EFFECTS OF COMPRESSION ON HUMAN PERFORMANCE AND AFFECTIVE STATES

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INTRODUCTION

Compression chambers are commonly used for simulating wet-dive conditions during training for sub-aquatic activities. The effects of nitrogen narcosis are reported to operate at depth below 30m and are manifested in a decrement in intellectual function (Bennett, 1972). Anecdotal accounts from divers describe a euphoric feeling referred to as the 'call of the deep'. This study attempts to monitor changes in mental performance, time estimation, grip strength and affective state at a simulated depth of 46m.

Baddeley (1966) explored the effects of reduced body temperature on time-estimation in scuba-divers. His results supported Hoagland's chemical-clock hypothesis – the higher the body temperature, the quicker the chemical reaction, the faster the internal clock and the faster the speed of counting up to 60 (Hoagland, 1933). The rate of counting was unaffected by pre-dive anxiety. On the basis of the chemical-clock model it is here hypothesised that perception of time is unaffected by compression in a dry-dive.

Procedures

Eight amateur scuba-divers participated in the investigation. The subjects were tested before and during a dry dive which consisted of a 65 minute period in a compression chamber. Eleven minutes of the period of enclosure were taken in descending from surface pressure, a bottom of 46m (approx. 150 feet) was simulated for 22 minutes while the remaining period of 32 minutes was taken in returning to surface pressure.

An adding test was administered as a measure of mental performance (Wilkinson, 1966). Subjects were given columns of five two-digit numbers to add for 15 minutes. The number of sums completed was used as a measure of speed while the number of incorrect additions was used to score accuracy.

Subjective time perception was assessed by the method of production of 60 second intervals. Subjects were asked to count to themselves up to 60 at what they considered to be a 1-second rate (Ptaff, 1968).

Grip strength was used as a measure of gross muscular function. Grip strength of the preferred hand was obtained using grip dynamometry (Clarke, 1967).

A Mood Adjective Check List was administered to assess ten mood factors. Mood check lists have been used as a method of identifying and assessing transient fluctuating affective states (McNair and Lorr, 1964). The mood check list employed consisted of 52 adjectives derived to measure ten factor moods (Harker, 1973). The factors were aggression, anxiety, surgency, elation, concentration, fatigue, social affection, sadness, vigour/general activation, nonchalance/general deactivation. Subjects were asked to rate how each word applied to their current feeling on a 4 point differential scale from minus to double plus.

Measurements were obtained before the dive and while at the simulated bottom. Subjects had prior practice in time estimation and adding to exclude possible learning effects.

Pulse rates were obtained before entering the chamber while the subjects sat for 5 minutes, and again after returning to surface pressure while seated in the chamber. Measurements were obtained by palpation at the radial artery over a period of 10 heart-beat intervals (Thomas, 1970).

Pre-treatment and treatment observations were compared using paired comparisons to analyse the difference between means. Kendall's tau test was used to investigate correlations within conditions among adding scores, selected mood factors and pulse rate (Kendall, 1938).

Results

Table I presents the results for the pre-treatment and treatment scores on the performance variables. The mean number of sums completed decreased from 55 ± 11.9 to 51 ± 19.3. This change is not significant. Six of the subjects slowed down during treatment, this number not being significant using a sign test (Walsh, 1946). The mean number of incorrect additions increased from 4± 2.25 to 7.75 ± 3.75. This increase is highly significant ($p < 0.001$). Accuracy deteriorated in all subjects. Incorrect additions tended to be evenly distributed over the whole of the test period.

TABLE I

Comparison of the pre-treatment and treatment observations on the human performance variables. Mean ± SD (n = 8)

Performance Variable	Pre-treatment	Treatment	Level of Probability
Sums Completed	55 ± 11.9	51 ± 19.3	$p > 0.05$
Incorrect Additions	4 ± 2.25	7.75 ± 3.75	$p < 0.001$
Time Estimation	55 ± 7.9	54 ± 9.6	$p > 0.05$
Grip Strength	48.5 ± 7.1	49 ± 7.7	$p > 0.05$

There was no significant difference between conditions in time estimation. Mean values were 55 ± 7.9 secs for pre-treatment, 54 ± 9.6 secs for treatment. Scores of grip strength were practically identical between conditions for all subjects.

Table II presents the results for the pre-treatment and treatment scores on the ten mood factors. Negative ratings were found in aggression, anxiety and sadness under both conditions. Two subjects tended towards a slightly positive rating in anxiety during treatment. Values for sadness remained identical between conditions for all subjects. Mean values were positive under both conditions for surgency, concentration, social affection and vigour. A significant trend towards a negative rating was observed in concentration ($p < 0.05$). A significant change from a negative to a positive rating was found in elation ($p < 0.05$). Mean values for fatigue were negative under both conditions but a significant trend towards an extreme negative rating was observed ($p < 0.01$).

TABLE II

Comparison of pre-treatment and treatment scores of affective states. Mean ± SD (n = 8)

Mood Factor	Pre-treatment	Treatment	Level of Probability
Aggression	-0.91 ± 0.18	-0.94 ± 0.12	$p > 0.05$
Anxiety	-0.70 ± 0.09	-0.55 ± 0.48	$p > 0.05$
Surgency	0.63 ± 1.01	0.85 ± 1.15	$p > 0.05$
Elation	-0.05 ± 0.77	0.70 ± 0.43	$p < 0.05$
Concentration	0.45 ± 0.32	0.13 ± 0.54	$p < 0.05$
Fatigue	-0.32 ± 0.62	-0.78 ± 0.06	$p < 0.01$
Social Affection	0.68 ± 0.64	0.60 ± 0.78	$p > 0.05$
Sadness	-0.91 ± 0.25	-0.91 ± 0.25	$p > 0.05$
Vigour	0.34 ± 0.78	0.44 ± 0.52	$p > 0.05$
Nonchalance	0.25 ± 1.00	0.00 ± 1.00	$p > 0.05$

Mean pulse rate increased significantly from 68 ± 12.9 to 80 ± 7.8 ($p < 0.01$). Pulse rate increased in all subjects.

Kendall's tau test revealed no significant correlations between scores of adding performance and the mood factors anxiety, concentration and vigour/general activation ($p > 0.05$). A positive correlation was found between pre-treatment scores of incorrect additions and nonchalance (tau = 0.58; $p < 0.05$). The relationship was not evident during the treatment condition.

Pulse rate did not show significant correlations with any of the mood factors.

Discussion

It is clear from the results that accuracy in mental calculations is significantly impaired by compression at the pressure investigated. Ordinarily the sensitivity of the adding test in detecting decreased function with intervention of a stressor is low, if the duration of administration is of the order of time employed here. Sensitivity improves with increased duration of testing. The decrement demonstrated in accuracy of adding was conclusive. Errors were evenly distributed throughout the test period, which suggests the impairment in performance is immediate. The implication of this result is that divers should not be expected to perform accurately tasks involving exact mental calculations at this depth. It is probable that more complex mental operations are similarly effected.

The data support Hoagland's chemical clock hypthesis. The rate of counting observed may be explained by the time of day. The investigation was carried out at midday when body temperature is highest and the chemical clock ticking fastest. It seems the operation of a counting strategy rehearsed under dry conditions is inappropriate to estimate time while under water without a correction factor. Baddeley's results show that the degree of error can be 25%. It may be that a counting strategy should be practised with feedback during wet conditions.

No changes in speed of mental operations or muscular strength were demonstrated. This, together with the concomitant increase in elation and decrease in fatigue, may lead to an assumption on the part of the diver in wet conditions that he can function normally. An awareness that accuracy of mental operations and concentration decrease with compression might prevent his being lulled into a false sense of security. The increase in elation is in accord with empirical observations but no changes occurred in surgency and social affection, changes which are explicit in articulations of the 'call of the deep'.

Emotional tachycardia is a well recognised phenomenon (Åstrand, 1967). The pre-treatment pulse rates were observed to be low and did not suggest an anticipatory acceleration. This is in agreement with the negative rating on anxiety. It is expected that anxiety

will be induced in field conditions, especially among inexperienced divers, and specific coaching techniques may be required to reduce this condition.

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