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PROGRESS REPORT ON SAN DIVER TRAINING, SEPTEMBER 1970.

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Johannesburg

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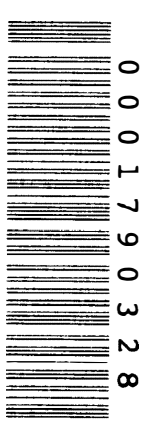
NATIONAL INSTITUTE FOR PERSONNEL RESEARCH

PROGRESS REPORT ON S.A.N. DIVER TRAINING

SEPTEMBER 1970

A.H. DEPPE AND P. MYBURGH



JOHANNESBURG.

September, 1970

CIRCULATION

Chief of Defence Staff	1-5
Surgeon-General	6-10
Chief of the Navy	11
Chief of the Navy (For attention : C.O. Diving School)	12-21
ASG (Navy)	22
President, CSIR	23
Director, NIPR	24
Leader : Defence Research Programme, NIPR	25
Head : Division of Work Study and Training, NIPR	26
Research Registry, NIPR	27
Military Registry, NIPR	28
CSIR Archives	29
A.H. Deppe, NIPR	30
Head : Personnel Selection Division, Jhb., NIPR	31
Head : Psychometrics Division, NIPR	32

CONTENTS

ACKNOWLEDGEMENTS

The authors with to express appreciation to the diving instructors who placed their time at the NIPR team's disposal and co-operated in every respect. In particular we wish to thank C.P.O. Vrey and P.O. Liebenberg.

Assistance given by Mr. G.K. Nelson, Defence Research Programme Leader, NIPR, in the compilation of this report is gratefully acknowledged.

Appreciation is expression to the trainees who submitted to frequent testing.

This work was done as part of NIPR Project 7034/97083, 65/5, Selection and Training of Divers, sponsored by the South African Defence Force.

SUMMARY

This report deals with three themes, viz. an SAN-NIPR discussion in respect of conclusions and recommendations of a previous report on diver training; training of SAN diving instructors in NIPR diver training (NDT) methods and a report on the success of NDT methods applied to an experimental Diver 3 training course.

Two diving instructors were trained in NDT methods so that one instructor could apply the methods under direct supervision of the other. Due to circumstances beyond the control of the NIPR the experimental course was applied by a third instructor, necessitating the attendance of one of the authors at the first two weeks of experimental training.

In spite of this drawback the experimental group proved superior to a matched group trained in traditional methods, in terms of criteria of underwater performance, freedom from anxiety and performance in a diving-related stress situation.

OPSOMMING

Hierdie verslag handel oor drie temas, naamlik 'n SAV-NIPN bespreking oor die gevolgtrekkinge en aanbevelings van 'n vorige verslag oor duikeropleiding; die opleiding van SAV-duikinstrukteurs in NIPN duikeropleidings (NDO) metodes en 'n verslag oor die sukses van NDO-metodes na toepassing op 'n Duiker 3-opleidingsgroep.

Twee duikinstrukteurs is in NDO-metodes opgelei ten einde die metodes op 'n eksperimentele kursus toe te pas, met die een instrukteur onder toesig van die ander. Weens toestande buite die beheer van die NIPN, is die NDO-metodes deur 'n derde instrukteur toegepas met die gevolg dat een van die skrywers die eerste twee weke van die opleidingskursus moes bywoon en die instrukteur behulpsaam wees.

Ten spyte van die probleme het die eksperimentele groep beter presteer as 'n afgepaarde groep wat met tradisionele metodes opgelei is, in terme van kriteria van onderwater prestasie, gebrek aan duik-verwante angs en prestasie in 'n duik-verwante spannings-toestand.

INTRODUCTION

NIPR commitments concerning the SAN Diving establishment primarily concern improvement in diver training and career development and the construction of a selection battery for first level divers. To satisfy all requirements in this project it has been found necessary to concentrate additional investigations on diving stress, in-training and occupational criteria, underwater ergonomics, etc.

Steps that have been followed in research on diver training up to the present comprised participation in a Diver 3 (first level) course, structured interviews and observations and a report on the results (1). A special study on SAN diver training procedures, career development in the Diving School and principles involved in first level training was fully reported (2).

This report concerns follow-up work on the above and deals with the following :

1. Points emerging from a discussion on the report on training (2) by SAN and NIPR representatives.

2. The training of two senior Diving School staff members in NIPR diver training (NDT) techniques.

3. Implementation of NDT at the SAN Diving School.

1 DISCUSSION ON DIVER TRAINING REPORT (February 1970)

1.1 Aim : To reach agreement on the recommendations presented in the report : Training of divers in the South African Navy : An appraisal and preliminary suggestions for improvement. (A. Deppe, U/Pers 21, July, 1969).

1.2 Participants :

SAN : Cmdr. Banks
Lt. Cmdr. P. Jonker (OC, Diving School)
Lt. A. Sibthorpe (Head of Training, Diving School)
CPO W. Dewey (Senior Instructor, Diving School)

NIPR and MMI : Mr. P. Myburgh

1.3 Conclusions :

Discussion revolved around both sections of the report, viz. an appraisal of present SAN diver training on all levels and an account of training methods relevant to the Diver 3 level.

The Diving School authorities had been aware of some of the problems described in the report, without in all cases fully realising the implications of these problems, for example, in the career limitations imposed by present training levels. In other cases they were made aware of problems not fully realised before, for example, shortcomings of the Diver 3 course. The major aim of this section of the previous report has therefore been achieved, that is to put personnel problems in perspective for those immediately concerned with them, thereby to stimulate thinking about them and, it is hoped, to bring about improvement through change.

The NIPR as an outside and unbiased authority on personnel problems has indicated solutions for the problems of this kind in the Diving School. While agreement was expressed in principle with the conclusions reached, SAN representatives did not consider it feasible to implement all the proposed solutions due to aspects of SAN organization and policy. The proposals in regard to post-Clearance Diver I training were vetoed for this reason. At this stage it is up to the Diving School authorities to reconcile proposed solutions to personnel problems with SAN organization and policy.

The second section of the report deals with the effectiveness of existing Diver 3 training methods and the results of an experimental diver training course conducted by the NIPR. While there was lively discussion on specific recommendations, for example, progression of depths in free ascent training, this section was on the whole well received. SAN representatives were sufficiently enthusiastic to request the NIPR to train two instructors in NDT methods.

Finally, it emerged in the discussions that the Diving School staff, while appreciative of research on diver training, keenly await the diver selection battery presently being developed by the NIPR. It should be made quite clear, however, as the NIPR representative pointed out at the discussion, that selection is meaningful in terms of the demands for which the selection occurs, in this case those of the Diver 3 training course. Our research has already highlighted discrepancies between the assumed and real training criteria, in other words, between the diver material the Diving School staff believed they are producing and what they are actually producing. This will be covered fully in a future report on selection.

1.4 Recommendations :

It was recommended that the NIPR train two diving instructors in NDT methods and that the instructors and the NIPR devise a modified Diver 3 course for experimental application at the SAN Diving School, Simonstown.

2 TRAINING OF SAN INSTRUCTORS IN NDT METHODS (9-13 March, 1970)

2.1 Introduction :

The above recommendations (1.4) were accepted by the NIPR, MMI and SAN.

It was originally intended to train the instructors in the field on a compact diving course but this proved impossible due to a shortage of people to function as trainees. The course was then changed to consist of lectures and discussions, attended by Lt. A. Sibthorpe and CPO W. Dewey from 9 to 13 March, 1970, at the NIPR, Johannesburg.

2.2 Aims :

The aims of the course were to impart NDT principles and techniques and to modify the existing Diver 3 course accordingly. A secondary aim was to agree on a procedure for applying the modified syllabus experimentally and comparing it with traditional methods.

2.3 Content of the course :

The course covered the following :

(i) Introduction to principles of the psychology of learning.

(ii) Underwater adaptation and learning to dive.

(iii) Instruction techniques.

(a) Orienting trainees

(b) Feedback techniques and conveying performance criteria

(c) Grading material to be learned

(d) Self-pacing and safety controls

(e) Use of group discussions and exercises

(iv) The nature and incidence of diving stress.

(v) Training in underwater skills.

2.4 The revised Diver 3 syllabus :

The proposed alterations to the existing syllabus largely reflect NIPR thinking on diver training. Major changes suggested are the following :

2.4.1 The first two weeks of the course will be seen as an adaptation period. The remaining course time will be devoted to increasing flexibility and to inculcating skills over and above diving per se, for example, exposure to cold, fatigue and zero visibility, training in group and individual assembly tasks, searches, etc.

The following specific changes*were proposed :

(i) Trainees will either be selected on the basis of physical fitness, as distinct from medical fitness, or they will be brought to a satisfactory fitness level before the course.

(ii) The intensive physical training programme concurrent with diver training over the first two weeks will be cut down to such an extent that trainees experience no physical fatigue beyond that from which they can immediately recover. The wide experience of the instructors was used to decide on a physical training maximum.

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*Principles underlying these changes are fully discussed elsewhere (2).

(iii) The speed of work will be progressively increased from the third week onwards until it equals or exceeds that of the traditional training. In addition dives will be made which simulate the conditions encountered by the qualified Diver 3, e.g. diving in cold water, in zero visibility and among obstacles; induced air hunger underwater, "diver lost" exercises, etc. Exercises will be included which accelerate specific skills used in diving and in teamwork, e.g. teamwork will be developed in group assembly tasks; correction for refraction will be encouraged by the use of tools in individual assembly tasks, etc. Basically this period will develop flexibility by widening the range of skills and experience in the trainee.

2.4.2 Learning to dive will be accelerated by the introduction of techniques and controls which have been shown to facilitate learning, by inter alia keeping stress to a minimum.

(i) Stress generating activities are all shifted forward into the flexibility training period, e.g. jumps off a ship (1, 2).

(ii) Existing feedback techniques have been extended and new ones introduced.

(iii) Skills will be practised on the surface before being applied underwater.

(iv) Daily group discussions will be conducted by the instructor in an informal climate. This will create opportunities for trainees to share experiences and promote sound within-group relations.

(v) Trainees will be adequately informed, before the course, of the complete academic and practical syllabus and of standards required by the instructor. For example, trainees will be given the complete set of notes before the course, in contrast to the traditional practice of issuing prècis (summaries) singly after each lesson.

(vi) All material to be learned by the trainee will be graded. Academic material is classified as "must know", "should know" or "could know". In practical work critical points are emphasized, for example, common faults in clearing the mask.

2.5 Instructors' reactions to the NDT course :

Initially instructors were dubious about the interpretations of diving stress and load in the proposed new Diver 3 course, and about the views expressed on the debilitating effect of stress on underwater adaptation and performance. However, after examining the available evidence from NIPR and overseas research, instructors found the views of the NIPR acceptable to such an extent that a common frame of reference emerged and no difficulties were experienced in preparing a revised Diver 3 syllabus.

2.6 Implementation of NDT principles :

A decision taken during the course was to recommend to NIPR and SAN that NDT methods be experimentally applied to two Diver 3 courses at Simonstown. The first application would familiarize the instructor with the training principles and iron out difficulties with the training method; the second would be run simultaneously with a traditional course to allow comparison of the two methods in terms of diver effectiveness. It was arranged that CPO Dewey would apply the NDT methods.

This recommendation was acceptable to both organizations.

3 FIRST APPLICATION OF NDT AT SIMONSTOWN (13 April -19 June 1970)

3.1 Introduction :

This section of the report deals with the first application of NDT principles. Although it had not been intended to compare the experimental and traditional training at this stage, the number of trainees available made a division into two groups necessary and it was decided to use the opportunity to make tentative comparisons on selected criterion measures. Accordingly the trainees in the two groups were roughly matched for home language, age and physical stature.

One of the authors attended the first two weeks of training to act in an advisory capacity to the instructor conducting the experimental course. As mentioned previously, the first two weeks are considered the most critical for diver training and incorporated the most significant changes from traditional training (2).

From the start severe setbacks were encountered with regard to the actual training and as a result of specific problems in the Diving School. In the first place, CPO Dewey, who had received the training for the experimental course and was to have conducted it, was assigned to another course at the last moment. Secondly, the Diving School is in a difficult phase in terms of manpower shortage and low morale. From discussions with several instructors it appears that this is mainly due to loose job structures caused by the manpower shortage, to a lack of clear career development* and of communication and guidance from the Diving School administrators. These problems are of interest here insofar as they form the context for the experimental course. Thirdly, in order to make valid comparisons between the courses it was considered necessary to keep the traditional course strictly to

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*Discussed in a previous report (2).

traditional methods of training. As it turned out, this group far exceeded the amount of diving scheduled. In comparison to the experimental group which had completed a mean of 2.5 hours of diving, the traditional course had completed a mean of 13 hours of diving at the end of two weeks, i.e. at the time the first criterion measures were obtained. Finally, those tasks which constitute the core of flexibility training were omitted. These were, among others, dives in extreme cold, dives in zero visibility (i.e. actual zero visibility, not simulated with blacked-out masks), the controlled production of air-hunger underwater and the execution of group emergency exercises and group tasks underwater.

Criterion measures obtained at the end of the course do therefore not adequately represent the full range of NDT principles, but simply reflect long term benefits of training by NDT methods during the first two weeks.

3.2 Aims and hypotheses :

In designing NDT principles the major aim was the provision of a training climate and methods which would promote adaptation underwater, and having done this, to teach the trainee to cope with diving stressors by progressively increasing exposure to these stressors. Hypotheses at this stage were :

(a) Hypothesis 1 : In the first two weeks, i.e. the "adaptation period", the trainee would adapt fully in that learned diving skills would be more effectively integrated and negative emotional responses avoided. At this stage the experimental group was expected to show less anxiety concerning diving than the traditional group, while performance by the two groups - in terms of the ability to transfer skills to the underwater situation - would be roughly equivalent.

(b) Hypothesis 2 : It was predicted that the experimental group would reach a higher plateau of performance at the end of the course. This was based on the assumption that (i) a lower anxiety level, if present, would have a lesser limiting effect on ultimate performance, and (ii) progressive exposure to diving stressors would increase the coping capacity of the individual by an acclimatization process, and this would increase the trainee's ability to utilize his resources (e.g. reasoning ability) underwater.

The hypothesized course of these events is shown in Figure 1.

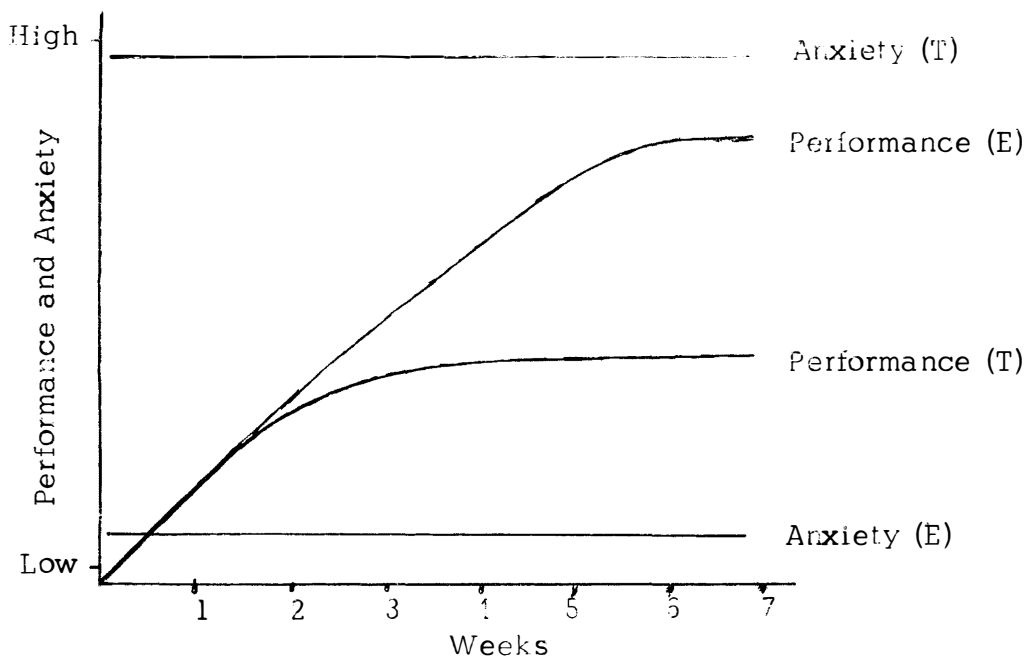

Figure 1. Predicted course of performance and anxiety for the traditional (T) group and experimental (E) group of diver trainees during the Diver 3 course.

3.3 Method :

3.3.1 Procedure

To test the hypotheses, criterion data on anxiety and performance were obtained at the end of two weeks (Criterion 1) and again at the end of the course (Criterion 2).

Results from criteria measurement were then compared in respect of the differences suggested by the hypotheses.

3.3.2 Criteria

(a) Criterion 1 : Criterion 1 comprised observations (by one of the authors) and quantitative measures of arousal and performance change associated with immersion.

Arousal was assessed by increases in heart rates from a control (rest) period to just before a dive to 10' in clear visibility.

Performance measures involved the application of two tests on the surface and underwater. The first of these, a reasoning test developed by Baddeley (3, see Appendix I) was applied three times on the surface in order to cancel out practice effects, and once underwater. The second, a test of manual dexterity (See Appendix II), was applied once on the surface and once underwater. More frequent application of the manual dexterity test to reduce practice effects would have caused an unwarranted intrusion into training time as the test is individually applied and takes approximately 10 minutes per individual to complete.

Performance tests were scored as last surface score divided by underwater score. Underwater performance in this context is defined as the extent of the individual's ability to make full use of his resources as they are presumably measured by his performance on the surface. Ratio scores were thus used as an index of the individual's adaptation to immersion. In the case of the reasoning test, scores obtained from the last surface application of the test (S_3) were used in computing the ratio.

(b) Criterion 2 : Criterion 2 comprised observations (by one of the authors), comments on the effectiveness of NDT methods by the instructor responsible for the experimental group, and quantitative measures of arousal and performance.

During analysis of Criterion 1 results it emerged that the manual dexterity test was rendered invalid as a measure of adaptation by some low scores believed to result from finger numbness rather than from lack of underwater adaptation; this measure was therefore excluded from the second criterion.

Increases in heart rates and underwater performance (ratio of reasoning test scores) were measured as before. The surface score for the latter was obtained from the application of the reasoning test for the fourth time, on the surface (S_4), a day before underwater testing.

In order to determine whether diver training resulted in a general increase in resistance to stress, and whether the different methods of training resulted in different levels of such stress-resistance, an adaptation score was obtained for a diving-related situation.

Subjects were seated in a compression chamber which was then filled to a pressure of 5 ata., equivalent to ambient pressure at a depth of 132'. This pressure is sufficient to induce mild effects of nitrogen narcosis (4), an inevitable concommitant to dives at this depth. A cognitive test was applied in the compression chamber and an adaptation score was derived as surface score divided by the in-compression score.

3.3.3 The sample

At the start of the course both groups consisted of 12 young male subjects, aged 17 to 19 years.

As two subjects failed in the first two weeks and individuals were medically unfit at times, the number of subjects tested on different occasions varied.

3.4 Results : Criterion 1 :

3.4.1 Observations

(a) Attendance : At the end of the first two weeks of training all trainees in the experimental group were actively engaged in diving whereas the traditional group had lost two trainees, one a permanent drop-out due to "claustrophobia"* and one who resigned voluntarily for "being unable to take it"*. The two failures constitute a 17 per cent loss.

(b) Reports by others : Instructor assistants who were initially strongly in favour of the traditional methods (probably because they themselves were trained that way) reported to one of the authors that they were favourably impressed with the speed at which trainees adapted, and with certain techniques,

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*Instructors' diagnoses.

particularly the "dry land practice", i.e. the repetition of diving skills (pneumatizing, clearing mask, sharing air, etc.) on the surface before application underwater.

When asked for their opinions on the NDT training, trainees were unanimously positive. They felt it gave them time to get used to the water and their equipment. Several trainees mentioned that they felt confident underwater and were ready to progress to other training activities at the end of two weeks.

Some caution should be exercised in accepting these reports as neither trainees nor instructor assistants had a broad experience on which to base their judgements.

(c) Morale : One of the authors, who attended both groups' activities, formed the impression that the morale in the experimental group was markedly higher than in the other. The experimental group was more talkative, there was more bantering and mutual assistance in adjusting equipment and experiences in diving were more freely discussed. In addition leadership roles became more quickly and easily established. It is likely that the daily group discussions held by the experimental group contributed substantially to the sound interpersonal relations necessary for a good morale level. Again it should be noted that some caution is required in accepting this observation, group morale may change considerably during the remaining five weeks of training and accidental group composition must affect morale level.

(d) Applicability of NDT methods : No obvious flaws emerged in the application of NDT to the 17 to 19 year old National Servicemen sample. It appears to be as applicable to this age group as to the university graduates on which it was developed. On the other hand the amount of assistance one of the authors was required to provide clearly indicated that an instructor cannot be expected to apply the system unless he has had thorough training in both the theoretical and applied aspects of NDT methods.

3.4.2 Quantitative measures

(a) Reasoning test : Group means and standard deviations (in brackets) of adaptation scores were 1.20 (.12) for the E (experimental) group and 1.26 (.28) for the T (traditional) group (N = 12 and 9 respectively). As a high ratio indicates relatively poor underwater performance, the E group fared slightly better. The difference between the groups, as assessed by the Mann-Whitney U test (5), was not significant at the .05 level.

(b) Manual dexterity test : Group means and standard deviations of surface scores on the test of manual dexterity were 4.3 (2.2) mins. for the E group and 4.3 (0.8) mins. for the T group. Underwater the E group mean and S.D. were 6.9 (1.8) mins. and the T group mean and S.D., 9.4 (5.6) mins. From the values of the means it would appear that the T group showed a greater drop than the E group; however, this drop was inflated by particularly long assembly times by two individuals who complained of finger numbness after immersion in the cold water. As expected, the two low scores lead to a comparatively high standard deviation for the T group underwater trials.

(c) Heart rates : Table 1 shows the control and pre-dive heart rate means and standard deviations.

	Control	Pre-dive	n
E group	66 (10.9)	87 (12.2)	12
T group	67 (7.0)	106 (9.0)	10

TABLE 1

Means and S.D.s in control and pre-dive heart rates

Whereas control values for the two groups were similar, both means increased prior to diving. To compare differences in heart rates for the two groups, each individual's increase from control to pre-dive was established and the increases for the two groups were compared by means of the Mann-Whitney U test (5). According to this test the increases were significantly greater for the T group ($p < .01$).

(d) Discussion of hypothesis 1 : The first hypothesis is fully confirmed. As predicted, the performance of the two groups was roughly equivalent in terms of the adaptation score, with the E group showing a slight and non-significant superiority. Anxiety in connection with an anticipated dive existed for both groups but significantly more so for the T group than for the E group ($p < .01$).

These results indicate that NDT methods succeeded in creating a climate of lower psychological cost for the diver trainees, and that this tended to be associated with higher performance, in spite of the advantage by the T group of a total immersion time five times that of the E group.

3.5 Results : Criterion 2 :

As pointed out in the introduction, the flexibility-training period between the second and seventh weeks was not conducted according to NDT methods and followed traditional methods. Performance and arousal measures in the seventh week therefore merely reflect the long-term benefits of training during the first two weeks. Moreover, by coincidence, one flexibility training exercise scheduled for the E group-dives in cold and dirty water was actually carried out by the T group at Saldanha Bay.

3.5.1 Observations

(a) Observations by one of the authors

(i) Group morale : To all appearances the group morale was even higher for the E group, comparative to the T group, than at the end of two weeks. In the test situation E group trainees would talk to each other, frequently make jokes, voluntarily assist each other in handing up test equipment and assist the instructor in preparing the test material. In the same situation the T group trainees would sit quietly while awaiting their turn to be tested. While they also assisted the tester and each other, this was only done after the instructor had told them to do so. The observer gained the impression that in the E group the focal point of member orientation was the group itself and the primary concern was the completion of tasks. In the T group the instructor was the focus of attention and the primary concern was with carrying out instructions. It follows that, in the absence of the instructor, the E group was more independent and more effective in carrying out a diving operation.

(ii) Attendance : No trainees dropped out after two weeks of training. By the end of the course the T group had lost two divers while the E group had lost none. While it appears that the E group is less likely to lead to failure, this may also be due to mismatching of the groups or differences in instructor standards. Furthermore, it may be argued that the T group uses training to eliminate weaker candidates.

(b) Observations by the instructor

The instructors report is repeated verbatim :

"1. This course consisted of 2 classes, with 12 ratings in each, and was held from 16.3.70 to 17.7.70.

2. The "A" class, trained by PO Liebenberg, followed the normal training procedure and were worked hard right from the start of the course. The "B" class, trained by CPO Vrey, used a modified training routine, as suggested by the NIPR. Here the class was gradually introduced to new skills, and was given time to discuss and analyse difficulties, thus gaining confidence. The tempo of work was speeded up in the later stages of the course.

3. The following points are noted in connection with the "B" class :

a. The reduced physical and mental stress was obvious from their pulse rate and other tests, and also from the calm manner in which the divers entered the water.

b. Morale in the class was high, and their attitudes to diving and the hard work involved most gratifying.

c. Learning occurred easily and successfully.

d. Because of the lower rate of progress, not quite so much diving practice as usual could be included in the course.

e. The overall examination results were not quite up to those of the "A" class, but this was to be expected as the "A" class were of above average ability and intelligence, while the "B" class were average.

4. The indications should be more marked even, with PF classes, and it is felt that this change in training procedure will be of great benefit."

Comments on the report

Point d. The course was largely slowed by the fact that a new training schedule was introduced. It is expected that future courses will not involve a loss in diving time.

Point e. While this statement may be quite valid, it would be necessary to have one examination for both groups before definite conclusions can be drawn regarding differences in academic proficiency. In respect of the groups studied, each instructor set and marked the examination papers for his group.

3.5.2 Quantitative measures

(a) Reasoning test

The slight lead held at the end of two weeks by the E group in respect of the Reasoning test performance ratio was increased. At the end of the course the E group obtained a mean of 1.14 (S.D. = .24, n = 12) and the T group a mean of 1.23 (S.D. = 2.5, n = 10). The difference between the means does not reach the .05 level.

To show performance trends over the whole course, results of the reasoning test are shown in Figure 2.

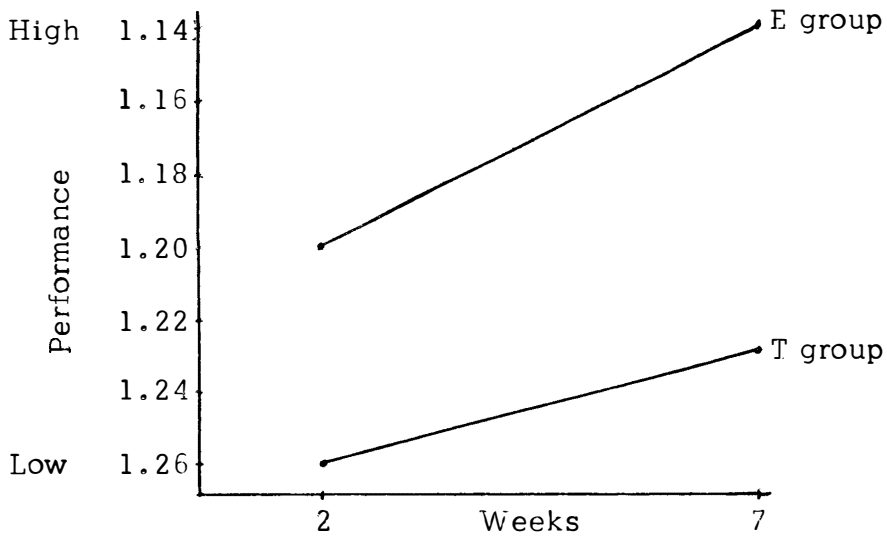

Figure 2. Mean group scores on the reasoning test : E and T groups after 2 and 7 weeks of training

While statistical comparison does not reveal the significance of difference needed to confirm the hypothesis (possibly due to the small size of the samples) the trends in performance clearly follow the expected course.

(b) Heart rates

Table 2 reflects the pre-dive values obtained at the end of the course. Control values are those obtained at the end of two weeks.

	Control	Pre-dive	n
E Group	66 (10.9)	72 (7.7)	12
T Group	67 (7.0)	84 (6.5)	10

TABLE 2

Pre-dive heart rates at seven weeks and control values (means and S.D.s)

Although heart rates dropped for both groups from the second to the seventh weeks, according to the results from application of the Mann-Whitney U test, the increases for the T group were still significantly higher than those from the E group ($p < .05$).

Control and pre-dive heart rates for the second and seventh weeks are shown in Figure 3.

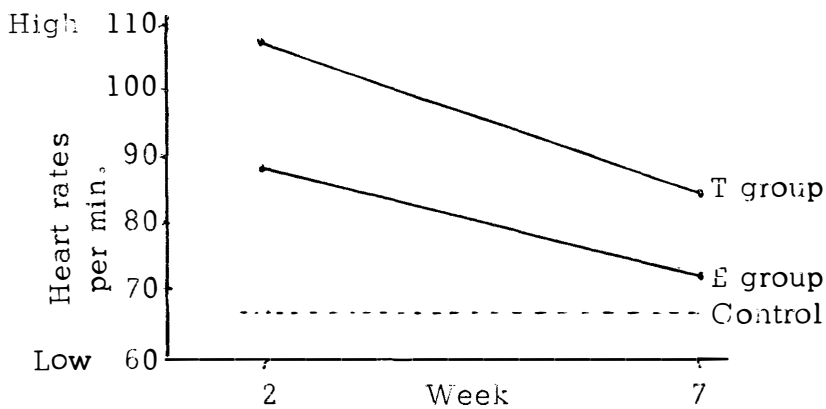

Figure 3. Pre-dive heart rates at two and seven weeks, and control values

In as much as pre-dive increases in heart rates indicate the degree of anxiety experienced in anticipation of the dive*, the T group was significantly more anxious than the E group throughout the course.

(c) Discussion of hypothesis 2

This hypothesis is partly confirmed. Underwater performance followed the predicted course; however, the difference between the two groups was not statistically significant, either because the difference is really not all that large or reliable, or because of the small sample sizes, or both.

*With physical effort before measurement held at a minimum.

The T group was, and remained, significantly more anxious than the E group. It is expected that the anxiety will have become irrevocably associated with immersion, and that this will impair performance in the diver when he encounters diving stressors not met with in immersion. As an example of such a stressor, subjects were submitted to compression in a chamber and tested under pressure. This experiment is described in the following section.

3.5.3 Compression chamber experiment

In order to measure decrement in performance resulting from compression to 5 atmospheres absolute (equivalent to 132 ft.), a cognitive test developed for this kind of situation, the Letter Series Test, was applied. This test is described in Appendix III. The Letter Series Test was applied once on the surface and once in the compression chamber at maximum pressure. A ratio score was derived as surface score divided by in-compression score.

It was evident that the subjects all experienced nitrogen narcosis in the chamber. The usual laughter, shouting and swearing indicative of nitrogen narcosis was heard over the inter-communication system linking the subjects with the personnel outside the chamber.

Table 3 shows the means and standard deviations of scores given by the E and T groups before (control) and during compression.

	Control	In-compression	n
E group	18.2 (4.6)	20.2 (6.6)	10*
T group	18.8 (4.8)	14.0 (4.8)	9

TABLE 3

Means and S.D.s obtained by the trainee groups on the Letter Series Test before and during compression

Means and S.D.s of the ratios of surface/in-compression performance are 1.00 (.43) for the E group and 1.26 (.33) for the T group. The in-compression performance was equivalent to surface performance by the E group but the T group scored lower in compression than on the surface. According to the Mann-Whitney U test the difference in means is significant ($p < .01$).

The compression study clearly showed that when both trainee groups were subjected to a novel situation, which was closely related to diving in that the subjects experienced increased ambient pressure, the E group subjects exercised greater inner control over themselves. Putting it another way, the resistance to stress learned in diving successfully carried over into a diving-related situation. It can be expected that the same control will transfer to performance in the presence of other diving stressors, viz. cold, low visibility, etc.

To show the relative positions of the groups in terms of all three performance measures, the scores are plotted in Figure 4.

*Three of the total group were not allowed to take part because an ear examination revealed infections.

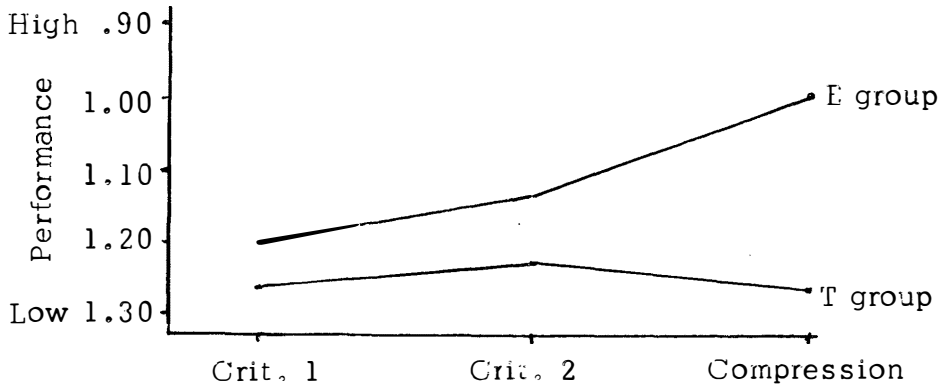

Figure 4. Comparison of performance by groups E and T : Mean ratios on three performance criteria

3.6 Discussion :

The results of this study suggest that training based, even partly, on NDT principles, leads to superior performance and lower anxiety in comparison with traditional training methods.

Supportive evidence was found for the rationale that underlies NDT principles, viz. that such techniques as self-pacing, frequent feedback, cathartic group discussions, etc., facilitated adaptation to immersion. Furthermore, it was shown that this approach lead to an increase in general stress-resistance as measured in the compression chamber experiment. This finding contradicts the generally held view (e.g. Miles, 4) that the stress-resistance of an individual is correlated with the amount of stress he encounters in diver training. This is not intended to imply that the trainee should under no circumstances be stressed; on the contrary, the whole idea of flexibility training is to train the diver to cope with increasingly difficult and dangerous situations rather than to make life difficult from the word 'go' and hope he copes.

If the NDT methods had no inherent advantages for diver training over traditional methods, the latter should have been followed by superior performance for the following reasons :

(i) The E group was subjected to 'adaptation' training but not to 'flexibility' training. (Roughly speaking, the former is intended to reduce anxiety and the latter to enhance the ability to cope in a variety of situations.) This was not the fault of the instructor who was not trained at the NIPR in NDT methods, but was due to the fact that Diving School administration assigned the instructor trained in NDT methods to another course at a critical stage. Also, the traditional course included an exercise, not normally included in training, which was scheduled for flexibility training but was not carried out.

(ii) The 'traditional' group spent more time underwater than the experimental group, both at two weeks (13 hours versus 2.5 hours mean diving time) and at seven weeks (approximately 50 hours versus 22 hours mean diving time). Usual mean diving time at the end of the traditional course is approximately 30 hours. A lower diving time is not intended by NDT methods; no doubt times will increase as instructors become familiar with NDT methods.

(iii) As a result of the loss of two divers, who were presumably poor diver material, the potential of the traditional group rose. Criterion data were thus obtained from the ten best out of twelve divers whereas the experimental group retained the full range of diver material.

3.7 Conclusions :

The stated hypotheses were supported by the data. Both the observations and the quantitative data indicate that divers trained by NDT methods tend to be more effective performers than those trained by traditional methods.

3.8 Recommendations :

It is recommended that NDT methods be applied to future Diver 3 courses at Simonstown.

A decision to this effect would have to be taken on the basis of results contained in this report. It is not considered practicable to replicate this study unless assurances can be given that training research will in future be given sufficient priority to avoid the difficulties experienced on this course.

It is further recommended that, should SAN wish to continue with NDT principles, instructors be trained by the NIPR.

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APPENDIX I

BADDELEY REASONING TEST

The test consists of 60 items, each a statement about a pair of letters (AB or BA) which, in describing the order of these letters, is either true or false.

			T	F
e.g.	1.	A precedes B - AB	x	
	2.	B does not follow A - AB		x

The score consists of the number of items answered correctly in three minutes.

Reported test-retest reliabilities are of the order of .80 plus. Practice effects are small after the first trial.

APPENDIX II

MANUAL DEXTERITY TEST

The subject is given a flat perspex plate (approx. 6" x 10" x $\frac{1}{2}$") drilled with two sets of 15 holes. The subject's task is to transfer 15 bolts and nuts from the one set of holes to the other set by unscrewing a nut, transferring the bolt to a hole on the opposite side of the plate and screwing the nut up against the plate.

The score consists of the time taken to transfer all bolts and nuts.

APPENDIX III

LETTER SERIES TEST

Two parallel forms of the test, Letter Series I and II, each contain 30 items.

An item consists of a series of five letters, e.g. CHLSW. The subject's task is to consider each pair of adjacent letters, i.e. C and H, H and L, etc. If a pair of letters follows alphabetical order, the value +1 is assigned to the pair. A letter pair opposite to the order is given the value -1.

Without writing down the individual values, the subject progresses through the letter pairs, recalling and summing values to obtain the final answer as one of the following alternatives - +4, +2, 0, -2 or -4.

The number of items correctly completed in 5 minutes constitutes the subject's score.

APPENDIX IV

CRITERION DATA FOR EXPERIMENTAL AND CONTROL GROUPS

		Criterion 1						Criterion 2				
		Manual Dexterity		Reasoning Test		Heart rate		Reasoning Test		Digit Series		Heart rate
		Mins.		Items		Per min.		Items		Items		Per min.
		Surface	Underwater	Surface (T3)	Underwater (T1)	Control	Pre-dive	Surface	Underwater	Surface	Compression	Pre-dive
Experimental group	1	3.6	3.5	17	15	62	108	16	18	10	-*	72
	2	4.6	7.0	22	18	50	61	31	31	20	19	72
	3	3.8	4.5	12	11	60	92	22	18	11	16	76
	4	4.0	7.1	29	29	72	98	35	36	14	22	84
	5	5.3	10	22	7	68	98	28	29	19	18	74
	6	3.9	8.0	17	15	68	88	20	19	19	21	64
	7	3.6	5.5	32	25	68	88	35	29	16	-*	66
	8	5.9	7.0	35	27	56	82	38	28	25	28	66
	9	4.0	6.5	36	30	94	92	38	30	25	28	70
	10	4.2	9.5	18	12	70	88	21	19	18	18	82
	11	4.7	7.0	16	14	58	74	18	19	13	6	64
	12	4.0	6.5	21	17	68	82	28	16	18	26	80
Traditional group	1	4.0	5.6	16	18	-*	-*	29	34	15	16	90
	2	4.9	20.1	21	14	60	106	38	21	16	9	82
	3	-*	-*	-*	-*	-*	-*	28	27	15	11	84
	4	3.3	8.6	40	30	58	86	40	33	18	10	84
	5	5.1	6.4	28	28	88	108	41	36	24	14	80
	6	4.7	6.4	22	26	66	116	26	18	8	-*	94
	7	4.0	87	24	19	64	102	37	35	24	16	74
	8	3.7	6.9	13	10	58	102	22	15	17	14	84
	9	5.7	4.3	27	20	76	106	47	42	27	25	78
	10	3.3	17.9	15	10	64	120	16	13	14	11	94

*Not available (medically unfit)

	ISSUE	RETURN		ISSUE	RETURN