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NAVAL AVIATION ATTRITION 1950–1976: IMPLICATIONS FOR THE DEVELOPMENT OF FUTURE RESEARCH AND EVALUATION

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PENSACOLA FLORIDA

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NAVAL AVIATION ATTRITION: 1950 - 1976. IMPLICATIONS FOR THE DEVELOPMENT OF FUTURE RESEARCH AND EVALUATION. NAMRL-1237 Pensacola, Fla.: Naval Aerospace Medical Research Laboratory.

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A review of research literature suggests that:

a. High levels of anxiety may be causally related to performance decrement and subsequent attrition.

b. Anxiety is a behavior expression or symptom of poor or inefficient student performance in the Navy aviation training program.

Both hypotheses appear to warrant further research and evaluation.

It is recommended that new research efforts be developed and funded that deal with anxiety as a causative factor, resulting in poor human performance in the aviator training environment. Previous research indicates that certain anxiety producing environments occurring as an integral part of the present naval aviation training program may be utilized to identify anxiety oriented individuals of which substantial portions later attrite. It is appropriate to evaluate this behavior utilizing new experimental concepts and new measurement technology (voice analysis), to objectively measure anxiety in a nonintrusive manner and determine its relation to attrition.

It is recommended that additional research and evaluation efforts be conducted to determine the relationship of symptomatic anxiety to attrition. The high rates of voluntary and flight failure attrition in conjunction with the students' first introduction to training aircraft (T-34B) and his transition to higher performance training aircraft (T-2, T-28) suggest that perceptual psychomotor, attentive, and divided-attention criteria will be useful in the identification of individuals deficient in multilimb coordination and those unable to efficiently synthesize multiple cognitive and sensory stimuli.

This recommended research emphasizes the evaluation of performance measures (rather than pencil-and-paper measures) which promise to be useful in the selection of naval aviation training populations.

Aviation attrition
Aviation personnel
Aviator selection tests
Stress
Anxiety
Motivation
Drop on Request
Voluntary withdrawal
Flight Failure

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SUMMARY PAGE

THE PROBLEM

Drop on Request, or voluntary withdrawal, is a continuing major source of attrition in the Navy aviation training program. A major reason for student voluntary withdrawal is expressed as his anxiety in the naval aviation training environment. Numerous research efforts have been conducted to analyze the relationship of anxiety to attrition. Generally, these efforts have been unsuccessful, or partially successful at best, as an objective and reliable measure of anxiety has been unavailable for use in research evaluations.

FINDINGS

A review of research literature suggests that:

a. High levels of anxiety may be causally related to performance decrement and subsequent attrition.

b. Anxiety is a behavior expression or symptom of poor or inefficient student performance in the Navy aviation training program.

Both hypotheses appear to warrant further research and evaluation.

RECOMMENDATIONS

It is recommended that new research efforts be developed and funded that deal with anxiety as a causative factor, resulting in poor human performance in the aviator training environment. Previous research indicates that certain anxiety producing environments occurring as an integral part of the present naval aviation training program may be utilized to identify anxiety oriented individuals of which substantial portions later attrite. It is appropriate to evaluate this behavior utilizing new experimental concepts and new measurement technology (voice analysis), to objectively measure anxiety in a nonintrusive manner and determine its relation to attrition.

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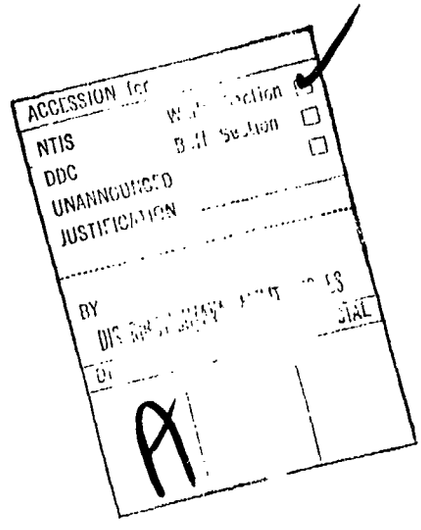
This recommended research emphasizes the evaluation of performance measures (rather than pencil-and-paper measures) which promise to be useful in the selection of future aviation training populations.

The conduct of research to identify individuals who exhibit high levels of stress or anxiety in early training situations has potential in the development of selection techniques to enhance the prediction of attrition prior to or very early in training. Such techniques have the potential to result in a considerable reduction in the number of individuals who fail to complete training, resulting in a considerable cost savings in Navy aviation training.



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INTRODUCTION

Since the 1940s, pencil-and-paper synthetic selection tests have been used to predict aviator success and proficiency. Tests which are consistently related to aviator success are those of 1) general intelligence or ability (usually of a verbal and numerical nature), 2) perceptual-spatial, and 3) mechanical comprehension. Personality and motivational factors are known to relate to aviator success; however, attempts to predict aviator success using standard projective, personality, and interest tests have met with limited success. Still, most aviator selection tests contain a biographical inventory composite based on interests and background factors known to relate to success in flying training. For the most part, Navy pencil-and-paper test instruments utilized to predict pilot success and performance have changed little since the end of World War II. These test instruments generally account for approximately 40 percent of the variance associated with success in aviator training (22). The fact that a large proportion of the variance associated with aviator success is not predicted by the test instruments used in primary selection is evident by the rate of attrition in aviator training programs. Consistently, the rate of attrition fluctuates between 25 and 35 percent in Navy aviation training. Recent attrition rates for student naval aviators and naval flight officers are presented in Figure 1 (6, 62, 63, 129).

Historically, the greatest amount of aviator attrition comes from personnel recruited directly from the civilian sector (4, 6, 11, 14, 29, 32, 38, 129, 130). The fact that Naval Academy and ROTC graduates consistently have a lower attrition rate (6, 11, 129, 130) attests to the ability of previous military experience to act as an efficient intermediate screening device.

Typically, 30 in 100 students fail to complete training in the naval aviation training program. Four categories constitute more than 90 percent of the total attrition. These categories of attrition are: DOR or voluntary withdrawal, flight failure, not officer material, and the not physically qualified (NPQ) listed in order of attrition importance. "Academic" attrition accounts for a relatively small proportion of the total and generally occurs very early in training. (It is the academic category of attrition in which the present pencil-and-paper selection tests contribute substantially to a reduction in attrition.) It is generally conceded that the NPQ problem is outside the realm of psychology, although a small proportion of these attrite for basically psychological rather than physical reasons (128). The flight failure attrite obviously fails to perform sufficiently well in the aircraft to warrant his continuation in training. Presently used Navy pencil-and-paper selection tests (especially the Spatial Apperception Test and Mechanical Comprehension Test) are useful in predicting this category of attrition. This review, however, will provide the rationale for the utilization of some new and old testing techniques to better predict flight failure attrition.

The not officer material category of attrition (NOM) is a statistic more related to the time during which attrition occurs rather than a specific type of attrition. Typically, personnel who withdraw voluntarily during preliminary

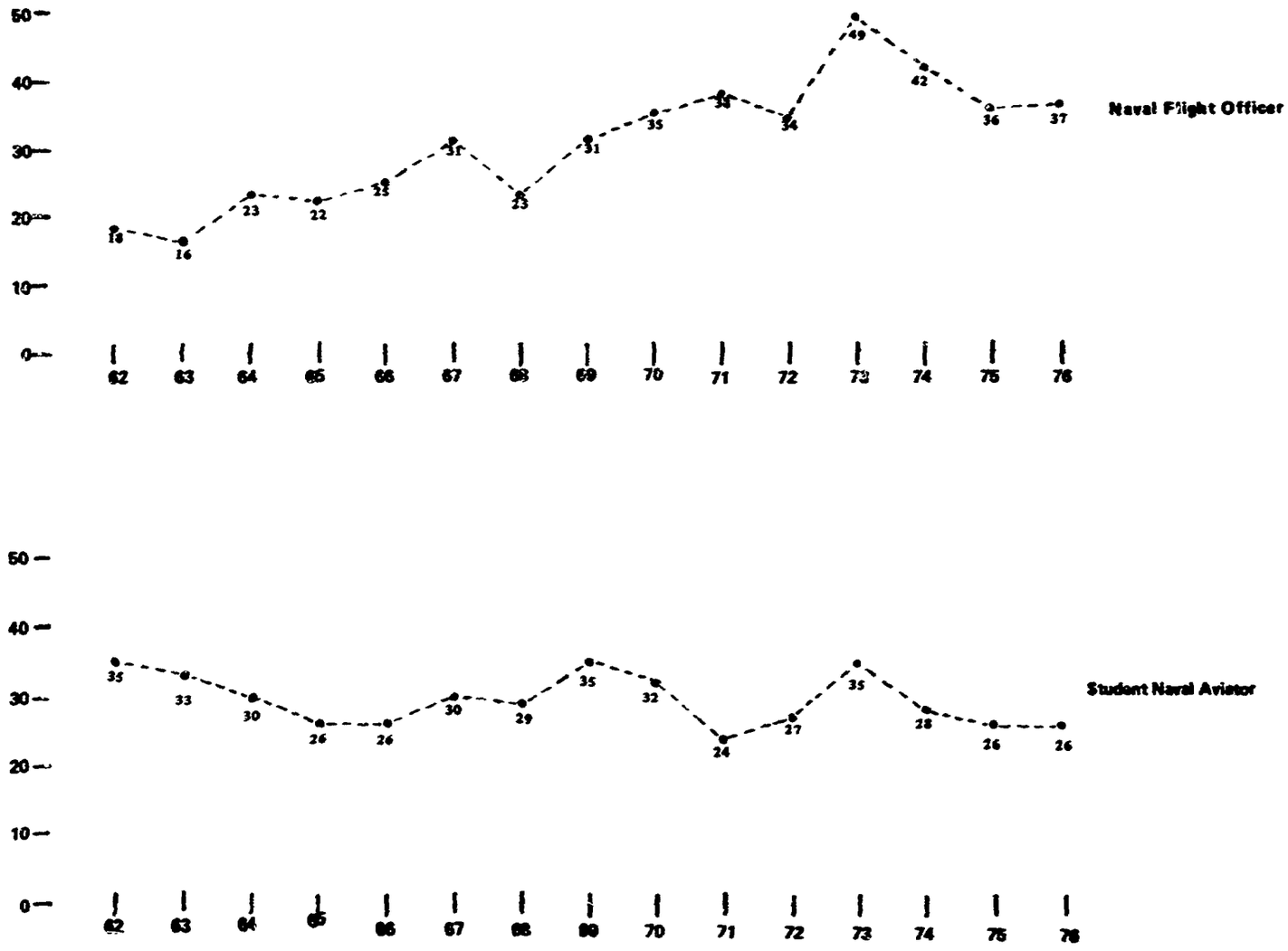


Figure 1. Student Aviator Attrition
FY62-76 - Percent of Input

training - prior to receiving a commission - are designated as NOM. Functionally, these individuals may not be greatly different from DORs.

The DOR or voluntary withdrawal group of attrites has received a great amount of research and study. However, little or no success has resulted in attempts to develop pretraining predictors of DOR attrition. Figures 2 and 3 depict recent Naval Aerospace Medical Research Laboratory (NAMRL) student naval aviation attrition (Jan 1973-June 1975) statistics as a percentage of total attrition (Figure 2) and as a percentage of the total student naval aviator training input population (Figure 3).

The following review of the NAMRL research literature deals primarily with naval research efforts to describe, categorize, and predict DOR attrition in naval aviation training.

OVERVIEW OF AVIATOR ATTRITION

VOLUNTARY WITHDRAWAL (DOR) ATTRITION

Research findings of expressed anxiety, tension, or fear associated with flying as reasons for voluntary withdrawal (DOR) from naval aviation training extend from the war years (WW-II) to the present day. Over fifty research reports have been prepared at NAMRL in Pensacola, Florida, dealing directly with the relationship of anxiety, fear, tension, and stress to attrition and human performance in the naval aviator training program between 1950 and 1976.

> Anxiety, as discussed in this review, is a convenient label for emotional states or behaviors that are sufficient in magnitude to impair performance and/or motivate individuals to voluntarily withdraw (DOR) from the naval aviation training program. Anxiety as used in this context, then, is quite different from the relatively mild and low level emotional states that have been shown to actually improve performance (188). The term "Stress" could have been used in place of anxiety. However, the use of the term "anxiety" throughout the NAMRL research literature mandates its use in this research review.

Specific reasons for voluntary withdrawal from the aviator training program are expressed as anxiety or tension with regard to flying, fear of flying, or lack of confidence in handling the aircraft. Other expressed reasons for voluntary withdrawal, i.e., dislike or distaste of flying, and a shift of career interest to civilian life or surface Navy, while valid reasons in their own right, are historically associated with fear and anxiety in the attrition research literature (5, 9, 12, 15, 17, 26, 28, 29, 31, 33-36, 41, 45, 89-92, 134, 143, 144, 161, 176, 185), and in research which factorially relates expressed reasons for voluntary withdrawal (175). It is appropriate to note that some research indicates that fear of failure in training may be a more potent reason for the expression of anxiety than fear of aircraft accidents or crashing (134).

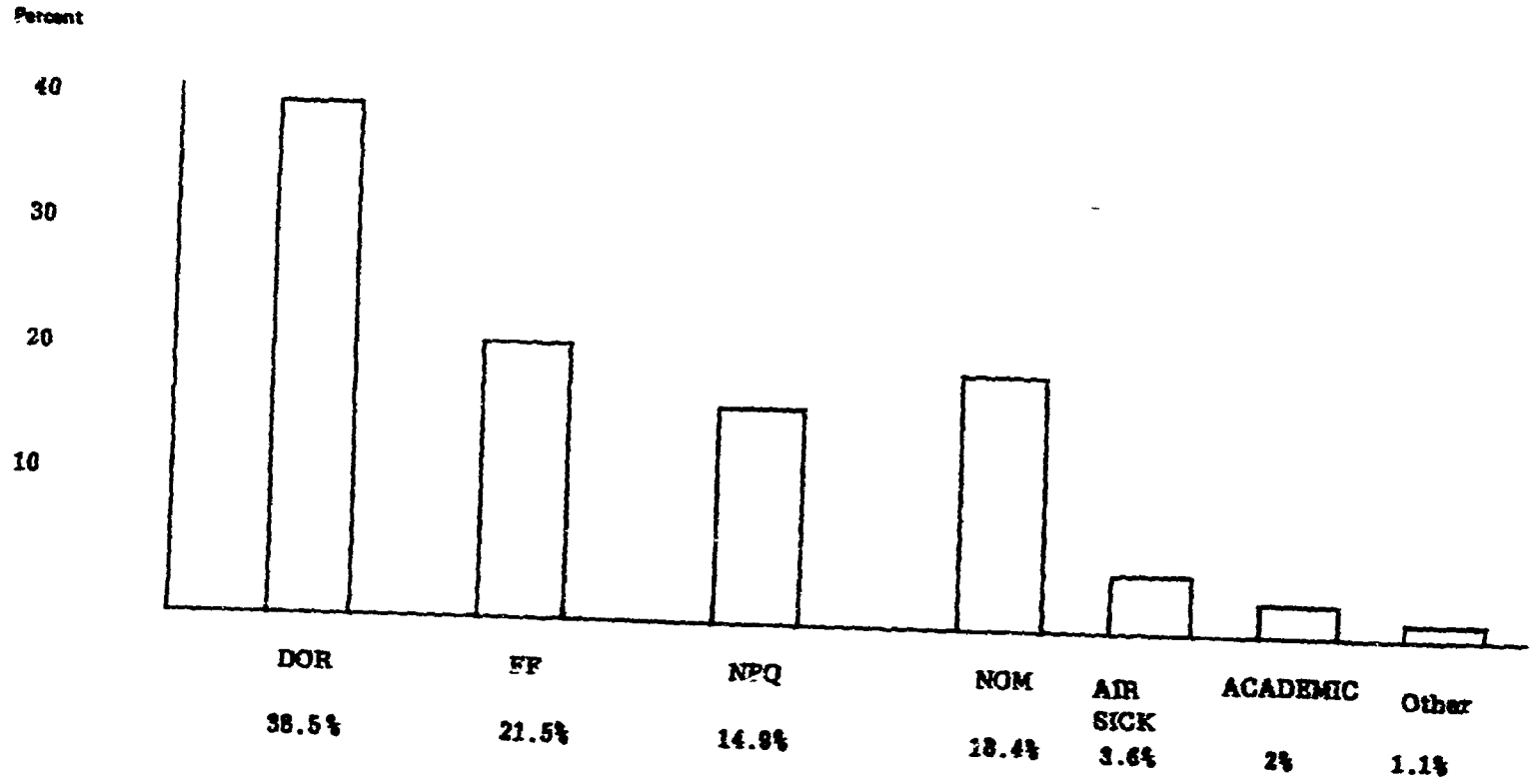


Figure 2. Student Naval Aviator Attrition Categories - Percent of Total Attrition - January 1973 – June 1975.

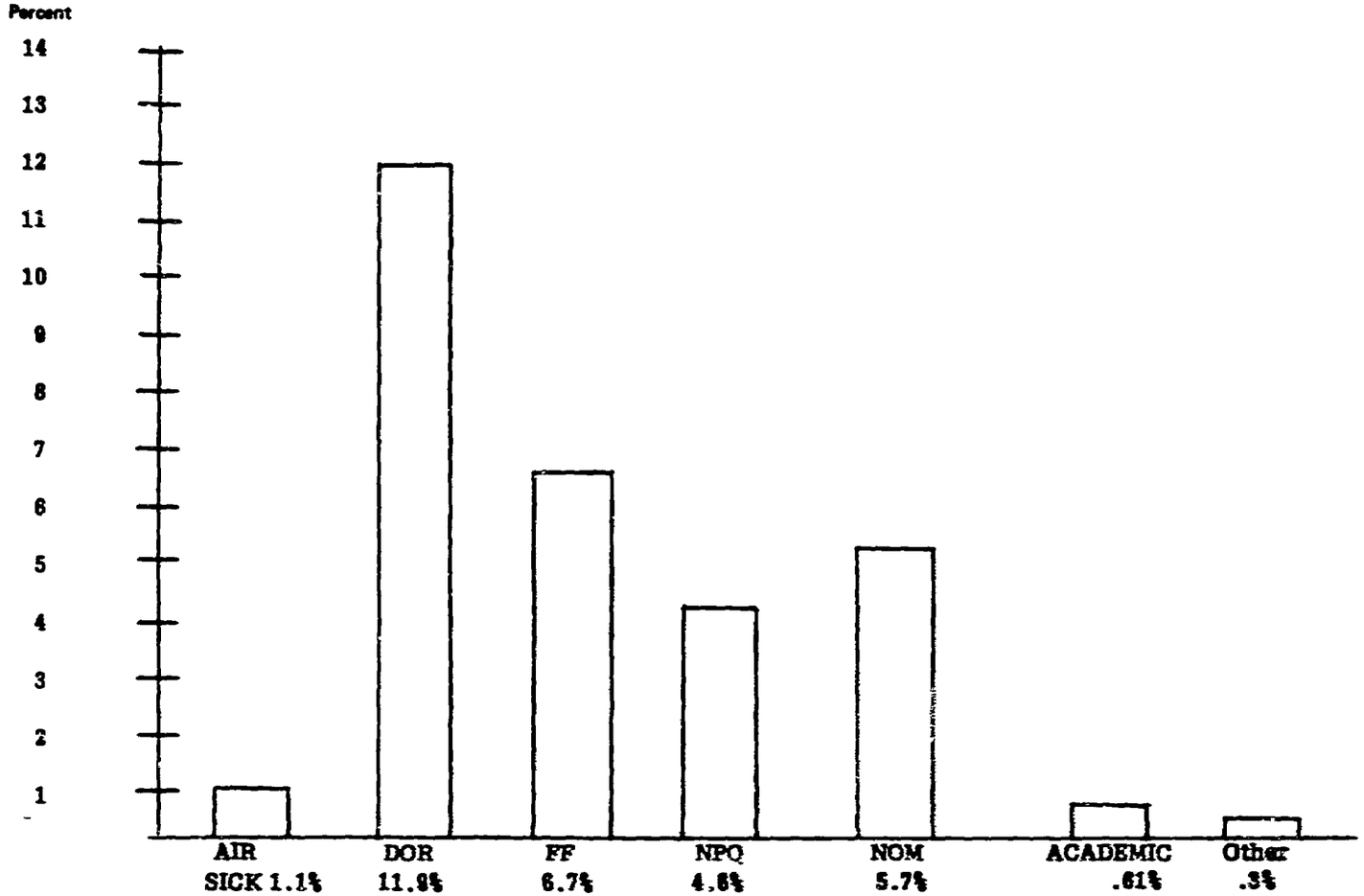


Figure 3. Student Naval Aviator Attrition Categories - Percent of Aviation Trainees Entering Training January 1973 – June 1975

Table I presents a tabulation of expressed reasons for voluntary attrition. The 1966 findings are representative of those found throughout the research literature published in the 50s and 60s. The 1973 data represent more recent findings which suggest a reduction in the proportion of students indicating fear, tension, and anxiety as reasons for withdrawing from flight training (173). Still, even more recent research in which aviation trainees ranked in order of importance various reasons for attrition (in 1976) reaffirms the importance of anxiety and/or apprehension as reasons for DOR attrition (69).

Ambler concluded that the first four attrition categories in Table I (1966 data) were directly linked with anxiety (5). Recent factor analytic research (175) suggests that the fifth category--"shift in career interest"--is also closely related to fear of flying. Together, these reasons support the hypothesis that a sizeable proportion of voluntary withdrawal attrition is anxiety related. While the first five reasons for voluntary withdrawal in Table I account for a sizeable proportion of the total attrition, it is possible that the relationship between anxiety and attrition is even greater due to the tendency of some Navy aviation students to indicate more socially acceptable reasons for voluntary withdrawal than those of anxiety, tension, or fear. This possibility is supported by a close review of the verbatim reasons for voluntary withdrawal contained in the research literature, factor analytic research previously mentioned (175), and studies by Gregoire (69) and Pomaroli (144) which indicate that successful aviators attribute more fear and anxiety reasons for voluntary withdrawal than do attriting individuals who voluntarily withdraw from naval aviation training. The studies of Pomaroli and Gregoire required successful pilots and DORs (144) and successful students and DORs (69) to rank in order of importance a series of more than thirty different reasons historically associated with voluntary withdrawal or DOR. Results of these studies are presented in Tables II and III. In Table II, successful aviators indicated their belief that DOR was a product of excessive nervousness, tension, fear, accidents, excessive pressure, and airsickness (Ranks 1-6). Unsuccessful aviators provided more socially acceptable reasons for DOR, such as shift in career interests, or loss of interest in flying. Recent work by Gregoire (Table III) indicates a relatively high degree of agreement between DOR and non-DOR aviator students with respect to the reasons prompting voluntary withdrawal. Both DOR and successful students ranked extreme apprehension, and nervousness/anxiety as primary reasons for voluntary withdrawal. The successful student group ranked these reasons 1 and 2, while DORs ranked them 2 and 4, just behind "loss of interest in flying" and "shift in career interest."

Other research suggests that a significant portion (approximately 60 percent) of not aeronautically adapted (NAA) attritions are anxiety related (37). As has been pointed out by de Rivera (73), "A person with high anxiety may see the flight surgeon when he has a symptom which he knows might result in his being dropped from the program; whereas, a nonanxious, highly motivated per-

Table I

Expressed Reasons for Voluntary Withdrawal

Reason	Student Naval Aviator		Naval Flight Officer	
	1966★	1973☆	1966★	1973☆
	(Percent)			
Disabling tension, anxiety or fear associated with flying.	34.9	13.3	6.9	6.2
Poor performance in training, or lack of confidence in aircraft.	20.3	12.0	13.9	11.3
Dislike or loss of interest in flying.	7.8	14.3	6.9	36.1
Airsickness.	1.1	1.5	--	3.1
Shift in career interest (Return to civilian life, surface Navy, reduce service time, etc.).	5.6	12.0	13.9	6.2
Not motivated to continue.	14.6	--	27.6	--
All other reasons: wife, girl friend, dislike military, pressure, leaving to get married, dislike treatment received in program, recruiter misleading, not physically qualified, etc.)	15.7	46.9	30.8	37.1

★ From reference (5).

☆ From reference (176).

Table II

REASONS FOR LEAVING FLIGHT PROGRAM (STUDENT NAVAL AVIATORS) ★
RANK OF DOR FACTORS ☆

	DOR STUDENT GROUP		SUCCESSFUL AVIATOR GROUP
1.	Pursue Civilian Career	1.	Excessive nervousness/tension
2.	Lost interest in flying	2.	Fear of flying
3.	Shift in career interests	3.	An accident
4.	Many doubts about choice	4.	Too much pressure
5.	A lack of incentives	5.	Airsickness
6.	No real satisfaction in flying	6.	Flight Instructor a screamer
7.	Flying isn't what I thought it was	7.	Flying isn't what I thought it would be
8.	Excessive nervousness/tension	8.	Shift in career interests
9.	Aviators tour too long	9.	Academic difficulties
10.	Don't like military	10.	Too much harrassment

★ From a total of 54 reasons associated with voluntary withdrawal.

☆ From reference (144).

Table III

RANK ORDER OF REASONS FOR LEAVING FLIGHT PROGRAM ★
STUDENT NAVAL AVIATORS ☆

	DOR ATTRITE		NON-ATTRITE SUCCESSFUL STUDENTS
1.	Lost interest in flight	1.	Extreme apprehension
2.	Extreme apprehension	2.	Too much nervousness/anxiety
3.	Shift in career interest - civilian	3.	Dislike obedience, discipline instilled by fear orientation
4.	Too much nervousness/anxiety	4.	Unable to perform well - flying
5.	Military life not for me	5.	Shift in career interest - civilian
6.	Prefer freedom of civilian life	6.	Unable to function well under pressure
7.	Shift in career interest - Surface Navy	7.	Dissatisfied with pipeline assignment
8.	Dislike obedience, discipline instilled by fear orientation	8.	Length of flight training
9.	Unable to perform well - flying	9.	Lost interest in flying
10.	Unable to function well under pressure	10.	Separation from family

★ From a total of 33 reasons associated with voluntary withdrawal.

☆ From reference (89).

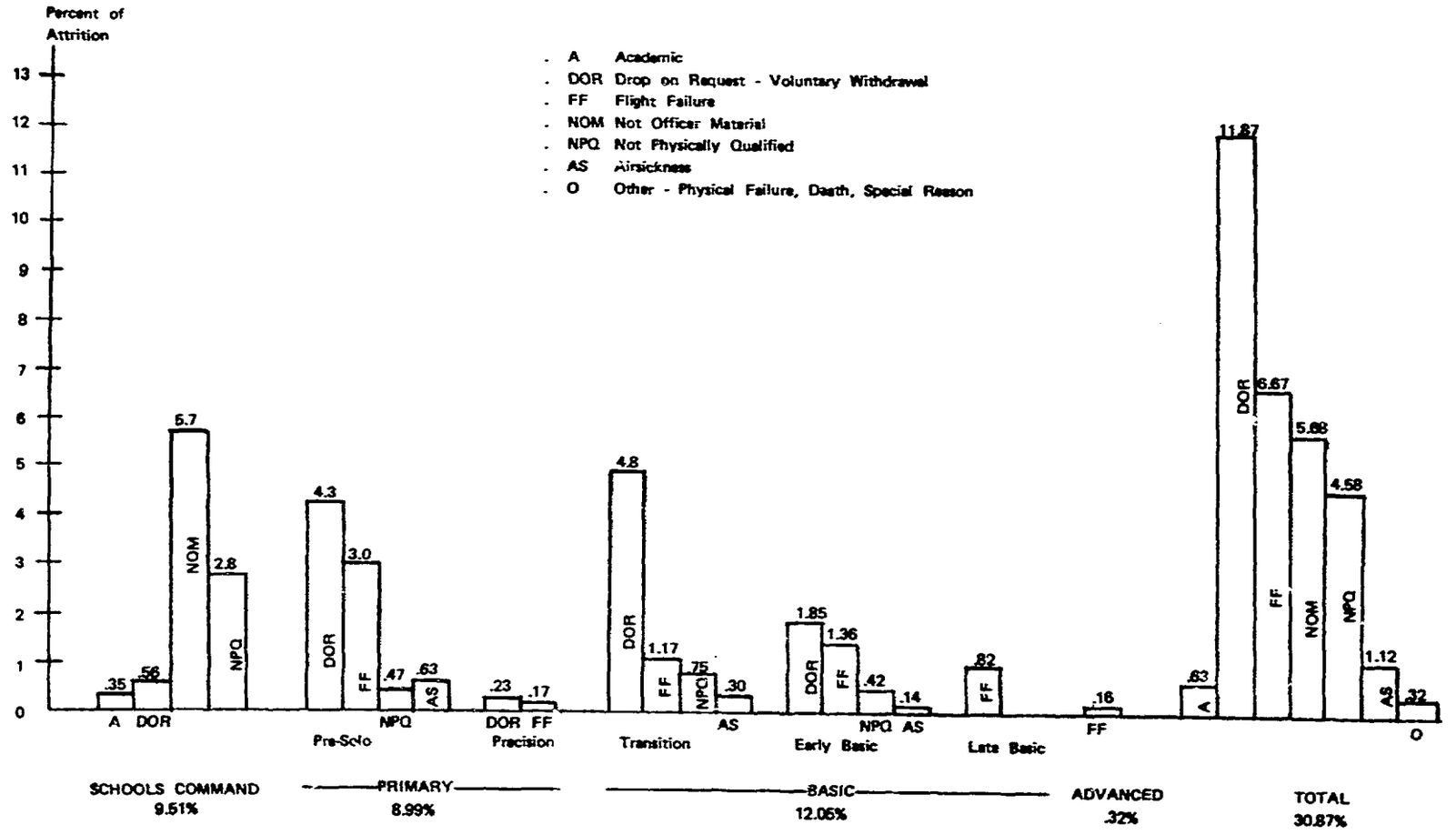
son might never go to the flight surgeon in the first place for fear of being dropped." Additional evidence supports the hypothesis that some not physically qualified (NPQ) (128) attritions are actually voluntary withdrawals. A 1972 NAMRL memorandum makes the point clearly, ". . . after arriving at Pensacola and being introduced to his new den mother in the form of a Marine DI he (student) suddenly acquires the medical history of an 80-year-old man . . ."

Additional research indicates that successful aviators are described as skillful in flying and emotionally stable while unsuccessful aviators are described as emotionally unstable and unskillful in flying (24, 50). Further, "liking flying" has been found to be one of the most significant attitude differences between successful and unsuccessful aviators (30, 41).

It is relatively common in the research literature to find the suggestion that some portion of DOR attrites are similar to flight failures since many DORs express definite problems in handling the aircraft. This suggests in turn that expressed anxiety associated with the DOR phenomenon is a result of poor human performance in the aircraft (34). Other research concluded that anxiety resulting from poor performance in the aircraft is reinforced and increased by instructor comment and disapproval (43). Additional work indicates that anxious voluntary withdrawals tend to have lower flight grades and MCT scores than voluntary withdrawals who express nonanxiety reasons for leaving the training program (8).

NAMRL attrition statistics compiled on student naval aviators entering training between January 1973 and through the first six months of 1975 are similar to earlier published results (12) and provide dramatic evidence of the relationship of voluntary withdrawal to the students' introduction to flying in primary training and in his transition to higher performance aircraft in basic training. (See Figure 4.) Note the especially high rates of both DOR and flight failure during presolo in primary (in the T-34B) and transition to the T-28 or T-2 in basic training*. The large proportion of both DOR and FF attrition in conjunction with the students' introduction to the aircraft supports the hypothesis that both types of attrition are uniquely related to human performance in flying the aircraft (34). Additionally, the large incidence of NPQ attritions occurring in primary and early basic stages of training support an earlier hypothesis by Bair and Ambler (37) that a number of these NPQ attritions are related to anxiety.

*This has import to future Navy aviation training. In the future training program the new training aircraft--T-34C--described as relatively easy to fly by training instructors (in comparison with the T-28 or T-2 utilized in Basic) may result in less DOR and FF initially. However, when students transition to jet or advanced-prop aircraft in the advanced portion of the future training program, the data of Figure 4 suggest that an increase in FF and DOR can be expected at transition. This may in fact increase the cost of attrition since the longer students remain in the training program prior to attrition the greater the cost per attrition.



(Attrition Category percentages less than .1 are not depicted but are reflected in total percentages.)

Figure 4 Student Naval Aviators - Types of Attrition by Stage of Training - - January 1973 — June 1975.

In summary, these data indicate a relationship between anxiety and attrition and further suggest that a substantial proportion of voluntary attrition is associated with human performance in aircraft flight upon the student's introduction to the training flight vehicle, and transition to higher performance aircraft. What is uncertain and a subject for discussion is whether anxiety is a symptom or a causative factor associated with attrition. To be more specific, the question posed is whether anxiety is a behavioral expression resulting from poor performance (a symptom) in the aviator training environment, or whether an anxiety response pattern of behavior is a cause of poor performance in the work environment.

There is agreement that high levels of stress inhibit performance. This has been the general finding of stress research conducted in the civilian research community and in stress studies at NAMRL (21, 64, 66, 71, 188). Importantly, small amounts of stress have been shown to actually increase performance (188). Interestingly, there is evidence that stress may act to lower motivation to perform on a performance task rather than actually impairing cognitive or motor skills (64).

Naval aviation research tends to disregard the causative-symptomatic anxiety distinction in favor of the pragmatic hypothesis that anxiety as a behavior pattern can be measured and related to attrition in the naval aviation training program. For example, aviation students expressing anxiety in a pressure chamber environment in preflight had a significantly higher attrition rate (50%) in later flight training (169). A related study indicated that student peer ratings of anxiety in preflight were predictive of subsequent physiological measures of anxiety (eyeblink) obtained in a stressful situation (119). One clinically oriented study of attrition supports the hypothesis that anxiety is a causative factor related to subsequent poor human flight performance (73).

Flight instructor observations, that highly anxious students in initial straight and level training flights are more likely to attrite, provide support for the causative hypothesis associated with anxiety and later poor performance (16, 160, 162, 174). Personality test results have occasionally indicated a relationship (though these have been transitory) between anxiety as measured in preflight and later attrition in flying portions of training (73, 81, 88, 181).

Finally, studies of student susceptibility to airsickness in a rotating chair environment suggest a relationship between observed measures of anxiety (pallor, sweating, etc.) in preflight and later attrition (18-21, 93). These results suggest that some individuals are more prone to anxiety than others . . . suggesting, perhaps, an individual anxiety threshold level.

On the other hand, there are many studies which tend to support the hypothesis that anxiety is a symptom rather than a cause of poor or inferior human performance in the aviator training environment. The research literature suggests that a sizeable proportion of DOR attritions are similar to flight failure

attrites, since many DORs have low flight grades and express definite problems in handling the aircraft. This is often expressed as poor performance (8, 17, 34, 37, 43, 73, 89, 115, 134, 161, 176). One study concluded that the DOR group with low flight grades, the total flight failure group, and the anxiety medical attrition group are sufficiently similar in flight aptitude, academic grades, and anxiety level to be treated as one group (37). More recent research supports this view (115). Of course, the flight instructor himself can be a source of anxiety through his comments and criticism of student performance in flying the aircraft (43, 44, 73, 134), and anxiety may be promoted by observing anxiety expressions of others (172). Finally, there are studies involving personality tests in which the investigator(s) conclude that anxiety, as measured by the particular personality tests being evaluated, is a result of training performance (a symptom) rather than a cause of performance in training (170, 171).

Generally, the research literature supports the view that anxiety is both a cause and a symptom of inadequate or inferior performance in training and subsequent attrition, suggesting that there may be two major DOR attrition subcategories.

1. A student group prone to anxiety or with an anxiety predisposition.

2. A student group going through a transient anxiety producing situation.

A third category, representing a combination of the two specified DOR subcategories, is, of course, an additional possibility.

ATTRITION PREDICTION RESEARCH

Though many studies in the research literature dealing with anxiety and its relationship to voluntary attrition simply report and categorize expressed reasons for withdrawing from training, or provide a rationale for the withdrawing student's actions, a number of research efforts have been concerned with the prediction of individual anxiety and voluntary withdrawal attrition as indicated below.

STANDARD SELECTION VARIABLES

Pencil-and-paper selection test variables indicate a varying but slight relationship to voluntary withdrawal. The relationships in Table IV are typical of those found in the research literature in restricted population samples (81, 189). These relationships may be appreciably higher in unrestricted populations, and when unreliability in the criterion (pass/fail) can be taken into account (78). The selection variable which tends to have a continual substantial relationship to DOR or voluntary withdrawal is the Biographical Inventory.

Table IV

Relationship Between Selection, Training Performance Variables and Attrition

Point-Biserial Correlations between Predictor Variables and Three Dichotomous Criteria

Predictor Variables	(Flight Failure)			(DOR)			Pass/Attrite		
	1	2	3	1	2	3	1	2	3
Selection Variables									
1. BI	.097	.055	.081	.130	.118	.168	.148	.123	.174
2. AQT	.066	.063	.146	.011	.019	.068	.029	.088	.136
3. MCT	.004	.070	.117	.014	.123	.114	.012	.167	.147
4. SAT	.101	.099	.105	.023	.031	.083	.074	.111	.115
Pre-Flight Variables									
5. Principles of Flight	.180	.100		.072	.055		.153	.155	
6. Navigation	.259	.195		.047	.064		.179	.239	
7. Engines	.226	.101		.041	.105		.156	.213	
8. Physical Training	.128	.083		.068	.042		.120	.111	
9. Peer Rating	.232	.160		.055	.035		.172	.130	

[1]From reference (81)

[2]From reference (189)

[3]Represents recent NAMRL validation data - 1973 Student Naval Aviator Input (over 1500 subjects).

There are indications that DORs who express anxiety in flight training as a reason for voluntary withdrawal have lower Mechanical Comprehension Test scores (35, 185). Generally, the AQT has demonstrated less of a relationship to voluntary withdrawal attrition than the MCT (2, 3, 35, 121, 141, 185). In some cases, pencil-and-paper selection test variables can predict both the flight failure (FF) and the DOR but cannot distinguish between the two groups, perhaps as a result of the similarity of performance by both the DOR and FF groups on the MCT (115, 185). This is yet another finding that supports the hypothesis that certain anxious DORs and FFs are closely related and that anxiety is a symptom of inferior human performance in the aircraft.

Recent NAMRL selection research suggests that certain spatial and hidden figure tests may be suitable nonduplicative predictors of success or failure in aviation training (80, 111, 187). Other ongoing research is evaluating the response latency of subjects on personality and pencil-and-paper "spatial" tests with the goal of determining the relationship of response latency to aviator performance and attrition (80). Research is continuing in these areas.

PERSONALITY INVENTORIES

Numerous personality tests and inventories have been evaluated in an attempt to identify students voluntarily withdrawing from naval aviation training. Many of these test instruments have also been applied to aviator population samples with the intent to identify the fearful or anxious individual (73, 81, 88, 106, 107, 170, 171, 181). Others are concerned only with the ultimate prediction of voluntary withdrawal for any reason (7, 27, 39, 42, 47, 59, 61, 94, 104, 108, 111, 126, 138, 150, 156, 177). Generally, these attempts to identify voluntary withdrawals have failed. Those few studies which indicate initial relationships with anxiety or voluntary withdrawal rarely survive cross-validation (47, 104, 17, 181), or indicate so little additional predictive power that their use is considered impractical (171). Others require additional study, or have not been cross-validated (61, 73, 81, 88, 181).

The inability of personality tests to predict work success in the civilian and military environment is common despite the high face validity of many of the personality test instruments. The common problem associated with these tests is that their validity or usefulness depends to a great extent on the honesty of the test taker. On those occasions when the tests are administered under a no-threat-no-consequence condition (i.e., "Your performance on these tests will in no way affect your continuation in flying training") or after attrition has occurred, small relationships with the anxiety or voluntary withdrawal criterion occasionally occur. However, when the tests are applied "for real," the relationship almost always disappears, or becomes so small and variable that its usefulness is severely limited. This occurs as a direct result of test subjects' ability to select the test-item response which is more socially acceptable or more congruent with success in aviation training. This phenomenon is commonly known as faking the test, or test response bias. Numerous research eval-

uations conducted at NAMRL have noted the susceptibility of personality inventories to faking and response bias (59, 60, 109, 165, 166, 168, 178-180). When one considers the quality of the aviator trainee population--practically all have college degrees, are above average in intelligence, and have taken literally hundreds of tests during their academic careers--it is not surprising that highly motivated potential aviators can readily determine appropriate and inappropriate responses for selection to aviator training. A list of personality inventories utilized in conjunction with naval aviation research is in Table V.

OTHER PREDICTION STUDIES OF ANXIETY AND DOR ATTRITION

Numerous noncognitive or nonpersonality measures have been employed in an attempt to predict anxiety and voluntary withdrawal. Many of these efforts are relatively novel, yet most developed as a result of previous findings reported in the literature. For example, the Kuder Preference Record, an interest inventory, provides evidence that successful cadets, and flight instructors are more interested in mechanical and scientific activities than are voluntary withdrawals who indicate more interest in literary, musical, and persuasive activities (58, 151). Although the Kuder demonstrated small but significant validity for all types of attrition, the factor it best measures--mechanical interest--is already being adequately assessed by the MCT Portion of the Flight Aptitude Battery. Thus the Kuder appears to be a redundant, less objective measure of mechanical ability or interest than the MCT (167). Other studies follow:

. Job sample or training tasks (Link trainer, (68); aircraft trimming, (105); landing device performance, (142)) have been investigated as potential selection variables in an attempt to predict success, failure, and voluntary withdrawal in training. Generally, these efforts have been unsuccessful. However, these devices, when properly developed for objective assessment of performance, have the potential to serve as valuable intermediate and final performance criteria.

. In the studies examining noncognitive, nonpersonality predictors of the various success and failure categories (1, 4, 10, 11, 13, 14, 25, 51, 65, 100, 110, 116, 117, 122, 130, 136, 167, 193), successful and significant predictors are age, pretraining solo time, procurement area, origin of commission, procurement source, rank, and college major.

. Analysis of aptitude and subsequent achievement in educational settings seemed extremely promising as a predictor of voluntary withdrawal (77, 120), and survived cross-validation. However, it did not significantly add to the predictive power of current selection variables.

. Research studies have indicated that voluntary withdrawals are more apt to view instructors as threat objects, and have less interpersonal relationships with instructors (97, 98). Related research indicates that beginning

Table V

Personality Test Inventories Utilized in Navy Research 1950-1976
(as reported in research studies and reports)

Year	Personality Inventory
1950	Purdue Biographical Inventory, Bernreuters Personality Inventory.
1953	Authoritarian Attitude Scale, Inventory of Social Attitudes Guilford Martin Personality Inventory, Bernreuter Personality Inventory, Multiple Choice Sentence Completion Test. The MMPI-Taylor Manifest Anxiety Scale Adaptation, California F. Scale.
1954	California F Scale, Necker Cube (2) * Guilford-Zimmerman Temperament Survey (2) * Authoritarian Attitude F Scale, Guilford-Martin Personality Test, MMPI.
1955	MMPI, Taylor Manifest Anxiety Scale, Pensacola Z Scale, Thurstone Temperament Schedule.
1956	Rosenzweig Picture Frustration Test (3)*, Aviation School Sentence Completion Test, Pensacola Z Scale (2)*, Taylor Manifest Anxiety Scale, Heineman Anxiety Scale.
1957	Guilford-Zimmerman Temperament Survey(1)*, Pensacola Z Scale, Pensacola TR Nervous Scale, Mandler-Sarason Inventory, MMPI, Saslow Screening Test, Heineman Anxiety Scale Taylor Manifest Anxiety Scale.
1958	Aviation School Sentence Completion Test, MMPI, Guilford-Zimmerman Temperament Survey.
1960	Gordon Personality Inventory.
1961	Gordon Personality Inventory.
1962	Gordon Personality Inventory.
1963	Bass SIT Inventory, Ego Strength Inventory, Revised Form of the Stotsky-Weinberg Sentence Completion Test, Maudsley Personality Inventory, Attitude Toward Quitting Scale (ATQ).
1964	Edwards Personal Preference Schedule, Gordon Survey of Interpersonal Values.
1965	Edwards Personal Preference Schedule, Preference Index, Gordon Survey of Interpersonal Values.
1966	Cattell's 16 Personality Factor Questionnaire Taylor Manifest Anxiety Scale Pensacola Z Scale, Adjective Check List
1967	Gordon Survey of Interpersonal Values, Edwards Personal Preference Schedule.
1969	Objectively Scoreable Apperception Test.
1970	Eysenck Personality Inventory, Maudsley Personality Inventory, Stait Trait Anxiety Inventory (STAI).
1971	California Psychological Inventory (CPI) Stait Trait Anxiety Inventory (STAI)
1975	Zuckerman Dimensions of Sensation Seeking
1976	Omnibus Personality Inventory. Eysenck Personality Inventory

* Associated number indicates that the inventory was featured in that many research reports that year.

anxious flight students view the instructor as a source of punishment and are more critical of instructors (44).

. There is evidence that successful students and voluntary withdrawals may differ in religious attitudes (27, 121). However, these findings failed to survive cross-validation (121).

. Physical fitness grades have been evaluated to determine their relationship to attrition categories. Although two studies indicate that physical fitness grades are not useful in predicting attrition criteria (67, 154), other evaluations indicate a significant relationship (73, 192). Further, ability to swim appears to be related to training success and flight failure (102). From a logical point of view it would appear likely that coordination factors, if adequately measured, would be predictive of success in flying portions of training. The fact that ability to swim and gymnastic ratings have correlated with success in training seems to support this view (102, 192).

. Frequent sick calls have been shown to be related to flight failure and DOR (195).

. Physiological measures have been evaluated to determine their relationship with anxiety and subsequent attrition in a variety of research studies. A test of postural sway did not identify anxious individuals (76), nor did pulse measures (73, 119, 164) or muscle tension (73) in threatening situations. However, earblock and eyeblink measures and other visually measured aspects of behavior, sweating, pallor, facial expression, etc., have been used successfully to identify anxious individuals (18, 19, 93, 119, 169).

. Recent acoustic research has demonstrated a relationship between stress or anxiety and brief vocal recordings of personnel in stressful situations. Acoustical analysis of recorded voice samples of individuals speaking in stressful situations reveal measurable acoustical differences when compared to voice samples of the same speakers speaking under nonstressful conditions (190, 191). The vocal attribute most often analyzed to detect such changes has been the fundamental frequency of the speaker's voice. There has been an increasing research interest in the possible application of voice analysis techniques as a potential nonintrusive methodology for monitoring the emotional and/or the physiological status of aircrew personnel. Williams and Stevens (190, 191) analyzed excerpts of tape-recorded conversations between pilots and control tower operators transmitted during known emotionally stressful situations. Quantitative and qualitative analyses of narrow band spectrograms of selected utterances indicated that measurements of fundamental frequency and range of fundamental frequency, together with observation of the fundamental frequency contour, may serve to signify when a pilot is undergoing emotional stress. Russian (152, 157) and Japanese (114, 131, 132) scientists also have devised measurement schemes based on the fundamental voice frequency to monitor both the emotional and attention state of pilots. Recently, Kuroda and others (114) presented calculations of what they term "Vibration Space Shift Rate (VSSR)" which is derived

from measurements of the fundamental vocal frequency. Application of the VSSR to 14 aircraft accidents (8 fatal) indicated the appearance of three distinct emotional phases, normal, urgent, and emergency, suggesting the use of VSSR-type measures as a method to determine the relationship of stress as a contributing factor in aircraft accidents.

Apparently, spectral analyses of voice communications uttered in emotion-producing situations is a potentially valuable tool for monitoring pilot emotional status. It is possible that spectral analyses may be useful in the objective measurement of stress or anxiety in pilot training and in determining the relationship of stress, as exhibited in initial training situations, to future aviation training performance.

PEER RATINGS, FLIGHT INSTRUCTOR RATINGS

Of all the measures studied in attempts to predict categories of attrition, peer ratings and instructor ratings have been shown to be consistently powerful predictors of success and failure. The literature abounds with studies which indicate that peer ratings are useful in predicting ultimate success and failure categories (49, 55, 79, 118, 135, 194), and that they can be used to identify anxiety oriented (73, 119) and psychosomatic individuals (103). Peer ratings apparently can predict intelligence (182), success as an officer (163), and are related to certain personality inventory scales (180, 197), course grades, and selection variables (139). These relationships suggest that one's peers, as a group, can efficiently predict individual performance on a task or skill that they have had the opportunity to observe. This finding is consistent with research conducted by the civilian community and other military research.

Flight instructor ratings provided on a confidential basis have been shown to be good predictors of success, failure, flight failure, and voluntary withdrawal from primary and basic flight training. To a large extent, flight instructor's decisions for success or failure appear to be based on the student's expression of observable anxiety in flying the aircraft (16, 23, 123, 173, 174). Considering the fact that a series of studies has indicated that flight instructors can successfully predict attrition based on the observation of students in initial aircraft flights, it may seem surprising that the naval aviation training program has not taken advantage of the ability of flight instructors to predict attrition very early in training. One of the disadvantages of using subjective instructor ratings, however, is that the ratings may be difficult to support and defend. This would be especially true in the case of false positives--those individuals identified as potential failures who in fact have the capability of being successful in training. Additionally, it is not known whether flight instructor ratings would continue to be predictive if instructors were aware that their early evaluations had the potential to eliminate a student from flight training. Finally, it has been suggested that anxiety oriented personnel presently attrite sufficiently early in the present training program (in "Schools Command" or pre-solo) and that the 12 weeksof training in Schools Command is the least costly of all training.

A number of research evaluations have been concerned with the relationship of the flight instructor to the voluntary withdrawal process. It has been generally assumed that the anxious student who is unlucky enough to obtain a "screamer" or an impatient instructor in flight training is unfortunate indeed. There is evidence to support this hypothesis (73), and studies do indicate that the instructor does affect a student's performance and flight grades (173, 187). However, the available research indicates that "patience" and other characteristics of instructors are not significantly related to voluntary withdrawal. Surprisingly, impatient or screamer instructors have no more DORs or flight failures than do those instructors rated as calm and patient (145, 173).

AVIATION TRAINING COURSE GRADES AND THE PENSACOLA STUDENT PREDICTION SYSTEM

Nothing predicts success like success, or the best predictor of future performance is past performance. This is certainly true of naval aviation training. Performance in preflight and primary academic courses has been shown time and time again to predict subsequent flying performance in training (48, 74, 85, 95, 96, 118, 137, 141, 146, 183, 184, 196). Course grades and flight grades in Primary and Basic can be useful in the prediction of advanced training performance or performance in the Fleet (49, 52-56, 69, 147, 148, 155, 186); and, as one might expect, students requiring extra instruction in preflight and primary portions of training have a higher probability of failure than those who do not (75, 83, 84, 127, 149).

While not much success has been forthcoming in the development of useful selection prediction variables prior to training, great progress has been made in predicting a student's potential for success or failure in future training based on student achievement in early portions of the aviator training program.

Nineteen-hundred sixty-two marked the initial development of the Pensacola Student Prediction System (PSPS) utilized to predict the ultimate success of trainees in naval aviation, based on their performance up to a given point of time in training (50). It is in this system that both test and nontest predictors of attrition play a major role. Especially important to this system are peer and instructor ratings, and course grades. The development and application of this system has been a major accomplishment of the Naval Aerospace Medical Research Laboratory. Estimated cost savings of the PSPS indicate that a great amount of instructor/student time, and monetary resources have been saved. The system functions to aid management decisions concerning students having problems in training. In one instance, and perhaps for the first time in history, the Pensacola Student Prediction System was used to select personnel out of training during a requirement for a personnel reduction (46). It requires a major effort to service and maintain these prediction systems. As time passes, it must be determined that previous predictors maintain their predictive power. Additionally, as new work environments and work tasks arise (new aircraft, differing NFO tasks, for example) new experimental efforts must be carried out to determine appropriate

predictors and their weights (57, 137) in the student prediction system. The same is true of substantial course modifications. For example, the present prediction system requires revalidation on student training performance in the newly reorganized Naval Integrated Flight Training System (NIFTS). The maintenance of these automatic, computer-based prediction systems is a continual effort concerning the Research Laboratory.

RELATIONSHIP OF AIRSICKNESS TO ANXIETY AND VOLUNTARY ATTRITION

No discussion of anxiety and voluntary withdrawal would be complete without a discussion of the relationship of airsickness or motion sickness to attrition in aviator training. Airsickness and anxiety are undoubtedly related, and airsickness is a common symptom associated with anxiety (100, 102). Still, airsickness is a physiological phenomenon involving the stimulation of the vestibular sensory system. Studies of subjects with defective vestibular sensory systems demonstrated that these individuals do not exhibit nausea under the most severe motion environments (112). The relationship between the incidence of airsickness and anxiety is a muddled one. Research studies indicate that the great majority of airsickness in the training program occurs during the first three introductory flights in presolo in straight and level flight when vestibular system simulation is minimal (100). Although 10 percent of students express some form of nausea or airsickness in training, only 1 percent of the aviator trainee population, on the average, attrites for this reason (6, 100). Is there a relationship between airsickness in flight and subsequent attrition by reason of airsickness? Apparently, no significant relationship exists in the literature to support this view, although some levels of significance approach the normally acceptable standard (i.e., 5 chances in 100) (102). There are studies, however, which indicate that motion sickness, as measured by a questionnaire and rotating environments, is significantly related to subsequent airsickness attrition (101, 113).

BRIEF VESTIBULAR DISORIENTATION TEST

A great deal of research has been undertaken to determine the relationship of motion sickness and anxiety to the observable physiological reactions of subjects in a rotating chair environment -- the Brief Vestibular Disorientation Test (BVDT).

It is unclear whether the BVDT technique measures susceptibility to motion sickness as a function of vestibular system simulation or whether it identifies the more anxious or anxiety prone aviation student. The fact that correlations between the BVDT technique and attrition by means of motion sickness approach .4 and the correlations with anxiety reasons for attrition are in the .2 range supports the former hypotheses (18-21, 93). However, it is reasonable to assume that the technique may be an effective measure of both types of attrition. It would be interesting to further evaluate this potential selection technique with a more objective measure of anxiety.

CONCLUSIONS AND RECOMMENDATIONS

FUTURE AREAS OF ATTRITION RESEARCH

This review of the literature was developed primarily as a base for the identification of pertinent areas of future research in the prediction of increased probabilities for student completion and failure in the naval aviation training program. In this regard, the following topics seem worthy of future research and evaluation.

A. Anxiety as a Causative Factor of Inferior Performance and Attrition

The research literature suggests that anxiety is a cause of poor or inferior performance resulting in voluntary withdrawal and some flight failure attrition. Previous efforts to measure and predict anxiety of student naval aviators and naval flight officers have met with limited success because an objective measure of anxiety has not been available. Since the time that "anxiety" was under intense research scrutiny in the 1950s, and early 60s, new technology has become available, fully within the present state-of-the-art, which can be used to more objectively and reliably measure stressful behavior in anxiety producing situations. A unique feature of this new technology (voice analysis) is that it can be a nonintrusive measurement means. That is, its collection and measurement will not interfere with present or future aviator training. It is suggested that physiological and psychological scientists combine their talents to measure anxiety objectively and to determine its relationship to aviator performance and attrition.

1. It is suggested that several stress or anxiety producing situations occurring as an integral part of training be evaluated, utilizing voice analysis techniques to determine the relationship of anxiety, as measured in nonthreat and threat situations, to subsequent performance. Suggested threat situations are: (a) office entry before the drill instructor on the sixth or seventh day of training, (b) hypoxia occurring in the pressure chamber run, (c) Dilbert Dunker training, and (d) the first three to four introductory flights in presolo flight training. Brief voice recordings developed under stressful training condition situations should be compared with a nonstress vocal recording collected early in training. Such a nonthreat base-line vocal recording should be made at the NAMRL test facility during the first week of normal psychological testing. The base-line recording would be compared with recordings collected under stress or anxiety in the development of an individual anxiety ratio for subsequent correlation with training performance variables and attrition categories.

2. It is suggested that an additional effort investigate the utilization of personality test instruments in a verbal format, using voice analysis technology. In this effort, a comparison would be required between responses in a pencil-

and-paper normal format and verbal responses. An evaluation of the relationship to subsequent performance and attrition in aviator training would establish the feasibility and suitability of this approach.

3. It is further suggested that the BVDT rotating chair selection technique be evaluated, utilizing voice analysis techniques for comparison with present measurement procedures to evaluate the relationship of airsickness to anxiety, and to determine the capability of this threat environment to elicit anxiety to be measured through voice analysis techniques and related to performance and attrition categories in aviation training.

B. Anxiety as a Symptom of Inferior Performance

The research literature also supports the view that anxiety is a symptom of poor or inferior performance and that many voluntary withdrawals and flight failures are similar in that they exhibit or demonstrate poor human performance in the aircraft. If voluntary attrition resulting from anxiety caused in turn by poor human performance in the aircraft is an important factor in attrition, then the addition of psychomotor, selective, and divided attention selection criteria may result in the reduction of a portion of both flight failures and DORs.

1. Psychomotor performance testing has been knwon to be related to aviator performance for a great number of years, and was used by the Army Air Corps as a screening device during the war years and into the early 50s. One such test, called Complex Coordination (Stick and Rudder), was the highest predictor of pilot success during World War II (70) ($r = .40$). Why, then, are psychomotor tests no longer used? Factor analysis of the complex coordination test indicated the major reason for its predictive goodness. It measured an appropriate amount of cognitive, spatial, and mechanical comprehension abilities in addition to the unique contribution of a psychomotor or multilimb coordination factor which no pencil-and-paper tests have yet measured (70, 82). Psychologists realized that paper-and-pencil tests available to measure nonpsychomotor skills were much more economical and easy to administer than the hardware-oriented psychomotor tests. Additionally, there was the great problem of unreliability with the psychomotor tests. In fact, the unreliability of these devices became such a problem that the Air Force gave up the use of its psychomotor selection tests in the early 50s. The rationale was that the extra amount of predictive variance accounted for by the psychomotor tests was not worth the extensive device upkeep (maintenance and calibration) effort (70, 124).

The Navy has never utilized psychomotor tests in the selection of aviators, even though early research studies indicated their predictive utility (159). It has been the policy of the Navy not to use test devices that cannot be administered easily or inexpensively at decentralized testing stations.

Studies conducted during the war years by Melton (125) suggest that approximately 7 to 8 percent of additional variance could be accounted for by the

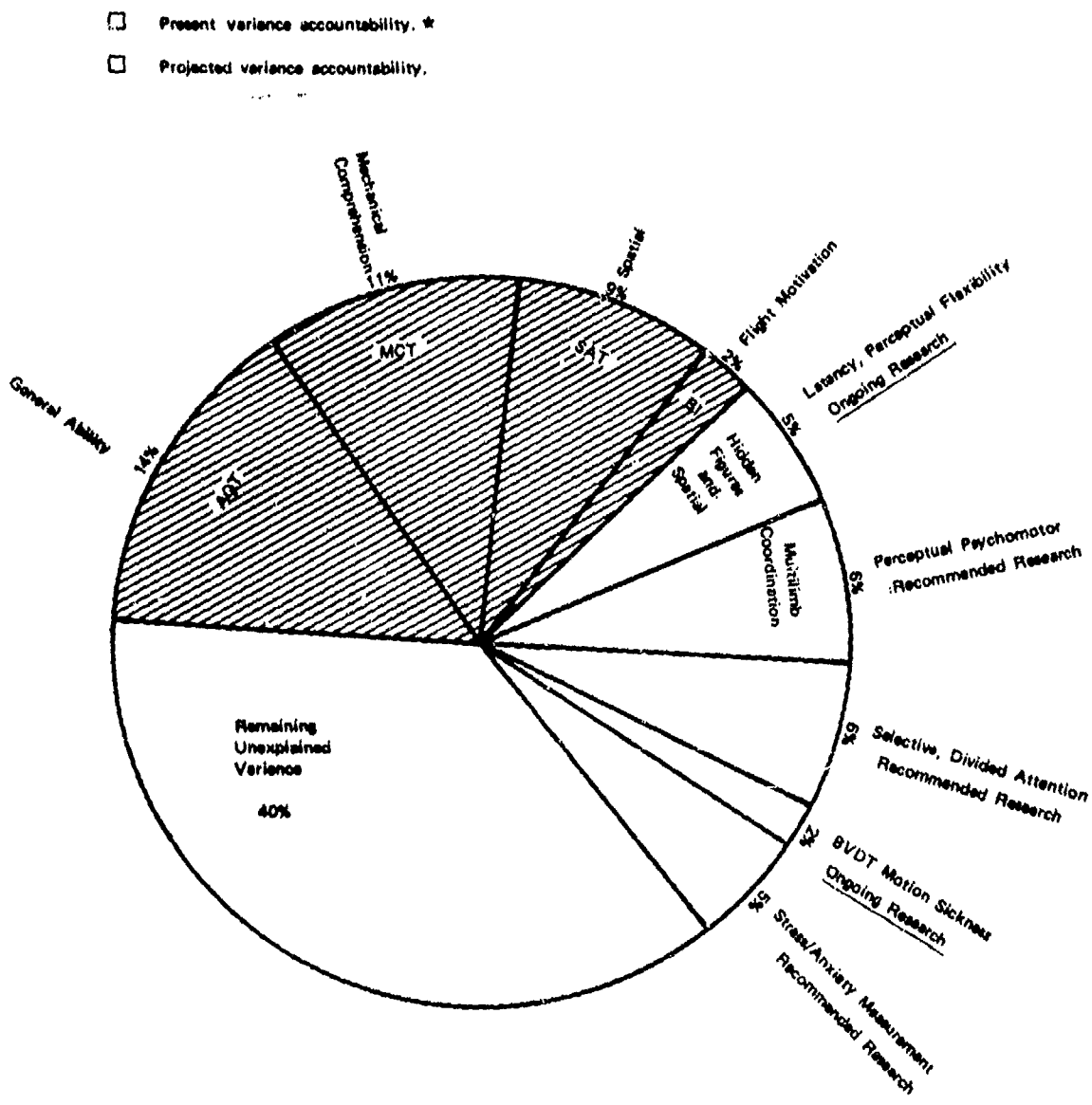
psychomotor factor "multi-limb coordination." With advancing technology, it may be possible to duplicate present psychomotor tests in a more reliable format, or develop entirely new psychomotor tests which will add much needed validity to the Navy aviator selection system in the ability area of "multi-limb coordination." A recent USAF contractual effort resulted in the development of two solid-state perceptual psychomotor tests based in part on the old two-hand coordination and complex coordination (stick and rudder test) of World War II fame. Both tests were transfigured into solid-state independent testing apparatus of high reliability (153). Subsequent validation of the test devices indicated that the complex coordination test was a reliable and valid predictor of success versus failure (graduation) and flight training deficiency (similar to the Navy term flight failure). Additionally, analysis of the validation test results indicated that the perceptual psychomotor complex coordination test made a unique contribution to the prediction of graduation from Air Force Undergraduate Pilot Training above and beyond that provided by the Air Force paper-and-pencil test selection instrument, the AFOQT (123). The Air Force is now completing a relatively large-scale validation effort of the AFOQT, GAT-1, and the perceptual psychomotor tests. In a discussion with an Air Force Laboratory representative it was learned that the perceptual psychomotor test (complex coordination) continues to provide additional and unique variance. Alternately, the complex coordination test is highly related to the GAT-1 performance. Since the perceptual psychotor test is easier and less costly to administer, it is probable that the perceptual psychomotor performance measure will be used in place of the GAT-1 as a predictor variable in USAF Pilot selection (158).

2. In addition to perceptual psychomotor abilities, experts have agreed that abilities to manage information from several sources simultaneously; adapt quickly to changing situations; integrate, store, combine, and compare data input in the course of performing several tasks concurrently are all attributes conducive to aviator success. Results of previous investigations of divided and selective attention measures for predicting success in flight training have been sufficiently successful to warrant the large scale application and assessment of several possible formats for measuring divided and selective attention capabilities. A dual-task performance situation indicated predictive validities for success of students in a private pilot course (72, 87). The test requried the operator to perform a continuous manual control task (compensatory tracking) concurrently with a discrete, information processing task (cancelling visually presented digits by a keyboard response). Additional research found that the dual-task performances on the digit-processing task were reliable and valid predictors of performance of students in flight training and discriminated between experienced pilots and flight-naive subjects (133). A selective attention dichotic listening test (86), requiring subjects to monitor a message in one ear while ignoring messages presented in the other ear, had promising validity for predicting different levels of proficiency in high-performance jet aircraft training in the Israeli Air Force.

It is highly possible that the proposed non-paper-and-pencil performance approach to aviator selection may be useful in the identification and prediction of both flight failure and DOR attrition in Navy aviator training.

RECOMMENDED RESEARCH: ITS POTENTIAL CONTRIBUTION

How good is the present naval aviator selection system, and how good might it be? Over the years, pencil-and-paper tests used to select pilots have correlated approximately .60 with pilot failure/success in unrestricted samples. Relationships of this size account for approximately 40 percent of the variance or explain approximately 40 percent of the factors associated with pilot success. Ongoing pencil-and-paper NAMRL selection research efforts (evaluation of hidden figures tests and latency measures, and the BVDT testing technique), together with the performance-based research proposed here, may have a positive impact on the prediction of aviator success in training. The diagram in Figure 5 is an optimistic but reasonable portrayal of the results of ongoing and proposed research to more effectively predict success and failure and other attrition categories in naval aviation training.



★ From reference (22).

Figure 5. Present and Projected Variance Accountability

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

Drop on request, or voluntary withdrawal, is a continuing major source of attrition in the Navy Aviation Training Program. A major reason for student voluntary withdrawal is expressed as anxiety in the naval aviation training environment. Numerous research efforts have been conducted to analyze the relationship of stress and anxiety to attrition. Generally, these efforts have been unsuccessful or partially successful at best, as an objective and reliable measure of anxiety has been unavailable for use in research evaluations. A review of research literature suggests that:

a. High levels of anxiety may be causally related to performance decrement and subsequent attrition.

b. Anxiety is a behavior expression or symptom of poor or inefficient student performance in the Navy aviation training program.

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Both hypotheses appear to warrant further research and evaluation.

It is recommended that new research efforts be developed and funded that would deal with anxiety as a causative factor, resulting in poor human performance in the aviator training environment. Previous research indicates that certain anxiety producing environments occurring as an integral part of the present naval aviation training program may be utilized to identify anxiety oriented individuals of which substantial portions later attrite. It is appropriate to evaluate this aspect of behavior utilizing new experimental concepts and new measurement technology (voice analysis), to objectively measure anxiety in a nonintrusive manner and determine its relation to attrition.

It is recommended that additional research and evaluation efforts be conducted to determine the relationship of symptomatic anxiety to attrition. The high rates of voluntary withdrawal and flight failure attrition in conjunction with the students' first introduction to the training aircraft (T-34B) and his transition to higher performance training aircraft (T-2, T-28) suggest that perceptual psychomotor, selective and divided attention criteria will be useful in the identification of those individuals deficient in multilimb coordination and those unable to synthesize multiple cognitive and sensory stimuli.

This recommended research emphasizes the evaluation of performance measures (rather than pencil-and-paper measures) which promise to be useful in the selection of future aviation training populations.

The conduct of research to identify individuals who exhibit high levels of stress or anxiety in early training situations has potential in the development of selection techniques to enhance the prediction of attrition prior to or very early in training. Such techniques would result in a considerable reduction in the number of individuals who fail to complete training, resulting in a considerable cost savings to Navy aviation training.

G. R. Griffin
J. D. Mosko, Ph.D.

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NAVAL AVIATION ATTRITION: 1950 - 1976. IMPLICATIONS FOR THE DEVELOPMENT OF FUTURE RESEARCH AND EVALUATION. NAMRL-1237 Pensacola, Fla.: Naval Aerospace Medical Research Laboratory.

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