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14. ABSTRACT

Recordings were obtained of the echolocation clicks produced by dolphin calves and their mothers during each calf's first year of life. The results demonstrate that dolphin calves begin to produce echolocation clicks within the first few months of life. Initially, the mothers' click trains may serve to prompt the calf to begin and to end click production. The results of this study demonstrated that young dolphin calves produce echolocation clicks, and suggest that the mother may influence the development of the echolocation system by modeling its use for her calf. Analyses currently being conducted will specify the nature of the relationship between the mothers' click trains and those produced by their calves. These analyses will also detail the developmental path that each calf follows as it learns to use its echolocation system. This information will provide a framework within which to investigate the developmental relationships of click production and echo comprehension, a necessary next step to determine the implications of the developmental data for designing models of echolocation systems, particularly models that can learn from their own mistakes.

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FINAL REPORT

Grant #: N00014-00-1-0427

PRINCIPAL INVESTIGATOR: Stan A. Kuczaj II

INSTITUTION: University of Southern Mississippi

GRANT TITLE: The Ontogeny of the Dolphin Echolocation System

AWARD PERIOD: April 1, 2000 - March 31, 2003 (extension granted until December 31, 2003)

OBJECTIVE: The long-term goals of this project were to investigate the ontogeny of spontaneously produced echolocation clicks in bottlenose dolphin (Tursiops truncatus) calves (including the role of the mother in shaping such behavior), describe individual differences in ontogeny and relate these to the mature echolocation system, develop a framework within which to investigate the developmental relationships of click production and echo comprehension, and determine the implications of the developmental data for designing and testing models of echolocation systems.

In order to achieve these goals, it was necessary to collect echolocation clicks from dolphin calves and their mothers throughout the first year of life. These data provide the bases for determining the age at which dolphin claves first start to produce clicks, the contexts in which such clicks are first produced, and developmental changes in individual clicks and click train production. The results of these analyses will be used to achieve the other long-term goals described above.

APPROACH: Ten dolphin calves born at the U.S. Navy marine mammal facility located at SPAWARS San Diego were the focus of this study. Audio recordings of each of these calves and their respective mothers were obtained during the first 12 months of each calf's life. Calf and adult echolocation clicks were recorded using a single Bruel & Kjaer (B&K) 8103 omni-directional hydrophone, B&K 2635 charge amplifier, and Stanford Research Systems Low Noise Preamplifier SR 560. Clicks were acquired, directly digitized, and saved to disk using an acquisition software program written in Labview. The acquisition program

consisted of two channels of data: (1) incoming data from the hydrophone and (2) a voice log in which the experimenter described the contexts in which recordings were being made.

Given that calves do not typically come under trainer control until 6-9 months of age, our data acquisition method relied on opportunistic audio recordings during mother-calf free swims. The hydrophone was placed in the water at a depth of 2 meters, and the experimenter observed the mother-calf pair. When the mother-calf pair or the calf alone swam towards the hydrophone, the experimenter used a hand-held trigger device to initiate recordings. Once the animal(s) had swum past the hydrophone, the experimenter used the same device to stop the recordings. The duration of a typical recording ranged from 10 to 30 seconds. From these recordings, click trains were extracted for subsequent analyses based on the following criteria: (1) the clicks were not clipped (above the maximum range of the recording system, (2) the clicks were of sufficient amplitude for subsequent analyses, and (3) the identity of the animal(s) that produced the train(s) could be reliably determined. In addition, extracted click trains were excluded from further analyses if the clicks that comprised the train were off-axis (see below).

ACCOMPLISHMENTS: Recordings were obtained of the echolocation clicks produced by 10 dolphin calves and their mothers during each calf's first year of life. As a result of the recording environment (free-swimming animals that could elect to produce or not produce clicks), it proved challenging to obtain click trains in which the majority of the clicks comprising the train were on-axis and so not distorted by an animal's position relative to the hydrophone. This challenge was met by collecting large numbers of recordings and then selecting the click trains that appeared to be on-axis, based on both the experimenter's voice log and acoustic analyses. As a result, we were able to obtain click trains that met our criteria for each of our target animals across the developmental period of concern.

CONCLUSIONS: Although many of the analyses on the developmental data are still being conducted, the following conclusions appear warranted by the analyses completed to date: (1) Dolphin calves begin to produce echolocation clicks within the first few months of life. However, there

are individual differences in terms of exactly when calves first begin to produce clicks. In addition, we know nothing about calves' ability to perceive and use the returning echoes from the clicks they produce. (2) The first click trains produced by calves are produced in conjunction with click trains produced by the mother. Initially, the mothers' trains may serve to prompt the calf to begin and to end click production. (3) Within 2-3 months of the overlapping click trains produced by mother-calf pairs, calves begin to spontaneously produce click trains by themselves.

SIGNIFICANCE: The results of this study have demonstrated that young dolphin calves produce echolocation clicks, and suggest that the mother may influence the development of the echolocation system by modeling its use for her calf. Analyses currently being conducted will specify the nature of the relationship between the mothers' click trains and those produced by their calves. These analyses will also detail the developmental path that each calf follows as it learns to use its echolocation system. This information will provide a framework within which to investigate the developmental relationships of click production and echo comprehension, a necessary next step to determine the implications of the developmental data for designing and testing models of echolocation systems, particularly models that can learn from their own mistakes.

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