# NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

## SUBMARINE BASE, GROTON, CONN.

REPORT NUMBER 751

EVIDENCE FOR A POSSIBLE MEMORY IMPAIRMENT
RESULTING FROM NITROGEN NARCOSIS
IN THE RHESUS MONKEY

by

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Bureau of Medicine and Surgery, Navy Department
Research Work Unit MF51.524.004-9015DA5G.13

Released by:

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## SUMMARY PAGE

### THE PROBLEM

To explore the possibility that nitrogen narcosis causes impairments in certain memory mechanisms in the Rhesus monkey.

### FINDINGS

Preliminary evidence suggests that impairments in memory do occur in Rhesus monkeys while breathing compressed air at 200 feet.

### APPLICATION

Because of the exploratory nature of these data, recommendations for direct Naval application must be considered premature. However, these data do provide evidence for one possible cause of performance impairments which occur under pressure, and at the same time offer a promising direction for future behavioral hyperbaric research.

### ADMINISTRATIVE INFORMATION

This research was conducted as part of Bureau of Medicine and Surgery Research Unit MF51.524.004-9015DA5G. The present report is Number 13 on this work unit. It was submitted for review on 3 August 1973, approved for publication on 30 August 1973 and designated as NavSubMedRschLab Report No. 751.

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## ABSTRACT

Three Rhesus monkeys were maintained at 200 FSW equivalent and tested on the reversal of a previously trained visual discrimination problem. All three monkeys displayed a higher percent of errors on this reversal problem than on another reversal problem tested on the surface. These data, supplemented by changes in the monkeys' post-response stimulus observation time, are interpreted as possible evidence for memory impairments resulting from nitrogen narcosis.

## EVIDENCE FOR A POSSIBLE MEMORY IMPAIRMENT RESULTING FROM NITROGEN NARCOSIS IN THE RHESUS MONKEY

### INTRODUCTION

Despite an apparent increase in interest in the behavioral effects of nitrogen narcosis (e.g., Jennings, 1968; Fowler, 1972), a very basic need still exists to isolate the particular types of behavioral processes or mechanisms which are most severely disrupted. This need exists because such information would not only offer a more complete understanding of nitrogen narcosis, but would also greatly enhance our ability to predict and control the undesirable effects of this underwater phenomenon. Since memory is a very important behavioral process underlying many different diving tasks, the following study attempted to provide preliminary information concerning the possible influence of nitrogen narcosis on memory capacities.

### METHOD

The general methodology closely followed that described by Bartus (1973). Briefly, three Rhesus monkeys were trained to perform various two choice visual discrimination problems in the Automated Primate Discrimination Apparatus (APDA) shown in Fig. 1 (described in detail by LeVere and Bartus (1969)). After a short series of preliminary dives, the monkeys were compressed to the sea water equivalent of 200 feet and tested on their ability to perform a series of visual discrimination problems, which included an easy brightness discrimination (white light vs. no light) and an easy color discrimination (green light vs. red light). As discussed in an earlier report (Bartus, 1973), the impairments observed on these two particular problems were not extensive, showing a mean drop in performance from 98% on the surface to 90% at depth. These problems were therefore selected for use in the present study of memory abilities.

Immediately preceding decompression from a 15 minute dive, and following a brief re-warm-up period, each monkey was tested on the reversal of either the brightness or color problem. That is, what had previously been designated as the correct stimulus now became the incorrect stimulus, and vice versa. The task for the monkey, therefore, was to quickly revise what he had previously learned about the stimuli and store into memory for immediate use the new reinforcement contingencies now associated with each stimulus. During decompression, a lengthy stop was made at 30 feet (where no measurable narcotic effects have been reported) and tests on the reversal of the second discrimination problem were made, also preceded by a short re-warm-up period. Each monkey was run on each of the two reversal problems for a maximum of twenty correctional trials, or until 10 minutes of testing elapsed. In addition to computing the "percentage

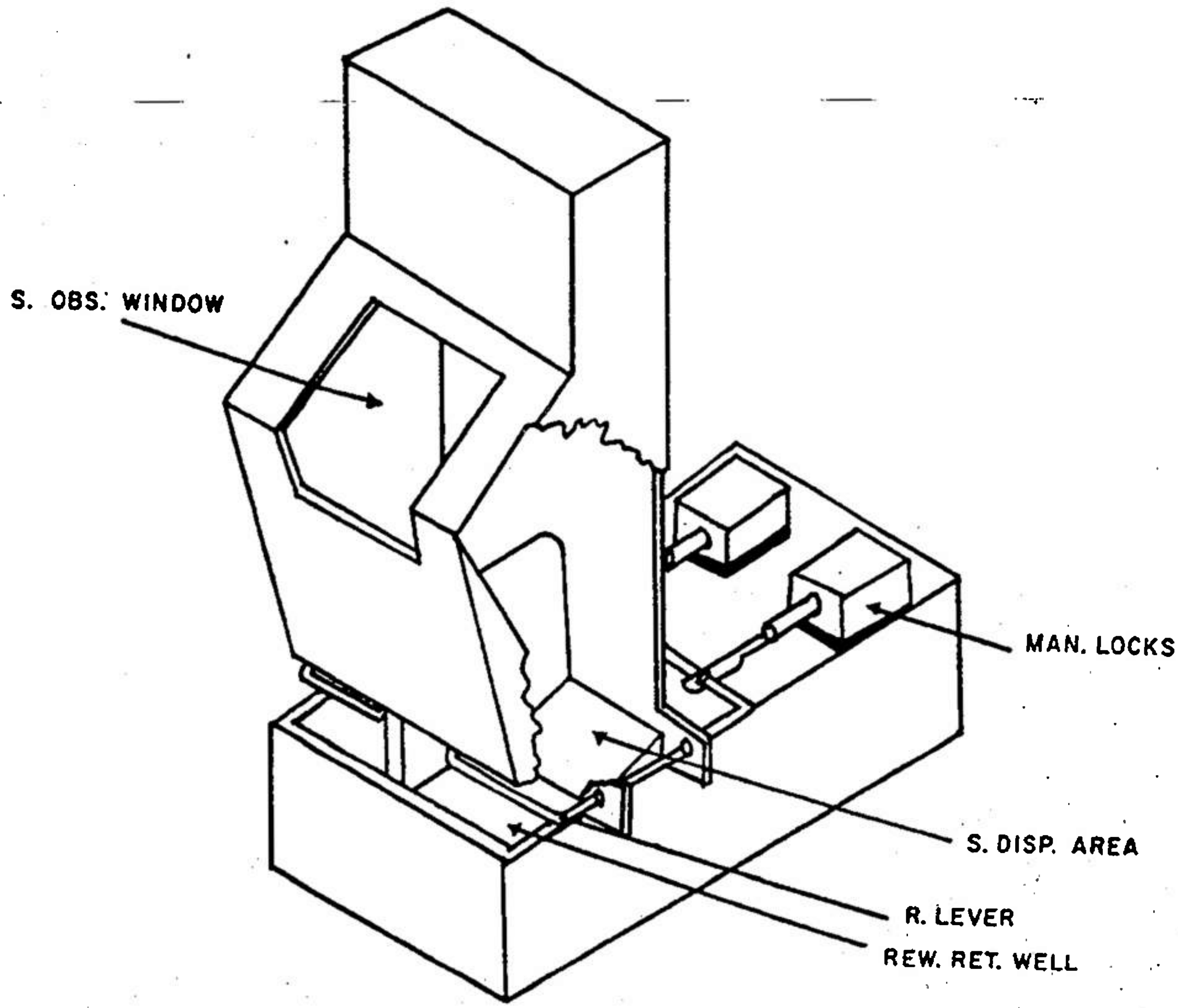


*Fig. 1. A schematic diagram of APDA: The Automated Primate Discrimination Apparatus.*

errors" on these reversal problems, discrete measures of the monkeys' post-response stimulus observation time were taken.

RESULTS AND DISCUSSION

The results of this pilot study are shown in Fig. 2 (left side), which demonstrate a significantly higher percent of incorrect responses at 200 feet than at "surface" (actually 30 feet) ($\underline{t} = 5.91$, $\underline{df} = 2$, $\underline{p} < .025$); also shown are changes in the monkeys' post-response observing behavior (right side).

These data suggest that mechanisms related to the storage and/or recall of environmental events may be seriously impaired when nitrogen in compressed

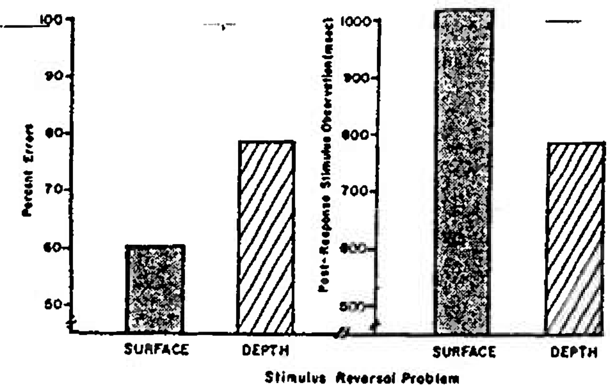


*Fig. 2. Composite of stimulus reversal data at surface and depth. Left side - Percent errors computed by dividing total number of lever responses into the number of incorrect lever responses.*

*Right side - Post-response stimulus observation time, computed by dividing total number of lever responses into the total time the stimuli were viewed after each response.*

air is breathed. However, the preliminary nature of this investigation is stressed, for other interpretations cannot yet be conclusively ruled out. For example, one confounding effect could have been the order in which the reversals were presented. That is, the "surface" reversal was always administered after the monkeys had already been tested on the initial reversal at depth. It might, therefore, be possible that the monkeys learned something about performing reversal tasks during their first experience, which facilitated performance on the second reversal. However, this possibility is believed to be unlikely since a very limited number of reversal trials were administered and the monkeys demonstrated little apparent improvement during this brief reversal-task experience at depth. Furthermore, extensive studies concerned with successive reversal learning indicate that transfer of the "reversal habit" from the first reversal to the second is insignificant, and it often takes longer to learn the second reversal than it does the first. (Dufort, Guttman, & Kimble, 1954; Schrier, Harlow, & Stollnitz, 1965). For these reasons it is assumed that the significantly inferior reversal performance at depth is in fact due to the effect of narcosis.

An obvious question that follows this conclusion is whether the impairment is actually the result of some memory dysfunction, as suggested, or due to the detrimental influence on some other behavioral mechanism. Changes observed in the monkeys' post-response stimulus observation behavior provide support for the notion of an impairment related to memory mechanisms. The post-response information is, of course, processed at the same time that memory consolidation is presumed to be most active (i.e., immediately following the response), and in fact the implication of some involvement of post-response information in memory functions has been demonstrated for both animals and man (Bartus, 1970; Dickerson & Ellis, 1965; LeVere, 1967; LeVere & Bartus, 1973; Sheridan, Horel & Meyer, 1962; Treichler, Hann, & Way, 1967;Treichler & Way, 1968). For example, during the acquisition of new behavior, or the modification of old behavior (when memory processes would seem to be most active), learning occurs significantly faster when the relevant stimulus information persists after the choice response is made. Similarly, learning is retarded when the information occurring after the response is either distorted or irrelevant to the new task. These effects do not occur if the treatments are introduced after a high level of performance has been reached. At this time consolidation processes are not believed to be active and the monkeys no longer observe the post-response information as long as before.

In the current study, it was found that all monkeys viewed the post-response stimuli less at pressure than at the surface while performing the memory reversal task (Fig. 2, right side). At the same time, they had greater difficulty modifying what they remembered about the stimuli from past experience. Thus, one possible explanation of these data is that some mechanism(s) necessary for the proper storage or modification of information in memory is impaired. Although additional work is required before suggestions related to diver training and diving programs can be made, the present preliminary data nevertheless suggest one mechanism which might be responsible for various task failures under pressure, and certainly provide a definite direction for future hyperbaric behavioral research.

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