Naval Submarine Medical Research Laboratory

NSMRL REPORT 1193 16 October 1993

PSYCHIATRIC SCREENING FOR THE SUBMARINE SERVICE: ENLISTED PERSONNEL

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Report 1193

NAVSEA Work Request
N0002493WR01142

Naval Medical Research and Development Command
Research Work Unit - 5306

Approved and released by

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SUMMARY PAGE

THE PROBLEM

Psychiatric care is not available onboard submarines. In the stressful environment of a submarine on patrol, it is important that the mental health of the crew be of the highest level. Psychiatric screening for submarine service is, therefore, required.

THE FINDINGS

The Subscreen test for psychiatric screening of enlisted prospective submariners successfully identifies approximately 75% of psychiatric drops from Basic Enlisted Submarine School (BESS). Further research is needed to refine the test and to test its effectiveness for prediction beyond BESS.

THE APPLICATION

Improved psychiatric screening for the submarine service.

ADMINISTRATIVE INFORMATION

This investigation was conducted under Naval Medical Research and Development Command Research Work Unit 5306, NAVSEA Work Request N0002493WR01142, "Subscreen." The views expressed in this report are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. government. This report was approved for publication on 16 Oct 1993 and designated Naval Submarine Medical Research Report 1-93.

ABSTRACT

A brief overview of 25 years of psychiatric screening of enlisted service members for submarine service in the United States Navy is presented. Current screening consists of administration of a submarine specific test, Subscreen, to all prospective Basic Enlisted Submarine School (BESS) candidates. Figures from 1991 and 1992 show that approximately 9.7% of these candidates are referred for more extensive testing at the Psychiatry Department of the Naval Hospital Groton. Less that two percent of all candidates are subsequently dropped from Bess. Two measures of test performance, sensitivity (the ability of a test to yield a positive finding when the individual tested actually has the condition being tested for) and specificity (the ability of a test to yield a negative finding when the individual tested does not have the condition) were studied. Both sensitivity (75%) and specificity (92%) were very good for Subscreen, especially compared to a test the USAF administers for similar purposes. Although some small changes will improve test performance, in general, Subscreen remains an effective tool for screening for Submarine Service.

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PSYCHIATRIC SCREENING FOR THE SUBMARINE SERVICE: ENLISTED PERSONNEL

History of subscreen

A submarine on patrol is a closed environment with limited access to the outside world for prolonged periods. Onboard medical care is available to treat most mild to moderate medical conditions. Psychiatric care is, however, not available. In the sometimes stressful environment of an operating submarine, it is important that the mental health of both prospective and actual submariners be of the highest levels (Weybrew and Noddin, 1979). Psychiatric screening for submarine service was, therefore, instituted early in the development of the submarine service.

The early history of screening for submarine duty has been described by Weybrew and Youniss (1959). In the 1940s testing consisted of the Shock Fusion Time Test, New London NDRC Confidential Questionnaire, the NRC Neurotic Inventory and the Personal Inventory (NDRC Project 44, Div. 7, 1943). The first three of these were eliminated due to length of presentation, lack of specificity or low reliability. The Personal Inventory showed low discriminability between normal and "unsuitable" individuals (Weybrew and Youniss, 1959; Weybrew, 1959). Weybrew and Youniss, therefore, developed the Personal Inventory Barometer (PIB) as a psychiatric screening tool (Weybrew and Youniss, 1959; Weybrew, 1959). This test used all of the questions from the Taylor Manifest Anxiety Scale (Taylor, 1953), but changed the response format to multiple choice rather than True-False responding. Additional questions were added to assess internal validity, attitudes toward submarine life and duty, motivation, suicide ideation, and depression.

The Personal Inventory Barometer became the single psychiatric screening tool used at the U.S. Naval Submarine School for submarine candidates (Weybrew and Noddin, 1969). The PIB, virtually unchanged, was given to all Basic Enlisted Submarine School (BESS) students for approximately 25 years. Demographics, ethical, and social characteristics of society are always in a process of change. Definitions of psychological health also have changed over the last quarter century. In the early 1980's it was recognized that, due to its age, the PIB might no longer be a valid measure of psychological adjustment in incoming students. Work began to develop a new screening test. At the same time, an analysis of causes for premature loss of non-nuclear trained individuals from submarine service was also undertaken (Bryant, 1986). This study showed that early losses were related to problems in BESS, middle losses were related to behavioral and psychological problems during deployment and later losses (greater than 3 years service) were related to misconduct. Motivation was not considered.

Bryant and Noddin developed a test that came to be known as Subscreen. Subscreen currently incorporates sixty percent of the questions from the original PIB but also includes additional questions from the literature on stress and adjustment and questions developed after consultation with BESS instructors and psychologists at the Naval Hospital Psychiatric Clinic. Subscreen and the PIB were administered simultaneously for several BESS classes. After this testing showed that both tests recommended the same people for further psychiatric evaluation and were therefore redundant, use of the PIB was discontinued. Test-retest reliability for the PIB was .80 (Weybrew and Youniss, 1959); test-retest reliability measures for Subscreen are unavailable. One reason for reviewing the development and testing of Subscreen is that

most of this work has been undocumented or unpublished. In the text that follows, the original sources of information are included and noted as unpublished.

Subscreen is given to all BESS students the first week they are at Submarine School. It takes approximately one hour to administer to the students. It is used to screen individuals for psychiatric problems that would preclude successful service in the submarine force. Students whose scores are above established limits are referred to the Psychiatry Department of the Naval Hospital Groton for psychiatric evaluation. Approximately nine percent of the students are referred. Following this evaluation the psychologist gives a recommendation to the Medical Department of the Submarine School. BESS 1992 summary records show that individuals may be recommended for return to BESS (75%), transfer to surface fleet (9.1%), or discharge (15.9%) from the Navy.

THE SUBSCREEN TEST

Subscreen contains 240 items scored on 5 scales comprised of 28 independent subscales and procedural scores. Items that are highly correlated and assess particular aspects of functioning, such as affect or socialization comprise a scale. The scales and subscales are listed in Appendix A.

The individual items are scored with five response categories. Four points are assigned for strongly agree, 3 for agree, 2 for disagree and 1 for strongly disagree. Questions that are worded in a negative manner are reverse scored. Neutral responses are evaluated separately. As of 1992, all scores for an individual are converted to Z scores based on population means and standard deviations from approximately 6000 BESS students. Prior to that date, Z scores were based on means and standard deviations from approximately 800 BESS students tested in 1986. A Z score is a measure of how far an individual score deviates from the average answer.

The scoring also includes further information concerning unusual response profiles, missing responses and indicates individuals who respond in the affirmative to questions relating to suicide and negative attitudes toward use of nuclear weapons. Two other scores measure how an individual describes himself. One, "Good Impression", contains items typically endorsed by someone trying to impress others. The other, "Distortion", a lie score, is also included on the scoring protocol. Factor scores are derived for Vulnerability, Motivation, Depression-suicide, Efficacy (competence), Manipulation and Social Isolation. These factors are also listed in Appendix A. The "Z" attached to each subscale score used in these factors indicates the individual's Z score used in the calculation.

Until early 1994, referrals to the Psychiatric Clinic were determined by a single individual (Mr. Noddin) with considerable experience in this area. In his absence, all Subscreen results were sent to the Psychiatric Clinic where a clinical psychologist reviews them. Heaton (unpublished, 1991) investigated whether a personal computer based expert system could be developed to follow the same rules that were used by Mr. Noddin to decide which cases to refer. She was able to develop a set of 31 rules which could reproduce referrals with a high degree of both sensitivity (98.9%) and specificity (96.8%). These rules are applied to the answers to two questions, the Z scores of 15 subscales and the percentage of missing and neutral responses. None of the submarine specific motivation subscales were used as a basis for referral by the screening psychologist and none are included in the expert system. The rules developed by Heaton are the current basis for referral by the NSMRL tester. A computer decision algo-

rithm has not been implemented in the scoring routine. An on-going NSMRL project is comparing an expert system to a neural nets approach for determining referrals.

The Psychiatry Department at the Naval Hospital Groton considered using the Minnesota Multiphasic Personality Inventory (MMPI) or another commercial test (J. Wallace, personnel communication, 1992) and is satisfied with Subscreen as a screening test. Interview of the clinical psychologist at the Psychiatry Department revealed that using standard scoring protocols the MMPI yielded "too high" a rate of referrals to the department and also took much longer to administer (2-3 hours) than Subscreen. A revision of the original MMPI, the MMPI-2, is currently used at the Psychiatry Department as a clinical instrument to provide further information to the clinician on referred individuals. The MMPI has also been found by the Canadian Forces to be inappropriate as an assessment tool for psychological fitness of applicants for Canadian Submarine service (Okros, 1989) for the same reasons. The same conclusion was reached by the US Air Force (Bloom, 1983). While use of revised norms would reduce the number referred, it would still take longer to administer and score the tests. Other established tests such as the California Psychological Inventory, Taylor Manifest Anxiety Test and the Gordon Personal Profile have not been tested for this specific use. The Air Force and the Navy are currently using the NEO-Personality Test Five Factor Inventory (Crawford and Fiedler, 1991) as the second step of basic recruit screening. Another important consideration is that the MMPI-2 and other commercial tests do not address either Navy or submarine specific motivation issues.

Reliability of subscreen subscales

Katz and Rexer (unpublished, 1990) assembled a data set of approximately 6000 men who took Subscreen at BESS between June 1986 and February 1990. The internal consistency of the subscales was assessed. New means and standard deviations for the subscales were also calculated. The reliability of subscales is measured by performing an item analysis on the components of the subscale. This analysis determines to what degree the items that make up a subscale are related (correlated). Cronbach's alpha, equivalent to the average split-half correlation, was used as the measure of reliability of the subscales (Cronbach, 1951). Alpha scores can range from 0 to 1.0. The higher the number the greater the reliability. Table 1 shows the mean, standard deviations, number of questions in the subscale and the alpha statistics for each subscale.

These data show that most of the subscales have reasonably high reliability (over .70). Only three subscales, Uncertain about Submarines (UNS), Problems Submarine School (PSS), and Self-Criticism (SCR), showed low reliability. One subscale, Coercive Attitudes (COE), showed a large number of failures to respond. Five other subscales showed problems with one or two items. These were Unconditional Acceptance of Submarines (UCS), Social Isolate (SOI), Impulsive (IMP), Dependency (DEPND), and Competency (COM). Katz and Rexer conclude these could all be improved by deletion or modification of these problem items. This process would increase the reliability of the associated subscales and not affect the overall utility of Subscreen.

Katz and Rexer (unpublished, 1990) also found differences between the means and standard deviations for subscales obtained for the original 1986 sample and for the larger sample they used. Ten of the subscales showed response patterns that suggested that the original scoring program should be revised. The Z scores for each subscale were

calculated using the original means and standard deviations. If the original values were still accurate the mean Z scores for each subscale for the new sample should be zero. Rather small departures were found for some subscales while considerably larger changes were found for others. Departures from a Z equal to zero were found for Impulsive (IMP) (.144), Social Isolate (SOI) (.056), Nervous or Worrying (ANX) (.054), Unusual Thoughts (BTH) (-.062), Claustrophobic Feelings (CLA) (-.063), Uncertainty About Subs

Table 1
Reliability for Subscreen Subscales

Subscale	Mean (M)	SD	No. of Questions	Alpha Reliability
Procedural				
Distortion	23.34	3.0	8	.71
Good Impression	38.8	3.7	12	.79
Submarine Specific Motivation				
Mistake Joining Subs	13.9	3.5	8	.80
Uncertain About Subs*	14.2	2.4	6	.46
Conditional Acceptance Subs	9.6	2.4	5	.72
Unconditional Acceptance Subs***	24.7	3.5	8	.76
Problems Submerging	7.9	1.8	4	.67
Problems Submarine School*	14.4	1.6	6	-.01
Affective				
Physical Well Being	15.0	9.2	9	.73
Low Situational Control	21.5	3.8	10	.76
Nervous or Worrying	24.6	4.0	11	.77
Depressed Mood	16.1	3.9	9	.86
Socialization				
Coercive Attitudes**	28.6	4.1	14	.72
Aggressive/Destructive	17.11	3.2	9	.73
Problems Home/School	20.8	4.2	11	.76
Social Isolate***	25.3	3.7	12	.63
Impulsive***	27.7	3.8	12	.65
Social Support	28.1	3.3	9	.68
Additional				
Unusual Thoughts	15.5	3.0	8	.73
Unusual Physical Complaints	9.6	2.2	6	.77
Suicidal Thoughts	9.1	2.4	6	.78
Claustrophobic Feelings	11.5	2.3	6	.74
Problems Nuclear	10.1	2.5	6	.63
Dependency***	25.7	3.6	11	.67
Self-Criticism*	21.6	2.3	9	.14
Competency***	21.6	2.4	7	.60

* Subscales with low reliability
** Subscale with failures to respond
*** Problems with one or two specific questions used in subscale

(UNS) (.398), Problems Nuclear (NUC) (.071), Problems Submarine School (PSS) (.384), Dependency (DEPND) (-.063), and Self-Criticism (SCR) (-.134). The new means and standard deviations were incorporated into the scoring program currently in use in 1992.

Subscreen and Psych Drops

Overall Performance

The majority of submarine candidates volunteer for submarine service either at the time they are recruited or following completion of Basic Recruit Training. Volunteers are also accepted from other segments of the Navy. Most BESS students, therefore, are younger than 20 years of age and in the lowest three military paygrades. Losses from BESS occur due to psychiatric disqualification and for medical, academic and motivational reasons.

Subscreen was developed to screen BESS students for motivational, affective and social problems that would preclude successful service in the submarine force. Although the test was developed with numerous scales, some of these scales (motivation) are not used in the decision process. Only three scales and a few additional items on Subscreen are currently used by NSMRL to refer students to the Psychiatric Department. These scales are composed of questions that measure affect and socialization. Subscales that measure unusual thoughts (bizarre cognition), unusual physical complaints, and claustrophobia are also used. These are listed under additional subscales in Appendix A. Positive answers to questions concerning suicide and negative feelings about serving in a force with nuclear weapons are also immediate grounds for referral. Although part of the scoring protocol includes factor scores with the weights as determined by multiple regression analysis, these are not currently used in the decision process for referral.

Figure 1 shows the results of the multiple regression analysis performed by Katz and Rexer (1990) to predict psychiatric drop status from BESS in a cohort of approximately 650 of the more recent cases from the same file used to analyze the reliability of the subscales. The coefficient of determination,

BESS PSYCH DROP = 0 - NORMAL
1 - PSYCH DROP

AFFECTIVE VARIABLE SCORE $r^2 = .128$ $df = 484$

PSYCH DROP = .029 + .031 (PWL) + .028 (SUI) + .014 (LOC) - .015 (BTH)

MOTIVATION VARIABLE SCORE $r^2 = .146$ $df = 486$

PSYCH DROP = .033 - .031 (UCS) + .022 (NUC) + .025 (MJS)

SOCIALIZATION SCORE $r^2 = .074$ $df = 501$

PSYCH DROP = .029 + .027 (PHS) + .024 (SOI)

Figure 1. Multiple regression to predict BESS psych drops (Katz and Rexer, 1990).

r^2, ranges from 0 to 1.0. It is close to 1.0 if the variables in the variable set are good predictors of psychiatric drop status. The Affective, Motivation and Socialization results for Subscreen are shown. These r^2s reflect the criteria used to refer individuals for evaluation. Because the affective and socialization scores are primarily used for these referrals they show the highest predictive values; because motivational scores are not used as a basis for referral, they show the lowest. These results should be looked at somewhat critically as only 13 psychiatric drops were included in the analysis. As would be expected the r^2 are low under these circumstances.

The Naval Submarine Medical Research Laboratory (Schlichting and Noddin, unpublished, 1992) recently evaluated all psychiatric drops from BESS for FY91 and FY92. A total of 3360 students were screened using Subscreen in FY91; 2166 in FY92. Slightly less than 10% were referred to the Psychiatry Department for evaluation; 1.7% of the total 5526 were dropped through the use of Subscreen. An additional .6% were dropped through other referrals. Subscreen referrals constitute 75% of the psychiatric drops from BESS for the two years. Comparable figures for AFMET, the Air Force Screening program, show that only 22% of the Psychiatric drops during the first six weeks of USAF training were identified by their testing protocol (Crawford and Fiedler, 1991; E. Fiedler personal communication, 1992). The final percentage of recruits dropped for psychiatric reasons is much lower, .4%, for Air Force basic training versus 2.3% for Submarine School students.

To evaluate screening tests one can compute several measures of test performance (Woolson, 1987). Sensitivity is the ability of a test to yield a positive finding when the individual tested actually has the condition for which he or she is being tested. Specificity is the ability of the test to yield a negative finding when the individual does not have the condition. Different screening levels or cutoff scores for what is considered a positive finding can be developed depending on the relative importance of detecting the condition and falsely declaring the condition. Positive predictive value of a test is the probability that a person who has a positive test has the condition. Prevalence of the condition in the population affects positive predictive value. Negative predictive value is the probability that a person who has a negative test does not have the condition. Appendix B contains a more complete description of these measures and their calculation.

The combined Subscreen data for FY91 and FY92 described above showed a sensitivity of 75%, a specificity of 92%, a positive predictive value of 17.4%, and a negative predictive value of 99.4%. Comparable AFMET data for the period 1975 to 1982 for Air Force basic recruits shows a sensitivity of 22%, specificity of 98.9%, a positive predictive value of 26.9% and a negative predictive value of 98.9%. While Subscreen is better at identifying people with psychiatric problems, AFMET is better at identifying people who do not have a psychiatric problem.

Internal Performance

Analysis of variance was performed on each Subscreen subscale and factor for the FY91 results to determine whether there were significant differences among all the actual Psychiatric drops identified by Subscreen (n=55), a random sample of the individuals referred by Subscreen who were not dropped for psychiatric reasons (n=101), all those dropped for psychiatric reasons who were not referred by Subscreen (n=21), and a random sample of those who were not referred by Subscreen and not dropped for psychiatric reasons (n=142).

Table 2.
Univariate F-Tests with (3,315) Degrees of Freedom

VARIABLE	*F*	*p*
AGE	.41	.74
EDUCATION	2.63	.05
PROFILE	20.03	.001
NEUTRAL%	5.90	.001
MISSING%	.34	.79
PROB	49.70	.001
Procedural		
Distortion	19.35	.001
Good Impression	16.53	.001
Classification	46.24	.001
Extreme Scores	.22	.88
Submarine Specific Motivation		
Mistake Joining Subs	62.44	.001
Uncertain About Subs	67.42	.001
Conditional Acceptance Subs	7.6	.001
Unconditional Acceptance Subs	64.89	.001
Problems Submerging	54.42	.001
Problems Submarine School	21.42	.001
Affective		
Physical Well Being	43.39	.001
Low Situational Control	72.36	.001
Nervous or Worrying	53.08	.001
Depressed Mood	68.18	.001
Socialization		
Coercive Attitudes	29.27	.001
Aggressive/Destructive	31.97	.001
Problems Home/School	57.8	.001
Social Isolate	29.65	.001
Impulsive	32.29	.001
Social Support	24.27	.001
Additional		
Unusual Thoughts	58.46	.001
Unusual Physical Complaints	31.31	.001
Suicidal Thoughts	65.74	.001
Claustrophobic Feelings	45.78	.001
Problems Nuclear	26.88	.007
Dependency	19.13	.001
Self-Criticism	24.13	.001
FACTORS		
Vulnerability	77.53	.001
Negative Motivation	92.86	.001
Depression/Suicide	59.24	.001
Competence	13.35	.001
Manipulation	32.61	.001
Isolation/Social Support	40.51	.001

Table 3.
Subscreen Z Scores.

Subscreen Psych Drop	Yes Yes	No Yes	Yes No	No No
Scale				
Procedural				
Classification	3.13*	.36	.73**	.00
Extreme Scores	.12	-.03	.06	.01
Distortion (Lie)	-.94*	.37	-.50*	.16
Good Impression	-1.18*	.09	-.46**	.02
Submarine Specific Motivation				
Mistake Joining Subs	2.68*	.41	.67**	-.04
Uncertain About Subs	2.02*	.47	.97*	.15
Conditional Submarine	2.28*	.79	.58	.30
Uncond. Submarine/Pro SubSchool	-2.21*	.42	-.45**	.19
Problems Submerging	1.18*	.62	.54	.17
Affective				
Physical Well-being	1.67*	-.28	.39	-.17
Low Situational Contro	1.79*	.06*	1.02*	-.21
Nervous or Anxious	1.43*	.04	.93*	-.21
Depressed Mood	1.91*	.14	.97*	-.24
Socialization				
Coercive Attitudes	1.30**	-.03	.94**	-.1
Aggressive/Destructive	1.13**	-.01	.83**	.27
Problem Home or School	1.50*	.14	1.00*	-.15
Social Isolate	1.07**	0	.85**	-.20
Impulsive	1.03**	.10	.96**	-.10
Social Support	-1.15**	.11	-.83**	.12
Additional				
Unusual Thoughts	1.46*	-.11	.84*	-.30
Unusual Physical Complaints	1.56*	.43	.52	-.05
Suicide	2.13*	.12	1.01*	-.25
Claustrophobia	1.78*	.20	.58	-.23
Problems with Nuclear	1.80*	.32	.58	.08
Dependency	.84**	.00	.61**	-.28
Self-criticism	.01	-.17	.65*	-.35

* Group differs from all others at $p < .05$
** Group differs from No/Yes and No/No at $p < .05$

The groups did not differ in age, education, number of neutral responses, number of extreme scores or number of missing responses. For all other subscales and factors there were statistically significant differences across the groups at the $p < .007$ or better level. These results are shown in Table 2.

Post hoc Newman Keuls tests showed that for most subscales the group that was referred

and dropped differed from both other groups that were not referred. The single exception was the self criticism (SCR) subscale. The group that was referred and dropped did not differ from the group that was referred but not dropped, on most of the Socialization subscales and on the dependency subscale of the Additional Scale. This is not surprising because these subscales are used as the basis of the referral decision. The two referred groups did differ on the all other subscales. Table 3 shows the results of all scales and subscales. Table 4 shows the results for the six factors. As noted above, Appendix A contains descriptions of each of the subscales. In each table, data are shown for the group that was referred by Subscreen and dropped for psychiatric reasons (yes/yes), the group that was not referred and was dropped for psychiatric reasons (no/yes), the group that was referred and not dropped (yes/no), and a group that was not referred and not dropped. A single asterisk is used to denote a group that differed significantly from all three other groups. A double asterisk is used to denote referred groups that differed only from the two groups that were not referred. For most subscales there appears to a hierarchy of scores. The group that was referred and dropped shows the largest Z scores (that is, they are the "most abnormal"); the group that was referred but not dropped shows intermediate Z scores. The groups that were not referred show the smallest Z scores and do not differ from each other.

The results of the analysis of variance reported above suggest that a set of discriminating variables could be developed that would more accurately determine which individuals should be referred to the Psychiatric Clinic for evaluation. A discriminant analysis (WILKS method) was performed to determine if there was a linear combination of subscale, demographic and factor scores that could discriminate between individuals who were referred and dropped and those who were referred and

Table 4.
Factor and other scores for SUBSCREEN

	SUBSCREEN FACTORS			
Subscreen Psych Drop	Yes Yes	No Yes	Yes No	No No
Vulnerability	1.54*	-.14	.94*	-.37
Motivation	2.70*	.26	.72*	-.22
Depression/Suicide	2.01*	.26	.77*	-.11
Competency	-1.08**	.02	-.32	.00
Manipulative	1.17**	-.17	.89**	-.24
Isolation vs Support	1.43**	.03	1.14**	-.06
	OTHER SCORES			
Problem	2.49*	.26	1.52**	-.19
Motivation	3.72*	.26	.66**	-.15
Affective	4.89*	-.13	1.86**	-.24

* Group differs from all others at $p < .05$
** Group differs from No/Yes and No/No at $p < .05$

not dropped. Table 5 shows the classification of individuals as a result of the discriminant function coefficients developed in this analysis. This table shows how well the discriminant function performs in discriminating drops from non-drops in this sample. Only students for whom a score was available on all subscales are included. Figures are included for the percentages of each group predicted to fall in each category by the function.

Discriminating variables included Good Impression, Mistake Joining Subs, Problems in Subschool, Physical Wellbeing, Low Situational Control, Nervous (Anxiety), Problems at Home or School, Suicide, Self-criticism and Vulnerability. These variables showed excellent discrimination of the two groups. Sensitivity of this function is 82.5%, specificity is 91.7%. Positive predictive value is 70.2% and negative predictive value is 90.6%. 88% of the total group were correctly classified. A second discriminant function analysis was performed to see how well a function could discriminate among those referred and dropped, those referred and not dropped, and those not referred and not dropped. This function correctly classified 83% of the students.

One interesting result of this analysis was that the Submarine Specific Motivational subscales showed better discrimination of drops versus non-drops than either the Affective or Socialization subscales (see Table 3). Students who were referred and dropped show a mean Z score of 2.0 or greater for 5 of the 6 Motivation subscales while the largest Z score for any of the Motivation subscales in the group that was referred and not dropped is less than 1.0, and in the not referred and not dropped group, the largest Z score is .30. This occurs despite the fact that these subscales were not used as a basis for initial referral. This strongly suggests that revision of the process used to refer students to include these subscales could improve the screening process by referring fewer students while keeping a similar number of drops.

One problem with discriminant function analysis is that it maximizes the sources of variance between groups and may include or capitalize on sources of variance unique to the particular data set. This unique variance is unrelated to the variables of interest and does not generalize to a different data set. A discriminant function obtained on one data set must therefore be tested on a different data set to assure that the function is valid. Another test procedure derives the function on half of the available data and tests the function on the other half (jack-knife procedure). Although the

Table 5.
Predictive results of discriminant analysis to discriminate psychiatric drops from BESS referred by Subscreen with individuals referred but not dropped for psychiatric reasons

Actual Group	#Cases	Predicted Group	
		Dropped	Not Dropped
Dropped	40	33 (82.5%)	7 (17.5%)
Not Dropped	85	8 (9.4%)	77 (90.6%)

data included above show considerable promise in being able to refine Subscreen scoring protocols to better predict those individuals who would be Psychiatric drops, further research with a larger data set would be required to accurately determine the best set of discriminant function coefficients. It would also be desirable to perform this analysis on a group of submarine school candidates for which the clinical evaluations were made without access to the Subscreen results. These functions could be incorporated into the scoring program. New norms to calculate the Z scores also need to be computed and added periodically to the scoring routines as the population characteristics change.

Subscreen used to predict passing or failing BESS

Although Subscreen was developed to assess psychological functioning, the possibility that it could be useful in predicting attrition from BESS for all causes has also been studied. Bryant (unpublished, 1987) performed a discriminant function analysis of Subscreen to determine whether it could be used to predict loss from all causes from BESS. Bryant analyzed Subscreen scores from 778 enlisted personnel in BESS. Eleven percent (n=83) of these did not graduate. This analysis included all students who did not complete BESS. Psychological drops were included in this group but were not studied separately. Bryant reported a general discriminant function that had a total canonical $r^2 = .38$ ($p < .001$, df=11). This figure specifies the proportion of variance in either variable which is linearly accounted for by the other. Note that this accounts for approximately 14% of the variance. Most of the variance is, therefore, not accounted for by these variables.

Eleven of the 28 subscales contributed to the general prediction equation. Separate functions for the Affective, Socialization and Motivation scales were also developed. The general predictive equation correctly classified 79% of the group. As Bryant notes, assigning all of the students to the pass group would have yielded a correct classification of 89% of the group. For attrites, 60.2% (n=50) were correctly identified and 19% (n=132) of the non-attrites were incorrectly identified as potential attrites. These data show a sensitivity of 60% and a selectivity of 86%. Positive predictive value, the probability that someone with a loss prediction was actually lost, is 27%.

Bryant concludes that Subscreen "does identify individuals who become attrites". He also concludes that to improve prediction accuracy, further research is needed to develop the most appropriate cutoff scores for the discriminant function. There are several reasons why individuals may not complete BESS. These include not only psychiatric problems but also motivational, academic and personal reasons. It would be naive to expect that a single discriminant function would discriminate among all attrites and non-attrites. Conceivably functions to predict each type of drop from BESS could be developed, but the use of a test designed principally to screen for psychiatric problems would seem inappropriate, and in this attempt, at least, was unsuccessful.

Subscreen used to predict less than honorable discharge

In fact, the possible use of Subscreen for just such a broader screening has been studied. In 1991, Katz (unpublished) examined data from 4695 enlisted men who took the Subscreen inventory in 1986 and summarized performance (attrition, pay grade) data obtained from Naval Personnel Research and Development Command (NPRDC) and Subscreen results using only the multiple regression results determined previously in Katz and Rexer (1990)

for the three scales that best predicted psych drops. He did not perform a multiple regression analysis of the raw item scores or all of the scale or factor scores.

Complete data were available for only 4675 of the people. Sixty-four percent were still on active duty in 1990. Thirty-two percent failed to complete their enlistment; 17.7% left with less than an honorable discharge.

This report looked only at the following Subscreen scores as predictors of attrition:

1. Affective Factor
2. Socialization Factor
3. Motivation Factor
4. Low Frequency (endorses items rarely endorsed by the main population).

The same regression coefficients determined in Katz and Rexer (1990) were used to evaluate discharge type. These were previously shown in Figure 1. The Socialization and Low Frequency scores were the most useful for predicting type of discharge. For the Socialization score the difference between the groups was statistically significant, but amounted to only 15% of one standard deviation (SD). The men in the attrition group also endorsed unusual items slightly more frequently. This result is less predictive than that obtained by Bryant for general Submarine School attrition or by Katz and Rexer (1990) for attrition from Submarine School. Very little of the variance between the groups is accounted for by these two scores, approximately 2%. That means that 98% of the difference between the two groups is not accounted for by Subscreen test scores. The Motivation and Affective scores did not distinguish between the groups for discharge type.

Katz recommends using a Socialization Z score of 1.5 or greater as an "at risk" criterion score for less than honorable discharge. He makes this recommendation because the percent of the individuals obtaining scores greater than this is higher in the Less than Honorable discharge groups (mean 15.8%) than in those still on active duty (1.9%) and those receiving an Honorable discharge (5.7%). The sensitivity (probability of a Z score greater than or equal to 1.5 given that a less than honorable discharge occurred) and the specificity (the probability of Z score less than 1.5 score when a honorable discharge or continuance of active duty occurred) of this recommended cutoff were examined. The sensitivity is very low, 7.6%. The specificity is fairly high, 97%. Specificity is high, of course, because of the large proportion of true negatives. If all the personnel still on active duty who received a score above 1.5 (and, therefore, were classified in the above figures as false positive) did, in fact, later receive less than honorable discharges) the sensitivity only goes up to 23%. In actual figures using this criteria would have correctly recommended that 47 men were at risk of less than honorable discharge; 94 men would have been recommended who did not actually receive a less than honorable discharge, and 564 men who would not have been recommended did, in fact, receive a less than honorable discharge. The remaining 3431 men would not have been recommended for discharge and, in fact, were not discharged. The positive predictive value of this test, the probability that someone with a positive test (Z score > 1.5) was actually discharged less than honorably, is 33%.

These men had already been through several selection procedures including basic recruit training, Subscreen, passing Subschool, etc. As Katz noted, the predictive value of Subscreen is, therefore, less in this group than would be expected if it had not been one of

the earlier selection tools employed. The prediction value also would probably be much higher if separate multiple regressions using all of the data, including demographic information, were calculated for the drop categories of interest.

To date the question of whether Subscreen is able to predict which individuals will become psychiatric disquals during active submarine duty has not been investigated. We are currently performing this research.

Summary and Conclusions

The use of Subscreen during Basic Recruit Training for individuals designated to continue on to BESS would be appropriate. In this context it would be used to screen individuals for referral to a professional psychologist, psychiatrist, or psychiatric social worker for clinical evaluation. Because it has submarine specific motivation subscales that should be used in the referral process, it would only be appropriate for individuals scheduled to attend BESS. Early identification of individuals who are psychiatrically and/or motivationally unsuited for submarine service would save additional training and travel dollars.

For FY91 and FY92, 124 BESS students were dropped for psychiatric reasons. Ninety-three of these were identified by Subscreen. BESS is a 6 week course with an approximate cost of $3724.00 per student (figures on training costs were obtained from Resource/Manpower Analysis Course Costing Branch, NETEMPSA, Pensacola, Florida). Identifying these individuals as unsuitable for submarine service resulted in a cost avoidance of $346,332.00 at BESS alone.

Fifteen BESS students who were already identified as candidates for advanced schools were dropped in FY91 as a result of Subscreen testing. The cost for these 15 students at Basic Electronic Rate Training (BERT), a 14 week course, would have been $12,511 per student, a savings of $187,665.00. For training beyond BERT, such as the Radioman pipeline, the savings per student would equal over $53,400.00; a total of $801,180. This latter example is illustrative. While all 15 men were scheduled for advanced training, not all were in the radioman training group. An additional four of the psychiatric drops were scheduled for guided missile school, and one of the drops was a corpsman scheduled to go to additional training at the Naval Undersea Medical Institute (NUMI). It is likely that at least 14 of the other psych drops would also have gone on to advanced schools at a conservative total cost of over 1 million dollars.

The majority of BESS graduates go on to receive additional training prior to submarine duty. For FY91 46% of BESS graduates reported to Advanced Submarine School for Basic Electronics Rate Training (BERT), 13% reported to an advanced school for guided missile training, 2% reported to the Naval Undersea Medical Institute, and 27% received orders directly to a submarine.

Since motivational factors are not part of the criteria for allowing a psychiatric drop by the Medical Department, many of those interviewed are passed psychologically but are dropped for other reasons. Perhaps an "Assessment Center" approach using information from instructors, administrators and medical (psychiatric) personnel would be useful. Often information about an individual is not known by all concerned in the evaluation process. For example, the clinician may have Subscreen results indicating low motivation, but may not be aware of disciplinary problems which could affect recommendation for drop. This type of approach is feasible for a relatively small command such as BESS, but is less practical for larger groups.

At the present, time Subscreen is not a useful measure for predicting attrition from BESS for other than what are considered to be psychiatric or motivational reasons. Subscreen is also not useful for predicting less than honorable discharges from the US Navy. A combination of Subscreen factors and other information such as AFQT, reading scores, high school class standing, etc. might yield a better prediction of non-psychiatric attrition. There is a long history of Navy research using demographic variables to predict performance and attrition. Numerous Navy and Air Force studies (Jensen, 1961; Noddin, 1969; Lachar, Sparks and Larsen, 1974; Weybrew and Noddin, 1974; McGraw and Bearden, 1988; Crawford and Fiedler, 1991) have identified motivation as a prime cause for unsuitable performance. Analysis of all of the FY91 BESS attrition data showed an additional 16 men were dropped from BESS for motivational reasons. Subscreen may have identified these men, but motivation information is not currently used as a basis for referral so this information was never available to the BESS staff. Individuals who desire to leave the service express this interest early and often. Clearly a good test of motivation would have great utility.

The Navy-AFMET test is currently being given by the Navy as a general screening test. The first phase of Navy-AFMET assesses family, school, legal, alcohol and anti-social problems. It includes demographic information, history of depressive problems and mental health treatment history. In the second screening phase, the NEO Personality Inventory FFI (Costa and McCrae, 1985) is given. This phase addresses issues of neuroticism, responsibility, suicidal ideation, unmodulated anger, perseverance, emotional stability, and self-confidence. At the third phase, an MMPI-2 and clinical interview are given. For the basic Navy population this appears to be a thorough and responsible approach to general screening. Since it has only recently been instituted (October, 1991) at US Navy Recruit Training Centers its specificity, sensitivity, positive predictive value, etc. in this population are unknown. Sensitivity of the Air Force version of the test, AFMET, is low, however (Crawford and Fiedler, 1991).

The submarine environment necessitates additional or revised testing that increases the importance of claustrophobia, sleepwalking, attitudes toward nuclear weapons, and feelings about submerging for extended periods. Claustrophobia (situation reaction) alone accounted for 29 percent of the Submarine School psychiatric attrition for FY91. Sleepwalking accounted for another 2 percent. These items are not adequately covered in a general screening program and must be included in any submarine specific screening program. There is clearly a need to continue to administer Subscreen and/or perform other submarine specific testing. Additional research designed to improve the sensitivity and specificity of Subscreen and to include motivational issues could save the Navy hundreds of thousands of training and travel dollars.

Acknowledgements

The author would like to thank Dr. L. Katz, Mr. E. Noddin, and CAPT P. K. Weathersby for their substantial help during the preparation of this review. Thanks are also due to E. Perkins for clerical support.

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APPENDIX A

SUBSCREEN

Procedural Subscales

GDS	Classification	A derived score that includes the following subscales (described below) - GIM, EXS, DIS, UCS, PSS, LOC, DEP, SOI, SUI, CLA. Different weights are attached to the subscales in computing this score.
EXS	Extreme Scores	Score based on the number of agree strongly and disagree strongly responses.
DIS	Distortion	Eight items related to traits which are desirable to have but which are almost statistically impossible to be found in one individual, e.g., "I am always honest"; "I never take advantage of anyone."
GIM	Good Impression	Twelve items which are socially acceptable and likely to be endorsed by someone trying to impress people, e.g., "I like to look at the positive side of life." "I'm very careful in my work."

Submarine Specific Motivation Subscales

MJS	Mistake Joining Subs	Eight items expressing dissatisfaction with the submarine force and/or the Navy, e.g., "It would take very little change in my life to cause me to leave the submarine service;" "Joining the Navy was a definite mistake on my part."
UNS	Uncertain About Subs	Six items which reflect ambiguous attitudes toward submarines, e.g., "At times I'm not sure I should have volunteered for submarines"; "I really don't know why I'm interested in submarines."

COS	Conditional Acceptance of Submarines	Five items expressing acceptance of submarines if certain conditions are met, e.g., "If my submarine were to be stationed outside the U.S. for long periods of time, I'd feel like quitting;" "If I didn't get my choice of a home port, I'd feel like getting out."
UCS	Unconditional Acceptance of Submarines	Eight items expressing the acceptance of submarines even under negative conditions, e.g., "I believe that even if submariners did not get extra pay, I would still have volunteered;" "I would accept almost any kind of job assignment in order to stay in the submarine service."
PSM	Problems Submerging	Four items related to working/living under submerged conditions on a submarine, e.g., "Working with the same people under the same conditions during long submerged cruises does not appeal to me."
PSS	Problems Submarine School	Six items that address learning skills and self-perception of capacity to do well at submarine school, e.g., "I believe Submarine School will be easy for me."
		Affective Subscales
PWL	Physical Well Being	Nine items related to the individual's perceptions of his health or stamina, e.g., "My health is excellent" (scored negatively) or "I tire very easily."
LOC	Low Situational Control	A group of ten items expressing elements of worry and the feeling that they have little control over the situation they are in, e.g., "I worry too much about things I cannot change;" "Sometimes planning ahead seems impossible."
ANX	Nervous or Worrying	Eleven items related to anxiety and nervousness, e.g., "I am a very nervous person;" "Often I become so upset I find it hard to get to sleep."
DEP	Depressed Mood	Eight items which are normally associated with depression, e.g., "I feel moody and depressed most of the time; Sometimes I get just plain sick and tired of living."

Socialization Subscales

COE	Coercive Attitudes	Fourteen items related to behavior which is not normally accepted by most people and often found in personality disorders, e.g., "I know how to make people feel uneasy when I want to; I can get away with just about anything I want to."
AGG	Aggressive/Destructive	Eight items related to argumentative behavior, fighting, and anger, e.g., "I like to see how far I can push people before they fight back; I have never backed down from a fight."
PHS	Problems Home/School	Eleven items related to negative behaviors or situations in the past, e.g., "I went into the military because I didn't like my home life; When I was going to school, I played hooky quite often."
SOI	Social Isolate	Ten items indicating problems associating with others, e.g., "I have very few ties to other people or places; I don't have many close friends."
IMP	Impulsive	Eleven items related to impulsive behavior, e.g., "I often do things on the spur of the moment without stopping to think; I would do almost anything on a dare."
SSP	Social Support	Ten items indicating emotional support by family or friends, e.g., "My home life was very happy; Many people care about me."

Additional Subscales

BTH	Unusual Thoughts	Seven items - thoughts which most people do not adhere to, e.g., "I think that people often talk about me behind my back; I am afraid of the dark."
BPC	Unusual Physical Complaints	Six items which are infrequently endorsed by most people, e.g., "I am almost always too hot or too cold; I often walk in my sleep."
SUI	Suicidal Thoughts	Seven items related to death or suicidal thoughts, e.g., "I have sometimes thought of taking my own life; I feel the world is not worth continuing to live in."
CLA	Claustrophobic Feelings	Six items related to discomfort in enclosed spaces or crowds, e.g., "I often feel uneasy in a crowd; I often feel cramped and hemmed in when I am in a small room."
NUC	Problems Nuclear	Six items related to fear or dislike of nuclear weapons or radiation, e.g., "I am concerned about the possibility of being exposed to radiation while aboard a submarine; Considering the feelings I have, I might disobey an order to fire a nuclear weapon."
DEPND	Dependency	Eleven items indicating need for social support, e.g., "I become frightened when I feel alone; I am very sensitive to others for signs of rejection."
SCR	Self-Criticism	Nine items that address feelings of self-worth, e.g., "I feel good about myself whether I succeed or fail."
COM	Competency	Seven items related to responsibility, goal setting, and self-image, e.g., "I set my personal goals and standards as high as possible." (Not currently included in printout but discussed in text.)

FACTORS

VUL	Vulnerability	Thirty-three items which reflect locus of control, nervous anxiety, depression, and suicide.
MOT	Negative Motivation	Nineteen items that address attitudes toward the military and submarine service.
DPS	Depression/Suicide	Twenty-four items that reflect self-reported depression and suicide ideation and attitude.
SCN	Competence	Twenty items that measure general competence and efficacy.
MAN	Manipulation	Eighteen items that reflect manipulativeness.
ISO	Isolation/Social Support	Nineteen items which measure social isolation and support.

Other Scores

Problem: Weighted score computed as follows:

$$\text{PROBLEM} = ((-2.25 \times \text{ZPHS}) + (2.19 \times \text{ZPHS}^2)) - 8.27$$

Motivation: Weighted score computed as follows:

$$\begin{aligned}\text{MOTIVATION} = ((&-.31 \times \text{ZMJS}) + \\ &(-1.18 \times \text{ZPSM}) + \\ &(.26 \times \text{ZNUC}) + \\ &(-.49 \times \text{ZUCS}) + \\ &(.31 \times \text{ZPSS}) + \\ &(-1.60 \times \text{ZCLA}) + \\ &(2.01 \times (\text{PXM} + \text{CLA})) \\ &-2.88\end{aligned}$$

Affective: Weighted score computed as follows:

$$\begin{aligned}\text{AFFECTIVE} = ((&-1.75 \times \text{ZDEP}) + \\ &(-2.43 \times \text{ZSUI}) + \\ &(3.40 \times (\text{DEP} \times \text{SUI}) + \\ &(.30 \times (\text{ANX} \times \text{LOC})) \\ &-11.45\end{aligned}$$

Appendix B

Evaluation of Screening Tests

Both a screening test and an actual diagnosis can give either a positive or a negative answer. The screening test may or may not accurately predict the true condition of the individual. The following table shows these possibilities:

		Diagnosis	
		Condition Present	No Condition
Test Procedure	Positive	a	b
	Negative	c	d
	Total	a+c	b+d

The grand total (n) = a+b+c+d

Estimating the Usefulness of a Test

1. The sensitivity of a test is an estimate of the probability of a positive test result given that a psychiatric condition exists.

Sensitivity = a/a+c

2. The specificity of a test is the probability of a negative test result given that no psychiatric condition exists.

Specificity = d/b+d

3. The positive predictive value of a test is the probability that a person with a positive test actually has the condition in question.

Positive Predictive Value = a/a+b

4. The negative predictive value is the probability that a person with a negative test does not have the condition.

Negative Predictive Value = d/c+d

In order to determine a cutting score for any test, one must also know the seriousness for the selection process of the two types of incorrect decisions, false positives, in this case persons recommended for psychiatric evaluation who will not be dropped, and false negatives, people who should have been recommended for evaluation and dropped but were not.

5. The percentage of correct decisions is the number of the cases in which both the test result and the diagnosis agree.

$$\text{Percent Correct Decisions} = (a+d/n) \times 100.$$

6. The Coefficient of practical validity is the difference between number of correct and incorrect decisions.

$$\text{Coefficient of Practical Validity} = (a+d)-(b+c)/n$$

A high positive COPV correlates with overall efficiency in the selection tool.

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SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF THE REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NSMRL REPORT 1193	5. MONITORING ORGANIZATION REPORT NUMBER(S) NA
6a. NAME OF PERFORMING ORGANIZATION Naval Submarine Medical Research Laboratory 6b. OFFICE SYMBOL *(If Applicable)*	7a. NAME OF MONITORING ORGANIZATION Naval Medical Rsearch and Development Command
6c. ADDRESS *(City, State, Zip Code)* Box 900, Naval Submarine Base NLON Groton, CT 06349-5900	7b. ADDRESS *(City, State, Zip Code)* National Naval Medical Center, Bld 1, Tower 12, Bethesda, MD 20889-5044
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Naval Sea Systems Command 8b. OFFICE SYMBOL *(If Applicable)*	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS *(City, State, Zip Code)* Commander, Naval Sea Systems Command Headquarters Washington DC 20362-5101	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE *(Include Security Classification)*
Psychiatric screening for the submarine service

12. PERSONAL AUTHOR(S)
Christine L. Schlichting

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT *(Year, Month, Day)*	15. PAGE COUNT
Interim	FROM ____ TO ____	1993 October 16	28

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
FIELD	GROUP	SUB-GROUP	Psychiatric screening

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

A brief overview of 25 years of psychiatric screening of enlisted personnel for submarine service in the United States Navy is presented. Current screening consists of administration of a submarine specific test, Subscreen, to all prospective Basic Enlisted Submarine School (BESS) candidates. Figures from 1991 and 1992 show that approximately 9.7% of these candidates are referred for more extensive testing at the Psychiatry Department of the Naval Hospital Groton. Less that two percent of all candidates are subsequently dropped from Bess. Two measures of test performance, sensitivity (the ability of a test to yield a positive finding when the individual tested actually has the condition being tested for) and specificity (the ability of a test to yield a negative finding when the individual tested does not have the condition) were studied. Both sensitivity (75%) and specificity (92%) were very good for Subscreen, especially compared to a test the USAF administers for similar purposes. Although some small changes will improve test performance, in general, Subscreen remains an effective tool for screening for Submarine Service.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT [X] UNCLASSIFIED/UNLIMITED [ ] SAME AS REPORT [ ] DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Susan Monty, Publications Office	22b. TELEPHONE *(Include Area Code)* (203) 449-3967 22c. OFFICE SYMBOL

DD Form 1473, JUN 86 *Previous editions are obsolete.* S/N 0102-LF-014-6603

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED