas, philosophies, ways, and means not previously conceived by the minds of men. If this is the case, the present program of research will quickly pass from the domain of scientists to that of powerful men and institutions and hence somewhat beyond the control of the first venturers. When that time comes, I hope that the ideas here presented will help those men of good will to lead wisely and that they will be a bit better informed than they were in 1945 concerning another scientific advance, that time in applied nuclear physics."

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MAN AND DOLPHIN gives the history of the development of the ideas and of the experiments which led to this prediction.

The whole problem of understanding of the marine mammal, the bottlenose dolphin, Tursiops truncatus, is explored. Presented also is the neuro-anatomical data on this animal which lead to the conclusions that:

1. It may be highly intelligent
2. It may have its own complex language used under water and
3. Its gentle relationship with man may be caused by its large and complex brain.

In order to test the information carrying capacity of the language of these animals, several basic research objectives must first be realized. They are as follows:

1. The language itself must be specified in physical and formal terms.
2. Situations must be devised in which one animal must transmit information to another one, in order for the second animal to solve a well defined set of problems.
3. The information to be transmitted must be appropriate to the language structure and understanding of the transmitting and of the receiving animals.
4. Background research requires finding the kinds of tasks and the kinds of information which these animals find necessary and sufficient in their daily lives.
5. Since the communication to be attempted is interspecies, the humans involved must also come more than half way towards understanding the situation of these animals and must learn to ask appropriate questions of the experimental designs and of the animals themselves.
6. Contributions to the understanding of the important variables in the lives of these animals supposes a knowledge of the important variables in the lives of humans as well. Mutual education between man and dolphin seems to be a necessary part of the interspecies communication attempt.

RESEARCH ACCOMPLISHED SINCE PUBLICATION OF MAN AND DOLPHIN

Reprints are enclosed to show progress made since the publication of MAN AND DOLPHIN.

A description of some of the sounds emitted by the bottlenose dolphin is in the Science article by Lilly and Miller published in May 1961 (Sounds Emitted by the Bottlenose Dolphin. Science, 133: 1689-1693.) They show unequivocally that the animals can produce whistles and clicks simultaneously and quite independently. They also show that in the presence of human beings the normal clicking and whistling change their quality and become more like that of those sounds emitted by humans.

In another paper by Lilly and Miller published in Science in December 1961 (Vocal Exchanges between Dolphins. Science, 134: 1873-1876, 1961.) some of the discoveries about the formal nature of the vocal exchanges between individual pairs of dolphins are presented. For the first time it is shown that bottlenose dolphins have vocal transactions in which each animal is quiet while the other one is transmitting. It is also shown that they carry on vocal transactions separately in the two spheres of clicking and of whistling. It is also shown that the frequency time contours emitted by these animals vary from one transmission to the next, somewhat in the way that words spoken by humans change their contours. A parallel with a whistling language from the Island of Lagamurra in the Canary Islands can be drawn here. This human language has whistle contours very similar to those of the dolphin and with it the natives transmit all of the information inherent in the Spanish language. A normal human with an advanced knowledge of Spanish can learn this language in a period of two months.

In a third paper by Lilly and Miller published in February 1962 (Operant Conditioning of the bottlenose Dolphin with Electrical Stimulation of the Brain. J. Comp. & Physiol. Psychol. 55: (1) 73-79. 1962.) the problem of operant conditioning of the bottlenose dolphin by means of electrical stimulation within the substance of the brain is presented. It was during these experiments that the fabulous ability of the bottlenose dolphin to copy human speech sounds was discovered. Electrodes were placed in various sites in the brains of these animals under local anesthesia by a newly developed technique. Both rewarding and punishing sites were found and the extremely rapid rate of learning in these animals was discovered. In an amazingly short time they learned to push the switch either to start a stimulus or shut off a stimulus, depending on which they wanted.

A paper by Lilly entitled "Critical Brain Size in Language" is in press (Based on a talk given to the Cincinnati Society of Neurology and Psychiatry, 15 March 1961. Perspectives in Biol. & Med. Winter 6: (2), 1963). This paper elaborates on a chapter from MAN AND DOLPHIN in which the point of view is taken that possibly language as humans know it depends upon achieving a certain critical level of brain size at which point such a language not only becomes possible, but highly facilitated in the learning process. Evidence is presented from the development of the human child and from the failure of development in the human idiot. Indicative evidence

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is then presented for the possibility that the whales have passed this critical brain size for a language and have such a language.

A paper by Lilly entitled the "Distress Call of the Bottlenose Dolphin", Science, 139 (3550) 116. This will be published in the beginning of 1963. This paper further elaborates the findings reported in MAN AND DOLPHIN, a discovery of the actual form of the distress whistle emitted by these animals under a large variety of conditions. The distress call is specified physically in this article, and the associated behavior resulting from its emission by an animal, causing other animals to come to its aid, is discussed. The subsequent vocal transactions between animals after the rescue seems to show that they do have a complex language because after the vocal exchanges take place, the rescue procedure changes to one of appropriate aid, not just lifting of the animal to the surface of the water. This is further evidence for the existence of a complex language in these animals.

The whole problem of interspecies communication is presented in an article entitled, "Interspecies Communication" McGraw-Hill Yearbook of Science and Technology, 1962, p. 279. A reprint of this article is also enclosed.

In "Some Aspects of the Adaptation of the Mammals to the Ocean". (Section 5: Adaptation to the Environment). Handbook of Physiology, Am. Physiol. Soc., Washington, D. C. (in press), there is a discussion of various physiological adaptations of the dolphins to life in the sea and a discussion of their adaptation to confinement by human beings. One adaptation which the dolphins make appears to be to copy the noises emitted by the surrounding humans in order to obtain further rewards from those humans.

A review paper by Lilly entitled "The Vocal Behavior of the Bottlenose Dolphin" was published in the Proceedings of the American Philosophical Society, 106, 520-529, 1962. Reprints of this paper will be sent when available. This paper reviews the evidence presented in the previous papers noted above and presents new evidence of the vocal capacities of this animal. For the first time, evidence is presented here that the dolphins have independent control of their two phonation mechanisms just below the blowhole, and that an animal, for example, may whistle with the right blowhole mechanism and at the same time click with the left; and independently control the production of emission or clicks or whistles in air or under water quite independently with the two sides. Evidence is also presented that they have a third mode of transmission in the ultrasonic region which they use for sonar purposes and also use as a high security communication length when needed. In other words, it is shown here that the dolphins can emit in the ultrasonic regions without concomitant emissions in the sonic regions.

Some of the philosophical problems involved in the revision of assumptions about these animals is presented in a paper entitled, "Productive and created Scientific Research with Man and Dolphin". (Fifth Annual Lasker Lecture, Michael Reese Hospital and Medical Center, Chicago, Ill., 1962) Arch. Gen. Psychiatry (in press).

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Reviewed therein is the problem of basic assumptions in regard to another species, other than man, and the eerie feelings of the investigators when the discovery was made that these animals could copy the human voice. Presented also is the point of view that anything as radically new as this is rejected immediately by the minds of the investigators, and that they must reconsider the evidence against them and get used to the new idea before a sense of weirdness and eeriness departs and they are able to continue with the research. Self doubts and similar problems arise when such discoveries are made. It is hoped that in the future time will be saved in productive and creative scientific research by realizing that such feelings occur naturally during the research and that one can push ahead in spite of them.

Further consideration of these problems is given in another paper entitled "Whales, Dolphins and Porpoises as Challenges to our Intelligence" (Symposium on The Dolphin in History, William Andrews Clark Memorial Library and Division of Medical History, University of California, 1962) (in press). This paper shows that Aristotle knew more about dolphins than modern scientific workers do, and that some of his apparently outlandish statements about dolphins and their relationship with the humans are perfectly correct. The paper traces the history of these ideas and of the rejection of them by scholars over the centuries; then presents the evidence for a change of our philosophy and point of view based upon our experiments with these animals.

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CURRENT RESEARCH PROGRESS SUBSEQUENT TO THE ABOVE PUBLICATION

The current research is proceeding along the two major lines outlined in proposal, i.e. an analysis of the dolphins' own emissions to one another and their development of the English language.

The analysis of the dolphin-man relationship which is so necessary to an understanding of these animals is going on at a rapidly increasing rate. During the summer, fall and winter of 1962 we have pursued the problems of reciprocal relations and closeness of contact between humans and dolphins. We have found that if one pursues close contacts in small tanks with the animals, they are much more amenable to conditioning experiments and testing situations than if they are treated as remote animals in confinement. By having humans into the tanks with the dolphins and swimming with them it can be shown that even a wild dolphin will accept physical contact with the humans and will tow and push them within a few hours of capture. The major problems of communication here seem to be to convince the animal that the human has a smooth skin and is not attempting to hurt the dolphin. A thorough knowledge of the physiology and anatomy of the animal is needed by those who are going to be and who are in contact with the dolphins in the water to avoid punishing experiences for the dolphins. If all the contacts can be made rewarding, i.e. gentle smooth stroking of their skin, and gentle handling of their delicate body parts, a mutual respect and confidence is set up between that particular human and that particular dolphin.

It was demonstrated unequivocally that a wild dolphin within a few hours will accept boys riding on their back as was expounded by Aristotle 350 B.C. We agree with Aristotle that a passionate attachment develops between the boy and the dolphin. This has now been observed with eight boys and five dolphins.

A study of their sleep patterns is increasing our understanding of when and how they are available for communication. The sleep study shows that they sleep with one eye at a time and wake up for every breath. Total accumulated eye closure time for a day is of the order of 130 to 140 minutes for each eye separately. This, of course, is related to the studies of Graveline and others on suspension of man in water which show that man needs only two to three hours sleep when he is suspended in water. The implications of this for the Space Program and the weightless conditions are obvious. A man in space who is not under stress presumably will drop his sleep requirement to about two hours a day, or even less, and he will take it in the form of short cat naps distributed throughout the 24 hours rather than in one long stretch. Such radical change in the sleep behavior

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of the human should not be a source of worry. This seems to be a direct consequence of freeing up of the brain from the necessity of the constant computations of the direction of gravity and the compensations of the antigravity forces.

A study has been done upon the width of the sonic spectrum available to these animals to be demonstrated in these studies so they can hear quite adequately up to 200 kc, using an avoidance method of training. They turn out to be very ingenious in eliminating an undesired ultrasonic stimulus in the water -- ultrasonic to us that is. We discovered that they had at least five different methods for eliminating unpleasant sonic stimuli. These include throwing the transducer out of the tank, lifting their own ears up out of the water, creating a bubble screen between them and the transducer to absorb the sounds, putting their head in a minimum in the standing field within the tank, and shutting off the stimulus by the method chosen by the observer; i.e., with a lever.

Studies on operant conditioning of the usual fashion done with human beings and chimpanzees have been initiated in collaboration with Dr. Peter Schiller and Dr. Hans Lukas Teuber of the Psychology Department of Massachusetts Institute of Technology. It is intended to derive a set of tests which can be used comparatively between the humans, the chimpanzees and the dolphins, to give us some idea of the relative intelligence of the dolphins in their appropriate spheres of action.

Anatomical examination with electromyographic studies is being initiated in order to understand the phonation mechanism in these animals. A special tank has been devised for restraining the animals swimming in a circular path so that the phonation can be picked up at a constant distance from a hydrophone traveling with the animal, and it is planned to simultaneously record electromyographically the phonation muscles and their movements. Special instrumentation for these studies is being devised by a scientist group for use with our dolphins. Using solid state microcircuitry it is expected that we will be able to transmit by FM radio sonic information some distances from the animal and recognize individual animals and their vocal emissions on separate FM bands, kilometered out of this special circular and other kinds of tanks.

It is proposed to act as consultants to a corporation which will develop the translator expander compressor mentioned in the proposal. Preliminary work on this by means of heterodyning methods of moving the animals' high frequencies down to our lower frequencies and moving our lower frequencies to the dolphins' higher frequencies have been accomplished. It is shown that a simple frequency translation by the difference method gives

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interesting results but cannot offer much for the humanoid or clicking languages. A preliminary model of a frequency compressor has been completed and tested and found to be very useful for the dolphins whistles but was not fast enough to follow their clicking language nor the humanoid emissions. It is proposed to develop a Vocoder-like device of 19 channels for frequency compression and expansion.

Work has begun upon the tape-time frequency converter in collaboration with the Space Science Laboratory at UCIA. Tape drive units are being obtained so that the dolphin will have one tape unit for reducing the velocity of his tape for playback after recording at high speed and for speeding up the human tape loop for playback after recording at low speed.

Three animals have been moved to St. Thomas to carry on communication studies in the large pool in that laboratory. The initial recordings look very promising and there seems to be an enhanced variety of their communication content in the larger pool at St. Thomas as compared to the smaller pools at Miami. There is also an enhanced complexity of relationship between them and the swimming humans. The motion pictures taken of the swimming there show that the new laboratory and the new position for taking movies directly above the pool will make behavioral analyses very much simpler than the angle shots previously taken at Miami.

RESEARCH PLANS FOR THE COMING SIX MONTHS

It is planned to continue the development of the various devices above mentioned and to move more of the communication work to the St. Thomas laboratory during the following weeks. It is intended to do the acute work in which morbidity and mortality among the animals is expected in Miami, and do the chronic work in which animals are expected to last for several years in the St. Thomas laboratory.

Close relationships with our NIH program are to be expected within the next year. A neuroanatomist is expected to join the staff in April, thus enhancing the scientific staff at a senior level.

It is planned to turn the problem of the high frequency Vocoder over to a commercial corporation and to aid them in making a proposal for a contract with NASA for the development of this piece of apparatus. We will furnish this commercial corporation with the necessary numerical values for the various variables involved and aid them in testing the apparatus during its development on the dolphins themselves.

The program of intellectual testing of the animals in cooperation with MIT will continue as Dr. Schiller and Dr. Teuber find time to come to the Miami laboratory and to St. Thomas. It is expected that Dr. Schiller will come



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down during the Easter recess and this coming summer.

The appropriate use of human English words by the animals continues to be tested. Listener tests are being carried out on some of the past emissions of these animals validating the accuracy of pronunciation by the dolphins of English words. Tests on their ability to count and add and subtract are also being completed at this time.

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JOHN C. LILLY, M. D.