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| NASA | NASA - Leave blank |
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Top Performer Survey: Computerized Psychological Assessment in Aircrew

CHRISTOPHER F. FLYNN, M.D., WALTER E. SIPES, Ph.D., MILTON J. GROSENBACH, Ph.D., and JON ELLSWORTH


There were 29 (80%) subjects from a squadron of 36 F-16 pilots who voluntarily participated in a newly developed anonymous, self-administered, computerized testing protocol. The test battery consisted of two 2.5-h blocks that gathered demographic information and measured personality (MMPI-2), cognitive capacity (MATB), crew coordination skills (PCI), and history of psychiatric diagnoses (C-DIS). The test battery also included a peer rating survey that collected information about the squadron's top performers and their personal qualities. Results indicated that aviators can agree who are top performers and what personal qualities are important in top performers. This pilot project demonstrated the success of the battery to gather aircrew information in a field location. Test data are presented.

The definition of "the right stuff" in aviators has attained a mystical aura at times. If you know what it is, you don’t need scientists to tell you; and if you don’t know what it is, then you haven’t been flying long enough. Nevertheless, questions remain largely unanswered scientifically: Are there identifiable and measurable personal/psychological qualities that define a successful military aviator? Are there differences between lead and wing aviators, other than flying experience? If aviators would offer details about themselves, their answers could lead to more focused training, improved selection criteria and enhanced mission performance.

Unfortunately, aviators are reluctant to submit to this type of questioning. There are at least three reasons for this. First, their responses on clinical tests might jeopardize their flying status. Second, the USAF has no standardized approach to psychological testing for gathering information at the squadron level. Without access to aviators at their locations, data collection occurs at locations convenient to scientists, and relies on select groups of aviators as subjects. These groups have been grounded aircrew seeking waiver, or special "high interest" groups required to undergo medical and psychological testing. Third, reporting a deficit is considered the admission of a weakness, and this is unacceptable within aviator group dynamics (10).

In approaching these barriers, we considered several studies that have documented greater truthfulness and privacy in subjects answering personal questions through computer query (12,21). Computerization also offered the flexibility of a consistent approach at any testing location, without needing highly specialized technical support. Finally, through computer query, aviators could give their responses anonymously, which we hoped would encourage both their participation and truthfulness.

For broadest applicability, psychological information is most useful when gathered from a truly representative group; in our case, the squadron. Although widely recognized as essential to a scientific basis of occupational mental health evaluations (20), the last normative psychological data derived on USAF aviators were completed by Fine and Hartman (6) in the early 1960’s. These data, now more than 25 years old, are based on outdated instruments, and on a select group of aviators that flew quite different aircraft. In the last 10 years, other specialized aviator populations have been studied, such as undergraduate student pilots (16), and U.S. Army helicopter pilots (15).

Ashman and Telfer (2) reported on a group of 14 Royal Australian Air Force (RAAF) pilots from one Mirage squadron, but data were gathered only on the Edwards Personality Questionnaire. The current study of Air National Guard (ANG) aviators sought to gather information on four psychological tests from a squadron of successful F-16 aviators. In addition, a peer rating
survey was developed to identify top performers in the squadron, and their personal qualities.

Some might consider the search for psychological differences among aviators analogous to sweeping a floor that has no dirt, because the expected psychological resilience of military aviators is a proud heritage (1). However, psychiatric disorders impact this population. One mission of the Neuropsychistry Branch of the USAF Aerospace Medicine Consultation Service (ACS) of Armstrong Laboratory, Brooks AFB, TX, has been to consult with more than 280 aircrew in the last 10 years who have sought waivers for mental health difficulties. If we could learn more about the mental health concerns of the average successful aviator, preventive medicine models could be developed to reduce lost man years due to these problems.

METHODS

Development of the Test Battery

The subjects in this study completed standard psychological tests and an epidemiologic survey processed through notebook computer/software technology. The following tests were chosen:

a) Minnesota Multiphasic Personality Inventory-2 (MMPI-2);

b) Computerized Diagnostic Interview Schedule (C-DIS);

c) Multi-Dimensional Aptitude Battery (MAB);

d) Personal Characteristics Inventory (PCI).

These tests offered a broad approach to measure different psychological characteristics of aircrew. The MMPI-2 is the newest version of the MMPI, a personality test that has become the most frequently administered psychological test (11). It is used at the USAF ACS to evaluate psychiatrically grounded aircrew who request a waiver to return to flying duties. Occupational norms have been developed for different populations (3,7); and Butcher (4) reported that at least one U.S. airline uses the MMPI as an adjunctive tool in employee selection. In a counter-balanced, repeated-measures study of the computerized MMPI versus the standard pencil and paper presentation, Honaker et al. (8) supported the software version of the MMPI’s equivalency. While not specifically tested, the equivalency of the computerized MMPI-2 is generally accepted (14).

The National Institute of Mental Health’s (NIMH) Diagnostic Interview Schedule (DIS) is a widely used epidemiologic survey developed by Robins and Helzer to screen the general population for the prevalence of psychiatric disorders (17). Up to now, there have been no reported attempts to define the prevalence of mental health disorders in the professional aviator population. This computerized version of the survey has been validated for test-retest reliability compared to the trained interviewer approach, and has shown good correlation in most diagnostic areas (3). Subject acceptance of the instrument as a self-administered questionnaire has been generally good (22).

The MAB is an IQ test developed by Douglas Jackson (9) that has a high correlation (0.94–0.98) with the WAIS-R. In general, the USAF aviator population has been noted to have above average IQ (6). It was expected that IQ might show a strong correlation to “top performer” aviators. Administered in 10 7-min blocks by computer with the use of an accompanying booklet, the computerized MAB measures verbal, performance, and full scale IQ. The subtests define ability scores on General Information, Comprehension, Arithmetic, Similarities, Vocabulary, Digit Symbol, Picture Completion, Spatial, Picture Arrangement, and Object Assembly.

Rose et al. (18) developed the PCI to assess “crew coordination qualities” in aviators. Some commercial airline corporations use it as part of their screening for pilot selection (5). It consists of 254 questions with a Likert scale response pattern. Aircrew responses are categorized into eight groups ranging from the “right stuff” to the “wrong stuff” in crew coordination. Already widely used in aerospace operations, it collects data more specific to aviation skills.

The overall format of the battery was arranged into two 2.5-h blocks, with a testing proctor supervising the use of the computers and preventing the two test sections from being completed by any one individual on the same day. Battery 1 consisted of demographic questions followed by the MMPI-2 and then by the PCI. Battery 2 contained the MAB followed by the DIS. To confirm confidentiality of answers, each subject’s test responses were recorded on an individual 3.5-in data diskette identified externally by a random number. Test responses could not be accessed or scored without the computer scoring modules, which were unavailable at the squadron.

The peer survey (see Appendix A) was given to each pilot with Battery 2. The aviators were asked to identify the top three pilots (lead and two wingmen) in their squadron with whom they would fly combat. They could not select themselves. For each individual they chose, they also rank-ordered importance four personal qualities from the list in Table 1. These characteristics were a modified grouping from two sources: a NASA peer survey of astronauts (18), and a summary of “top pilot” characteristics suggested by past aces (13). This survey provided a frequency count of most chosen characteristics, and also offered a rank order of personal qualities in selected pilots.

After testing ended, each pilot’s name and random numbers were known only to a disinterested third party (trustee) chosen by the squadron. Each subject’s two random numbers were linked. The trustee also replaced the names of the top performers on the peer survey with their respective random numbers. Once completed, the key and the nameless surveys could be used to compare

<table>
<thead>
<tr>
<th>TABLE 1. PERSONAL CHARACTERISTICS RANK ORDERED BY PILOTS.</th>
</tr>
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<tbody>
<tr>
<td>General Knowledge</td>
</tr>
<tr>
<td>Job Performance</td>
</tr>
<tr>
<td>Stress Tolerance</td>
</tr>
<tr>
<td>Leadership</td>
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<tr>
<td>Group Cohesiveness</td>
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<tr>
<td>Teamwork</td>
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<tr>
<td>Personality</td>
</tr>
<tr>
<td>Communication Skills</td>
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<tr>
<td>Aggressiveness</td>
</tr>
</tbody>
</table>

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testing responses and personal qualities of top performers.

Subjects

There were 29 volunteers from an ANG F-16 squadron consisting of 36 pilots recruited as subjects. These 29 (29/36 = 80%) pilots completed the peer rating survey of top performers, defining characteristics of their selections. Demographic information was available for 23 pilots (64% of the 36 in the squadron; 79% of the 29 pilot subjects). All were male and none had ever divorced. Fig. 1 shows the range of experience in flying time in the F-16 and total military flying hours in the squadron. Table II reports the variety of demographic qualities in the participants.

Procedures

Data collection occurred over approximately 4 months, covering four active duty ANG weekends. All subjects initially signed a consent form which described the experiment, the anonymity of their data, and their right to terminate project participation at any time.

Descriptive statistics were run on the test results, peer surveys and demographics in this “pilot” project. Peer surveys were tabulated for the frequency of individuals chosen as top performers and their qualities. Data were analyzed using the Statgraphics statistical program.

RESULTS

There were 29 pilots (80% of the squadron) who participated in the psychological testing and voted for aviators to complete their preferred combat 4-ship. Of 87 possible votes (29 for lead and 58 for wingman), 3 aviators received 38 (38/87 = 48%). The same two pilots were chosen most frequently for both lead and wing positions. The third was chosen for wing position only; possibly, he lacked the upgrade qualification, or he had the most desirable characteristics to fill the wingman position. After these three pilots, votes were scattered for the rest of the aviators by votes of one or two. Although pilots who did not perform psychological testing got 21 votes (21/87 = 24%), the important qualities of all 4-ship aviators are known.

Qualities chosen for the lead and the two wingmen positions showed many similarities when considering total frequency counts (Fig. 2). However, when considering rank order (RO), the most chosen characteristics for lead were different from wingman position (Fig. 3). These results are an encouragement to continue the search to define the unique qualities of these aviator positions.

Scores for 15 pilots (51%) were available for the MAB. Mean scores were Verbal IQ = 125; Performance IQ = 127; and Full Scale IQ = 127. These scores were all in the Superior range of intellectual functioning.

![F-16 Hours, Total](image)

**Fig. 1.** Squadron flying hours and variety of flying experience. (n = 23; 64% of squadron.)

![Per Cent of All Choices](image)

**Fig. 2.** Lead vs. Wing personal qualities. (n = 29; 80% of Squadron.) Lshp-Leadership; JobP-Job Performance; Aggr-Agressiveness; Know-Knowledge; StrT-Stress Tolerance; Pers-Personality; Team-Teamwork; Comm-Communication; GrpC-Group Cohesiveness.

**Table II. Demographic Questions. N = 23, 64% of Squadron.**

<table>
<thead>
<tr>
<th>Question</th>
<th>Number</th>
<th>Percent</th>
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<tbody>
<tr>
<td>Combat Hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>5</td>
<td>22</td>
</tr>
<tr>
<td>No</td>
<td>18</td>
<td>78</td>
</tr>
<tr>
<td>Rank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Company Grade</td>
<td>13</td>
<td>57</td>
</tr>
<tr>
<td>Field Grade</td>
<td>10</td>
<td>43</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 years or younger</td>
<td>8</td>
<td>35</td>
</tr>
<tr>
<td>31 to 40 years</td>
<td>8</td>
<td>35</td>
</tr>
<tr>
<td>41 years or older</td>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>Education Level</td>
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<td></td>
</tr>
<tr>
<td>Undergraduate</td>
<td>18</td>
<td>78</td>
</tr>
<tr>
<td>Graduate</td>
<td>5</td>
<td>22</td>
</tr>
<tr>
<td>Previous Active Duty</td>
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<td></td>
</tr>
<tr>
<td>Yes</td>
<td>15</td>
<td>65</td>
</tr>
<tr>
<td>No</td>
<td>8</td>
<td>35</td>
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</table>
All of the subtest means were elevated at least 1 SD higher than the general population normative sample (9), with Arithmetic, Vocabulary, and Digit Symbol subtests having the highest scores. MAB scores are summarized in Table III.

Scores from 23 (79%) MMPI-2 tests were obtained (Table IV). Of note was the reduced level of the fake bad scale (F) in this population. The clinical profile was within normal limits with expected low scores on physical health complaints (Hs), depressive complaints (D), acknowledging stereotypical gender roles (Mf), and comfort in social settings (Si). Higher scale means were noted on being optimistic (Hy) and being active, outgoing and energetic (Ma). This pattern of clinical scores was similar to that found in an earlier retrospective study comparing Army and Navy pilots’ scores to older USAF norms (19).

PCI scores in 20 pilots (69%) were available. Participants’ scores clustered into three groups regarding traits suited for multiphase aircraft crew coordination: Best (8/20 = 40%), Middle (8/20 = 40%), and Poor (4/20 = 20%). Goal seeking, achievement motivation, and interpersonal orientation were key qualities of the eight pilots in the “best” group. Eight “middle” group aviators had scores that fell into patterns thought to be neither helpful nor detrimental to crew resource management. However, high verbal aggressiveness, and low interpersonal orientation categorized four aviators into the “poor” group for crew coordination. None of the pilots taking the test scored in the “worst” group, which categorizes those individuals with undesirable scores on all PCI scales.

C-DIS data was obtained from five pilots (17%). In those respondents, only one showed a psychiatric diagnosis: nicotine dependence. Unfortunately, computer instructions in this initial trial confused many subjects who erroneously ended testing in Battery 2 before proceeding with the C-DIS.

**DISCUSSION**

The major goals of this project were the development and field testing of a computerized battery to gather normative psychological information about military aviators. Choosing the squadron as the closest group to a representative sample, we thought it optimal to take our tests to the field. To attain the goal of gathering information on clinical tests, anonymity was considered crucial. An ANG F-16 squadron with a range of ages and flying experience offered to participate in this innovative program.

This project considered the following five questions:

1) *What instruments should be included in a psychometric test battery for aircrew?*

The development of a computerized version of the PCI was one of the major accomplishments of this project. This custom-designed protocol queried a broad range of mental characteristics using tests that measured intelligence (MAB), personality (MMPI-2), crew coordination attitudes (PCI), and history of psychiatric health (C-DIS).

2) *What would aviators’ scores reveal if they were to anonymously volunteer sensitive information about themselves?*

A total of 80% of this squadron participated in the testing. By maintaining anonymity, this battery revealed that pilots would voluntarily offer sensitive information about themselves and their peers.
formers? 

performers’ profiles bup functioning among this group. It was not surprising that Multiple payoffs could result from wider aviator par-
to study a range of aircrew who fly military aircraft. As tems Center, AFMC, United States Air Force. Brooks AFB, TX.

necessary refinements, it could be widely implemented 
data from a normative aircrew sample. With minor but 
identifications with their personal qualities, as seen by squad-
tron; with 80% falling into the best and middle 
groups, and 20% into what is considered the poor group.

It might be surprising that no F-16 pilot participant scored in the worst group category for crew coordination 
skills. However, deployed in one or more pairs of 
aircraft, it is sometimes forgotten that single-seat fighter 
pilots still need crew resource management skills. Com-
munication between pilots, and delegation and division 
of tasks are critical mission duties.

None of these aviators’ MMPI-2 scores indicated cur-
rent mental illness, suggesting that a lack of significant 
scale elevations could be a “measurable” factor in the 
successful military pilot. While pilot groups may be ho-
genous in certain areas like these, the PCI data re-
vealed areas of individual diversity. Picanco (15) has sug-
gested that there is no “one type of personality” 
identified as best in selecting military aircrew. Our pre-
liminary data lends support to the notion that a variety 
of different kinds of individuals are currently used to fly 
and complete the mission.

3) Could aviators agree on their squadron’s top per-
fomers?

4) Could they agree on the qualities important in 
those chosen?

Squadron members did tend to agree about two of 
their top performers, choosing two individuals for lead 
and one for wing with a consensus (62%, 44%, and 12%, 
respectively) of their votes. Rank order #1 qualities 
were different for lead and wing positions. While both 
positions were expected to know their jobs well, higher 
skills in leadership and stress tolerance differentiated 
the lead pilot from the wingman who was expected to be 
more aggressive and personable (when considering rank 
order #1 qualities chosen). This battery can define the 
aviator qualities important to the squadrons that fly the 
missions. With more aviator participants, personal qual-
ities of top performers can be studied.

5) If truly normative data were gathered, would top 
performers’ profiles be different?

The question of correlations between top performers 
and their testing results remains to be answered. This 
testing protocol was a successful approach in obtain- 
data from a normative aircrew sample. With minor but 
necessary refinements, it could be widely implemented 
to study a range of aircrew who fly military aircraft. As 

the sample size grows, attempts can be made to define 
desirable personal qualities and testing profiles that sig-
ificantly distinguish top performer aviators of each air-
craft type from their fellow aviators.

Recommendations for Future Research

Multiple payoffs could result from wider aviator par-
ticipation in this test battery. Aviator occupational psy-
chometric norms could be updated, and aircraft specific 
norms could be developed. USAF psychiatric aircrew 
standards and ACS waiver recommendations would 
benefit greatly from the scientific update and expansion 
of normative data. Baseline cognitive measurements on 
aviators would become available, that could offer help-
ful comparison data in future health evaluations. Gath-
ering information about aviators throughout their 
careers could yield important data about successful traits 
of long-term military aviators. Primary and secondary 
prevention of mental health difficulties would benefit 
aircar (and mission) performance through data ob-
tained with the C-DIS.

Attempts to correlate top performers’ psychological 
profiles with their personal qualities, as seen by squad-
ron mates, would be possible with sufficient aircrew 
participation. Data from this battery could enhance the 
preparatory training of future flight leads. Current 
USAF research into situational awareness, a skill 
thought to be highly related to combat survivability, 
could gain from information about top performers’ per-
sonal qualities and their psychological profiles.

As the U.S. Armed Forces adapt to face the chal-
enges of the 21st century, one thing will remain con-
stant. The success of the flying mission will depend 
upon the capabilities and performance of the aviator. 
Payoffs follow an improved understanding of the psy-
chological (human) factors of well-adapted aircrew. 
This test battery can gather information that will ad-

course the future training of successful military aviators.

The data on personality (MMPI-2), intelligence 
(MAB), interpersonal qualities (PCI), incidence of psy-
chiatric diagnosis (C-DIS) and peer ratings will lead to 
breakthroughs in the identification of the personal 
attributes military aviators need for success. The wide-
spread acceptance of cockpit resource management 
training for aviators is one current example of the inter-
face between psychological skills and effective aircrew 
mission performance. By identifying psychological fac-
tors of successful pilots and those personal qualities 
needed for lead and wing positions, this computerized 
tool will help project our understanding of the next gen-
eration of aviators into the 21st century.

ACKNOWLEDGMENTS

Our thanks to the following people for their dedicated support: SSgt Steve Chartier, Sgt Gary Schofield, Sgt David Mizelle, and SrA Jac-
queline Bonney. Without their willingness to work odd hours, to give 
up weekends with their families, and to dedicate their efforts to help 
aircar, this project could not have been completed.

The voluntary, fully informed consent of the subjects used in this 
research was obtained as required by 169-6. Opinions, interpretations, 
conclusions, and recommendations are those of the author and are not 
necessarily endorsed by the U.S. Air Force. The research reported in 
this paper was supported by the Armstrong Laboratory, Human Sys-
tems Center, AFMC, United States Air Force, Brooks AFB, TX.
APPENDIX A. PEER SURVEY

Choose from your squadron those three other pilots you would want to fill your four-ship for combat, and place their names in the spaces below. Considering those qualities on the facing page, name those that were most important in your choices and rank these in the spaces provided beneath each name (most important #1, next most important #2, etc. #3, #4). Remember that we are looking for the ‘best’ person you feel will fill each job, but DO NOT choose yourself.

Lead: 1st Choice Wingman: 2nd Choice Wingman: (name) (name) (name)

What qualities were most important in choosing this person?

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<tr>
<th>#1.</th>
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<th>#3.</th>
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[Trustee: remove top portion of this form and destroy]

Aircrew member: Trustee will simply separate names from top of page and send bottom of page with assigned random numbers to principal investigator.

RATING CATEGORIES

1. GENERAL KNOWLEDGE
   - possesses a good fund of information
   - absorbs new information quickly
   - reduces complex issues to essential elements
   - valued for opinions on technical matters

2. JOB PERFORMANCE
   - accomplishes any task thoroughly and efficiently
   - uses initiative to solve difficult problems
   - is predictable, consistent, reliable in performance
   - able to prioritize multiple critical tasks quickly

3. STRESS TOLERANCE
   - demonstrates prompt and accurate reactions
   - effective in an unexpected emergency
   - effective under prolonged periods of stress
   - arrives at practical conclusions in emergencies

4. LEADERSHIP
   - motivates others to complete tasks
   - delegates work and allows person to complete task
   - is decisive/flexible when required
   - has determination and projects decisiveness

5. GROUP COHESIVENESS
   - puts group goals ahead of individual goals
   - shares credit and accepts blame
   - tolerant of individual/cultural differences
   - works effectively with many different people

6. TEAMWORK
   - easy to get along with, good sense of humor
   - pulls own weight (does own share of undesirable tasks)
   - gives and accepts feedback/criticism well
   - good listener

7. PERSONALITY
   - tolerates difficulties and frustration well
   - few irritating qualities
   - personable and amiable
   - self-sufficient, motivated, self-starter

8. COMMUNICATION SKILLS
   - presents self well, speaks clearly and effectively
   - represents squadron well
   - concise and focused
   - gets point across

9. AGGRESSIVENESS
   - pursues goals rather than waiting for them to occur
   - accepts calculated risks
   - "makes" opportunities where few seem to exist
   - desire to excel

REFERENCES