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Longitudinal study of performance after deep compressions with heliox and He–N_2–O_2

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Lemaire, C., and E.L. Murphy. 1976. Longitudinal study of performance after deep compressions with heliox and He–N_2–O_2. Undersea Biomed. Res. 3(3): 205–216.—This study concerns three hyperbaric experiments. During SAGITTAIRE IV, compression to 610 msw was accomplished in 11 days with an atmosphere of helium–oxygen. For the two CORAZ experiments, compression to 300 msw was done in 4 hours with He–N_2–O_2 trimix, varying nitrogen concentration from CORAZ I (2.8 ATA N_2 = 9%) to CORAZ II (1.4 ATA N_2 = 4.5%). Oxygen partial pressure was always maintained at 0.4 ATA except during decompression. The same two subjects participated in all three experiments and underwent the following psychometric tests: manual dexterity, visual choice-reaction time, and number ordination. Results show a large decrement in performance at 610 msw after slow compression (−50% and −47% on the number ordination test, −34% and −24% on the visual choice-reaction time). Test performance was less affected after the rapid compressions to 300 msw, and recuperation to control values occurred within 1 day at 300 msw. Our data show that 1.4 ATA N_2 is less detrimental to performance than 2.8 ATA N_2 for trimix compressions to 300 msw in 4 hours.

performance	deep diving	helium
trimix	HPNS	tremor
compression rate	manual dexterity	mental behavior
alertness	recovery	behavior

From deep-diving experience, it has been observed and well-documented that neurological problems affect divers living at pressures greater than 16 ATA. These disturbances increase in severity with increasing depth and a higher rate of compression.

Symptoms include dizziness, muscular tremor, nausea, and a change in the subject's level of alertness. Related to the observed neurological symptoms are changes in the subjects' electroencephalograms, especially an increase in the slow theta wave activity (4–6 Hz) and a depression of the alpha waves when the subject's eyes were closed. (Fructus X., Naquet, Gosset, Fructus P., and Brauer 1969; Bühlmann, Matthys, Overrath, Bennett, Elliott, and Gray 1970; Bennett and Towse 1971a). These neurological modifications affect the psychomotor performance of the subjects to varying degrees, depending upon personal susceptibility to the conditions.

In order to reduce the symptoms due to the rate of compression, various methods have been utilized, including the introduction of stops during the compression (Bennett and Towse 1971a, b), changing the compression profile (Fructus, Agarate, Naquet, and Rostain 1976),

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and the addition of nitrogen to the breathing gas mixture (Bennett, Blenkarn, Roby, and Youngblood 1974; Bennett, Roby, Simon, and Youngblood 1975). The narcotic effect of nitrogen at elevated pressures could be expected to ameliorate the effects of the high pressure nervous syndrome from the results of animal experiments (Brauer, Goldman, Beaver, and Sheehan 1974). Narcotic gases added to the breathing atmosphere of animals allowed compression to greater pressure before convulsions occurred. The mode of action of the narcotic gases against pressure or helium is not known but Bennett et al. (1974) have presented a comprehensive review of the theory relative to these questions in their study of rapid compressions.

A rapid diving intervention must not compromise the safety of the personnel involved, and it must preserve their efficiency to accomplish any task on the bottom. It was in the interest of measuring such efficiency that this experiment was undertaken.

During three different simulated dives (SAGITTAIRE IV, CORAZ I, and CORAZ II) we have had the opportunity to observe the psychometric performances of the same two divers, C.B. and A.J. This permitted us to make a comparison of results after different compression protocols and to judge the relative merits of such compressions. Such an opportunity is rare, because most tests of this nature are carried out with different subjects and hence lose the advantage of comparability.

METHODS

All three dives took place at the Centre Experimental Hyperbare of COMEX in Marseille, France. The pressure chamber is a group of three interconnecting spheres, the lowest of which may be flooded with water to permit testing of diving equipment during the hyperbaric exposure. The system has a maximum simulated depth of 720 msw.

During the compression and bottom time of each of the three dives, oxygen partial pressure was maintained at 400 millibars (mb). P_{O_2} during the decompression phase was 500 mb for SAGITTAIRE IV and CORAZ I, and 600 mb for CORAZ II. Carbon dioxide was always maintained below a partial pressure of 1.5 mb. Ambient temperature was adjusted with depth for the comfort of the divers—29 ± 1°C at 300 msw and 33 ± 1°C at 610 msw. Relative humidity was maintained at 55 ± 10%.

Description of the Dives

SAGITTAIRE IV A depth of 610 msw was reached during this experiment, after 11 days of compression interrupted by a 17-hour stop at 200 msw and 3 stages of 2 days duration (400, 550, and 580 msw). The depth of 300 msw was reached after 54 hours of compression and 400 msw (the first psychomotor tests) after 67 hours (decreasing rate from 10 to 6 msw/hour). Such a slow rate of compression allows one to see almost solely the effect of pressure on the results of the tests (Fig. 1). The breathing gas for SAGITTAIRE IV was a helium–oxygen mixture.

CORAZ I and II On the other hand, compression rate was the predominant factor for our other experiments (300 msw in 4 hours) (Fig. 2). The purpose of the series was to test the efficacy of using nitrogen in a trimix breathing gas (P_{N_2} = 2.8 bars for CORAZ I and 1.4 bar for CORAZ II). As we have stated in our introduction, the nitrogen should theoretically counteract the deleterious effects of rapid compression.

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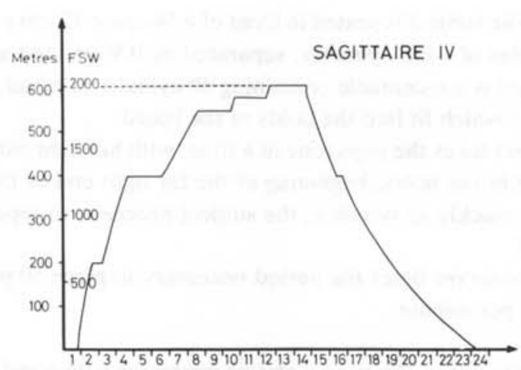

Fig. 1. Dive profile of the SAGITTAIRE IV hyperbaric experiment. Helium–oxygen was used as the breathing mixture, with O_2 partial pressure maintained at 400 millibars during the compression and bottom time. The compression rate was 10 to 8 msw/hour from 0 to 200 msw; 8 to 6 msw/hour from 200 to 400 msw; 3 msw/hour from 400 to 550 msw; and 10 msw/h from 550 to 580 msw, and from 580 to 610 msw. The compression was interrupted and pressure kept constant for 17 hours at 200 msw, 46 hours at 400 msw, 45 hours at 550 msw, 45 hours at 580 msw, and 50 hours at 610 msw.

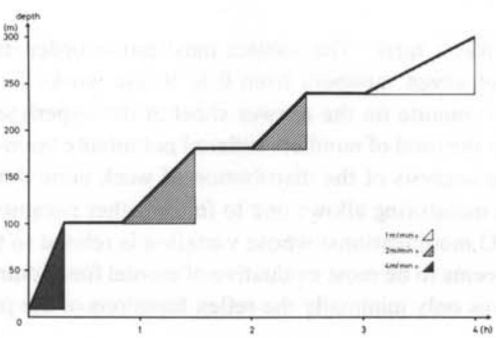

Fig. 2. The compression profile for the CORAZ I and II experiments was maintained constant; only the percentage of nitrogen in the breathing mixture differed (2.8 ATA N_2 for CORAZ I and 1.4 ATA N_2 for CORAZ II). The compression rate was 4 msw/min to 100 msw; 2 msw/min from 100 to 240 msw; and 1 msw/min from 240 to 300 msw. The compression was halted for 30-min periods at 100, 180, and 240 msw.

Description of the Tests

Three psychomotor and intellectual tests were used: *manual dexterity*, which measures the speed and precision of a simple hand and finger movement; *visual choice–reaction time*, which measures eye-hand response time as well as the level of vigilance of the subject; and *number ordination*, which evaluates the condition of the higher mental functions in the subject.

We are very familiar with those well-known tests in the special situation of diving, inasmuch as we have used them as guidelines since 1970 for all experiments at the Centre Experimental Hyperbare (Charpy, Deyts, and Wide 1973). With all tests of this nature one notices a learning period during which performance improves. For manual dexterity and visual choice–reaction time, the subjects have generally completed their learning period before the dive.

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Manual dexterity The subject is seated in front of a 54-cm × 12-cm plastic board which has been drilled with 50 holes of 1-cm diameter, separated by 0.9 cm, and arranged in 4 columns. At each end of the board is a receptacle containing 50 cylindrical metal pegs (height = 4.4 cm and diameter = 0.9 cm) which fit into the holds of the board.

At a signal, the subject takes the pegs (one at a time, with his right hand) from the left of the board and places them in the holes, beginning at the far right end of the board. Once he has completed this task as quickly as possible, the subject proceeds to repeat the task symmetrically with his left hand.

For each hand, the observer times the period necessary to place 50 pegs and calculates the number of pegs placed per minute.

Visual choice–reaction time We used a classic apparatus with a red and a green light. The subject rests his index finger between two buttons 6 cm apart. He must push, as quickly as possible, the button corresponding to the signal lamp which lights up. A random series of 33 signals comprises the test. The response time in hundredths of a second is noted by the experimenter for each signal.

The test is scored by calculating the median and interquartiles of the distribution of time values. This method gives the median response time as well as an indication of the dispersion, or spread, of the response times.

Number ordination (Rey's test) The subject must put in order, from smallest to largest, many random groups of seven numbers from 0 to 9. He works for 10 min and marks his progress from minute to minute on the answer sheet at the experimenter's time signal. Test performance is given by the total of numbers ordered per minute (*npm*—average of the 10 min) and, more finely, by an analysis of the distribution of work done during each of the 10 min. Such minute-to-minute monitoring allows one to follow other parameters (such as heart rate, breathing rate, and EEG modifications) whose variation is related to the test performance.

Number ordination seems to be most evaluative of mental functioning—that is, of the higher nerve centers. It involves only minimally the reflex functions of the peripheral system.

RESULTS

Manual dexterity The results of the series of manual dexterity tests are presented in Figs. 3, 4, and 5. During SAGITTAIRE IV, the results show a continuous diminution of performance for the compression phase. The differences from control values were −11% for C.B. and +3% for A.J. at 400 msw (average of both hands) and respectively −20% and −8% at 610 msw. The experimental evolution is identical for the right and left hands, and could be a consequence of *helium tremor*.

The results obtained during CORAZ I and II are similar to each other, although different from those of SAGITTAIRE IV. For CORAZ, interindividual difference is well-evident. For the two compression phases, the diver A.J. shows diminished performance with both hands, followed by stabilization at 300 msw. The diver C.B., on the contrary, did not show diminished performance during compression except for the right hand in CORAZ I. For both CORAZ dives, compression diminished the manual dexterity of A.J. (−12% and −1%) without having an adverse effect on C.B. (0% and +9%). Right- and left-hand results followed the same evolution for each subject.

During CORAZ I, muscular tremor (measured separately with an accelerometer placed on the subjects' right hand) was of small amplitude. During CORAZ II, it reached a level even

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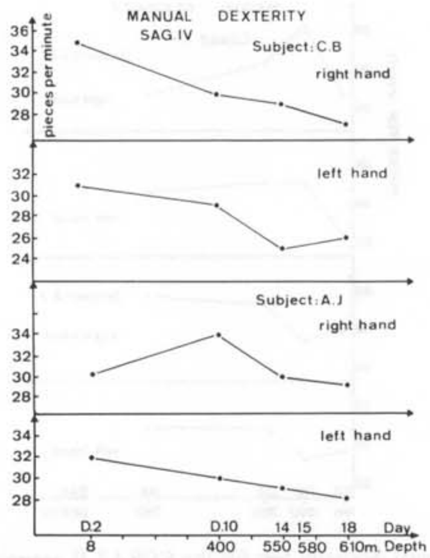

Fig. 3. Results of the manual dexterity test for the SAGITTAIRE IV experiment. The score shows the number of pegs placed per minute. The time and depth of each test are noted along the bottom of the figure.

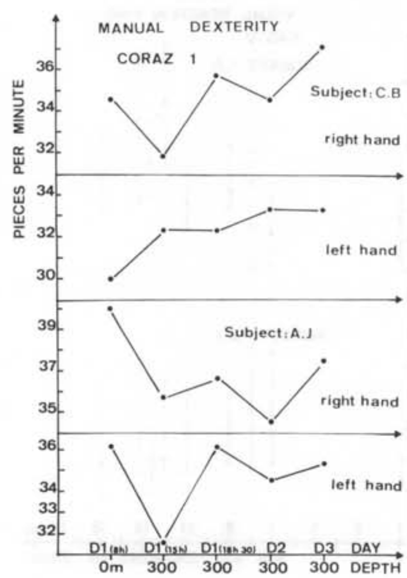

Fig. 4. Results of the manual dexterity test for the CORAZ I experiment. Time and depth of each testing are noted on the abscissa.

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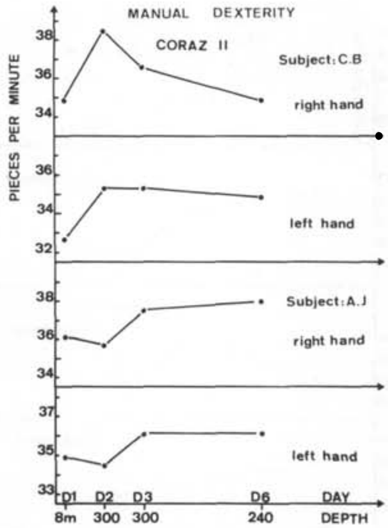

Fig. 5. Results of the manual dexterity test for the CORAZ II experiment. Day and depth of each testing are noted on the abscissa.

slightly higher than that of SAGITTAIRE IV at 400 msw. This tremor was always more marked for subject A.J. than for subject C.B.

Visual choice–reaction time Results of the second series of tests appear in graphic form in Figs. 6, 7, and 8. Because the visual choice–reaction time test measures, among other things, the level of vigilance of the diver, there is much variability in the results. Nevertheless, the results of our two subjects show a parallel evolution during each experiment.

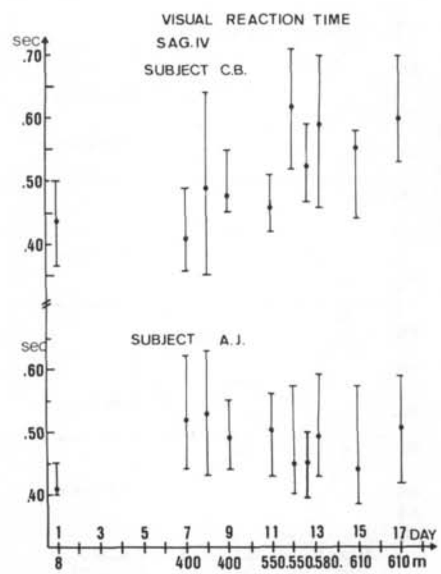

Fig. 6. Results of the visual choice–reaction time test for the SAGITTAIRE IV experiment. The point indicates the median response time of 30 responses and the brackets represent the interquartile values. The length of the brackets relates to the dispersion or spread of the response times.

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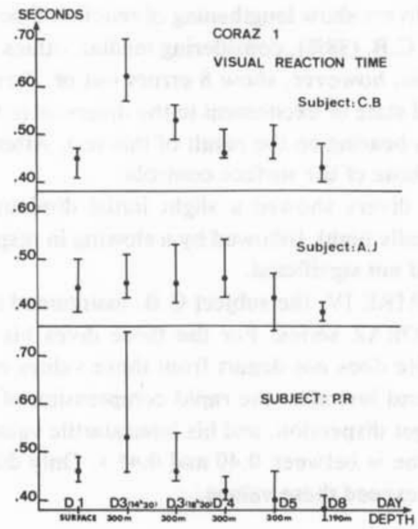

Fig. 7. Results of the visual choice–reaction time test for the CORAZ I experiment. The representation of the values is the same as in Fig. 6.

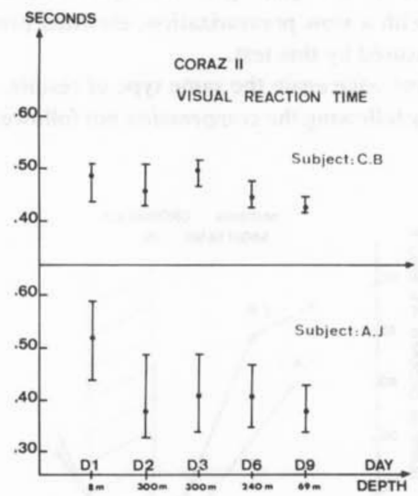

Fig. 8. Results of the visual choice–reaction time test for the CORAZ II experiment. The representation of the values is the same as in Fig. 6.

For C.B. during SAGITTAIRE IV, the reaction time lengthened all during the compression with an increase in the response-delay of 9% at 400 msw and of 34% at 610 msw, relative to surface-control values. For A.J. reaction-time increases were 19% and 24%, respectively.

For the two divers, the variability of response times grows larger with respect to the reference value, as can be seen by the larger separation of interquartile values. This suggests that the capacity of concentrating on a task (or vigilance) is strongly affected by exposure to high pressures.

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For CORAZ I, the two divers show lengthening of reaction time just after the compression. This increase is greater for C.B. (38%), considering median values. A.J., who does not show a significant modification, did, however, show 8 errors out of 33 responses. Subjectively, the observers noted an unusual state of excitement in the divers after this rapid compression, and we feel this probably had a bearing on the result of this test. After a day at 300 msw, the test scores are comparable to those of the surface controls.

In CORAZ II, the two divers showed a slight initial diminution (we considered A.J.'s control value to be abnormally high), followed by a slowing in response time. In any case, the differences are minimal and not significant.

As opposed to SAGITTAIRE IV, the subject C.B. maintained a level of performance with little dispersion for the CORAZ series. For the three dives his normal reaction time was between 0.45 and 0.50 s. He does not depart from these values except for the deepest tests during SAGITTAIRE IV and just after the rapid compression of CORAZ I. The diver A.J. always showed a much larger dispersion, and his interquartile values are more displaced from the median. His normal time is between 0.40 and 0.45 s. Only during the deepest phases of SAGITTAIRE IV does he exceed these values.

Number ordination Figs. 9, 10, and 11 show number ordination results from all three dives. The data for SAGITTAIRE IV show a steady decrease in performance to 610 msw. The two subjects follow the same pattern. C.B. begins at a value of 48 npm and scores only 24 npm at 610 msw (50% diminution) (−6% at 400 msw). A.J. has a drop of 47%, passing from 43 to 23 npm (−19% at 400 msw). With the beginning of decompression, the two divers improve their performance. Thus, even with a slow pressurization, elevated pressures produce a perturbation in mental work as measured by this test.

In CORAZ I, one observes once again the same type of results, namely a marked decrease in performance immediately following the compression but followed by an amelioration during

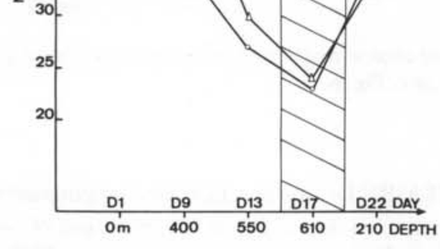

Fig. 9. Results of the number ordination test for the SAGITTAIRE IV experiment. The number of digits put in order per minute (*npm* score) by the subject is denoted by the ordinate, and the time and depth of each testing are noted on the abscissa. The cross-hatched portion of the figure represents the period spent at bottom depth.

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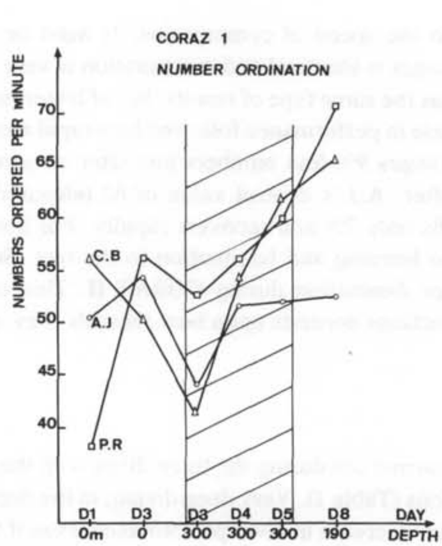

Fig. 10. Results of the number ordination test for the CORAZ I experiment. The representation of the data is the same as in Fig. 9.

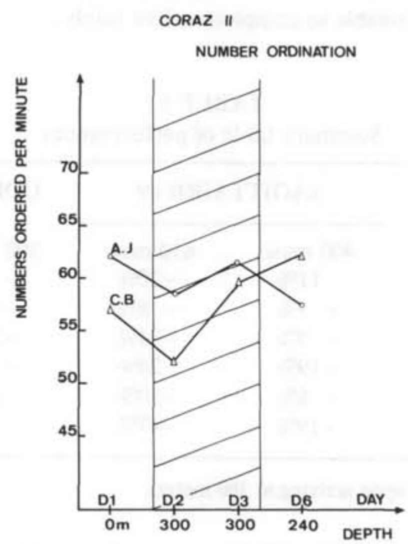

Fig. 11. Results of the number ordination test for the CORAZ II experiment. The representation of the data is the same as in Fig. 9.

the stay at 300 msw and at the decompression. This suggests that the process of learning this test was inhibited by the compression.

C.B. and A.J. show control values for CORAZ I more than 8 npm higher than those for SAGITTAIRE IV. From 56 npm, the diver C.B. falls 23% to 43 npm just following the compression. A.J., with a control value of 54 npm, completes 19% less numbers upon reaching 300 msw. The next day the values return to normal. On the whole, the percentage diminution is less than that observed in SAGITTAIRE IV but is produced much more rapidly and,

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therefore, is attributable to the speed of compression. It must be noted that for the three subjects, the pattern of changes is identical and recuperation is very rapid.

Once again, CORAZ II has the same type of results, but of lesser proportion. The two divers show the same slight decrease in performance followed by a rapid recuperation of their control values. The diver C.B. arranges 9% less numbers just after compression, but recovers to a level of 60 npm the day after. A.J.'s control value of 62 (elevated in comparison with his previous performances) falls only 7% and recovers rapidly. For both divers, the higher performance scores are due to learning and habituation to the test. Such an habituation could explain the relatively minor diminution during CORAZ II. This could also mean that the susceptibility of learned functions depends upon how recently they were acquired.

DISCUSSION

The results of each test carried out during the three dives with the same two divers allowed us to draw certain conclusions (Table 1). Very deep diving, in the depth range approaching 610 msw., produces an important decrease in diver performance, even if the compression has been done slowly. For the lesser depth of 300 msw, analogous performance decrements can be observed if the compression is carried out rapidly. Such ergonometric changes indicate that the diver would not be in optimum condition to perform a task underwater. In fact, subjective comments of our divers confirmed this; during the periods of marked psychometric deficiency, they felt themselves unable to complete a dive safely.

TABLE 1
Summary table of performances

	SAGITTAIRE IV		CORAZ I	CORAZ II
	400 msw	610 msw	300 msw*	300 msw*
Manual	−11%	−20%	− 0%	+ 9%
Dexterity	+ 3%	− 8%	−12%	− 1%
Visual choice–	− 9%	−34%	−38%	+ 6%
Reaction time	−19%	−24%	− 2%	+27%
Number	− 6%	−50%	−23%	− 9%
ordination	−19%	−47%	−19%	− 7%

*Performances immediately upon arriving at 300 meters.

The data for the 610-msw SAGITTAIRE IV dive confirms other published observations on the high pressure nervous syndrome (HPNS). Even with the slow rate of compression, our psychometric tests revealed performance decrements complementary to the neurologic impairments reported by Rostain and Naquet (*in press*) for the same dive. Other hyperbaric experiments to lesser pressures had already given an indication of the extent of these modifications. Bennett and Towse (1971b) reported a decrease in psychomotor performance due to helium tremor, as well as the other signs of HPNS during a dive to 457 msw. For SAGITTAIRE IV, there was no improvement in the diver's condition over the entire 50-hour period spent at 610 msw.

The neurologic modifications as they appear in very deep dives appear to be a steady-state phenomenon, at least over a 2-day period of time. Pressure and saturation of all tissues with

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helium are the only likely causes of such modifications. The recovery of psychomotor function that we observed in the CORAZ dives seems to indicate that the rapid compression syndrome is of but a transient character. The subjects recovered almost to control performance levels on manual dexterity and visual choice–reaction time tests within 4–6 hours after compression to 300 msw. Performance on the number ordination test was slower to recuperate.

Bennett et al. (1974) found diminished performance after compression, which did not subside notably after a period of 40 min. However, the nitrogen percentage of 18%, significantly higher than in CORAZ, may play an important role. Bennett et al. (1975) demonstrated that 10% was more effective in suppressing psychomotor decrements with a 33-min compression to 31 ATA. The adaptation of performance was well-shown by Bühlmann et al. (1970) where the best results were obtained 72 hours after the compression (70 min to 31 ATA; 1.5% N_2) with no HPNS at that time.

Comparison between the tests is only possible for manual dexterity. Reaction time is not one of Bennett's battery and the intellectual test we use is very different from his arithmetic test. In fact, the duration of our test (10 min instead of 1) makes it much more difficult to perform.

Bennett et al. (1975) stated that the optimal percentage of nitrogen for a dive to 31 ATA is 10%, but our quite different opinion is that 4.5% N_2 is more effective. But the compression rate must not be disregarded and, perhaps, for the same depth 10% nitrogen is better for a 33-min compression and 4.5%, for a 4-hour compression.

Pressure, compression rate, and the different levels of dissolved helium and nitrogen in tissues are the factors with which we are concerned in trimix rapid compressions. The role of each factor cannot be considered separately because they interact. More experiments are needed to clarify these points, including studies of different combinations of rates of compression and percentages of nitrogen and exposure of many more divers.

The authors are grateful to the divers, Claude Bourdier and Alain Jourde for their cooperation; to Ms. Paulette Matheron for her technical assistance; to Jean-Pierre Charpy and Pierre Dejours for their advice.

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Lemaire, C., et E.L. Murphy. 1976. Etude longitudinale de la performance apres des compressions profondes à l'heliox et au trimix $He–N_2–O_2$. Undersea Biomed. Res. 3(3):205–216.—Cette étude se rapporte à trois expérimentations. La compression de SAGITTAIRE IV pour atteindre 610 mètres a été réalisée en 11 jours avec une atmosphère helium–oxygène. Pour les deux expérimentations CORAZ, la compression à 300 mètres était effectuée en 4 heures avec un mélange ternaire d'helium, d'azote et d'oxygène, la concentration de l'azote variant d'une plongée à l'autre (CORAZ I: 2, 8 ATA N_2=9% et CORAZ II: 1, 4 ATA N_2=4, 5%). La pression partielle d'oxygène a toujours été maintenue à O, 4 ATA sauf pendant les décompressions. Les deux mêmes sujets ont participé aux trois plongées, et ont effectué les tests psychomoteurs suivants: dextérité manuelle, temps de réaction visuel de choix, ordination de chiffres. Les résultats montrent une diminution importante de la performance à 610 mètres après une compression lente (−50% et −47% pour l'ordination de chiffres, −34% et −24% pour le temps de réaction visuel de choix). La performance est moins affectée par les compressions rapides jusqu'à 300 mètres, et la récupération des valeurs de contrôle est totale en moins de 24 heures. Nos résultats montrent que la performance psychométrique pour une compression à 300 mètres en 4 heures est meilleure avec 1, 4 ATA qu'avec 2, 8 ATA d'azote.

performance
mélange ternaire
vitesse de compression
vigilance
plongée profonde
SNHP
dextérité manuelle
récupération
helium
tremblement
comportement

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REFERENCES

Bennett, P.B., G.D. Blenkarn, J. Roby, and D. Youngblood. 1974. Suppression of the high pressure nervous syndrome in human deep dives by He–N_2–O_2. Undersea Biomed. Res. 1(3): 221–237.

Bennett, P.B., J. Roby, S. Simon, and D. Youngblood. 1975. Optimal use of nitrogen to suppress the high pressure nervous syndrome. Aviat. Space Environ. Med. 46: 37–40.

Bennett, P.B., and E.J. Towse. 1971a. The high pressure nervous syndrome during a simulated oxygen–helium dive to 1500 ft. Electroencephalogr. Clin. Neurophysiol. 31: 383–393.

Bennett, P.B., and E.J. Towse. 1971b. Performance efficiency of men breathing oxygen–helium at depths between 100 ft and 1500 ft. Aerosp. Med. 42: 1147–1156.

Brauer, R.W., S.M. Goldman, R.W. Beaver, and M.E. Sheehan. 1974. N_2, H_2, and N_2O antagonism of high pressure neurological syndrome in mice. Undersea Biomed. Res. 1(1): 59–72.

Bühlmann, A.A., H. Matthys, G. Overrath, P.B. Bennett, D.H. Elliott, and S.P. Gray. 1970. Saturation exposure at 31 ATA in an oxygen–helium atmosphere with excursion to 36 ATA. Aerosp. Med. 41: 394–402.

Charpy, J.P., J.P. Deyts, P. Wide. 1973. Etude psychologique sur les travailleurs sous-marins à moyennes et grandes profondeurs. Försvarsmedicin 9: 452–458.

Fructus, X., C. Agarate, R. Naquet, and J.C. Rostain. 1976. Postponing the high pressure nervous syndrome to 1640 feet and beyond. *In* C.J. Lambertsen, Ed. Proceeding's of the fifth symposium on underwater physiology. Federation of American Societies for Experimental Biology, Bethesda, Md.

Fructus, X., R. Naquet, A. Gosset, P. Fructus, and R.W. Brauer. 1969. Le syndrome nerveux des hautes pressions. Marseille Med. 6: 509–512.

Rostain, J.C., and R. Naquet. (*in press*) Human neurophysiologic data obtained from two simulated heliox dives to 610 meters. *In* Proceedings of the sixth symposium on underwater physiology, San Diego, July 1975. Federation of American Societies for Experimental Biology, Bethesda, Md.