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Suitability Screening Test for Air Traffic Controllers

By Dr. Suresh Arumugam, Dr. K. Ramachandran & Mrs. Angana Bhattacharyya

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Dr. Suresh Arumugam [α], Dr. K. Ramachandran [σ] & Mrs. Angana Bhattacharyya [ρ]

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I. Introduction

An air traffic control specialist is described often as one who provides for the safe, orderly, and expeditious flow of air traffic both in the air and on the ground. Air traffic controllers coordinate the movement of air traffic to make certain that planes stay a safe distance apart. Their immediate concern is safety. Some regulate airport traffic; others regulate flights between airports. Air traffic controllers direct the flow of aircraft in and out of airports and during flights to prevent accidents and minimize air traffic delays. Most of the decisions of air traffic controllers are split-second ones, affecting the safety of pilots, crews, and passengers. Therefore, air traffic controllers *must thrive on stress and* they have *no margin for error*, as even the smallest mistake could lead to a deadly accident. In air traffic control the consequences of human errors may be immediate and catastrophic. Choosing the wrong person for such a safety -sensitive job can have visibly disastrous consequences. The method by which an organization selects the operators of intrinsically Choosing the wrong person for such a safety -sensitive job can have visibly disastrous consequences. The method by which an organization selects the operators of intrinsically complex ATC systems is an important factor in achieving the goals of aircraft safety. The selection method must take into account the nature of the ATC task, the range of human abilities relevant to performing the task, and the meaning and structure of performance. No selection system is perfectly accurate; all will involve a degree of error. The investigation of how operators actually accomplish their tasks is relevant not only for designing appropriate personnel selection and training procedures, but also for designing interfaces that support operators in their tasks by reducing the probability of errors. Errors in prediction can be of two types. *Type 1 error* results when an applicant who could have been successful is rejected, and a *Type 2 error* results when an applicant is accepted and is ultimately unsuccessful. Therefore, to perform ATC'S duties efficiently, some of the inherent psychological qualities are prerequisite.

Psychological tests form an integral part of Air Traffic Controllers that examines the potential capability for controlling the air traffic of military and civil aircrafts. There is paradigm shift in aviation technologies and machines, especially airplanes and towers infrastructure. Though there is advancement in information, automation and radar technologies, the man behind the control machine plays a vital role, as machines cannot make decisions especially under critical stages because, it is not a simple algebraic or geometric equation. While employers may be somewhat unsure of what type of employee would best fit into their organizations, they are usually more certain of the types of employees they do not desire. Select-out criteria, or guidelines for eliminating applicants with a disqualifying psychiatric diagnosis (lack of fitness), results in the identification of a very small subset of the candidate pool but does not identify the most qualified or adaptable applicant. Select-in methods determine who is best suited for challenging tasks but are relatively ineffective at screening for psychopathology.

"Non-cognitive" is a term used to describe all of the personality and motivational characteristics of an

Author α σ ρ: Defence Institute of Psychological Research (DIPR) Defence R & D Organization (DRDO) Ministry of Defence, Delhi, India. e-mails:suresha080176@gmail.com/suresh@dipr.drdo.in

individual, other than physical and cognitive characteristics. Cognitive characteristics refer to an individual's capability to acquire process and retain information. They are measured largely with tests of mathematics knowledge and verbal ability. Cognitive tests yield among the highest criterion-related validities available in personnel selection settings. Non-cognitive predictors promise comparable criterion validities in personnel selection though they are used infrequently relative to cognitive predictors. Research suggests non-cognitive selection devices display meaningful incremental criterion-related validities in combination with cognitive ability predictors.

A number of studies using personality as a predictor of performance-based criteria for air traffic controllers have been reported over the last thirty years. Karson and O'Dell (1970) examined relationships between personality factors measured by 16PF and job performance ratings for a group of 264 controllers. They reported no significant correlations between personality profile scores and job performance ratings. . Using the State-Trait Personality Inventory (Spielberger, 1979), Nye and Collins (1991) found male and female Air Traffic Control trainees (N = 1,284) exhibited less anxiety and anger than normative groups of college students and Navy recruits. Another important finding was students who had higher than average anxiety and anger scores were more likely to fail at the FAA air traffic controller academy. A similar study (Nye, Schroeder, & Dollar, 1994) investigated scores from Jenkins Activity Survey (Jenkins, Zyzanski, &Rosenman, 1979) for 474 Air Traffic Control trainees, focusing on prevalence of Type Abehavior patterns in air traffic control students found that students in Air Traffic Controller training courses demonstrated higher incidence of Type A behavior than a normative sample. A study investigating 16PF scores of post-strike FAA Academy trainees by Schroeder & Dollar, 1997found that Air Traffic students exhibited less anxiety, higher self discipline, higher emotional stability, and were more self reliant and assertive than normative samples. In the same study, data originally gathered by Karson and O'Dell (1970) were reexamined. The same pattern of ATC student profile characteristics was found.

Schroeder, Broach, and Young (1993) examined relationships between personality and FAA Academy performance using a measure explicitly developed to tap Big-5 construct domains. Using the NEO Personality Inventory (Costa & McCrae, 1985), Schroeder et al. found Air Traffic students (N=1,030) exhibited lower than average Neuroticism scores and higher than average Extroversion, Intellectance and Conscien-tiousness scores than normative samples. They also found Big-5 measures predicted significant incremental performance variance over measures of cognitive ability. Personality measures are currently being used for Air Traffic Controller selection in the United States, Germany, Sweden, and the United Kingdom (Broach & Manning, 1997). In the United States, personality assessment has been 26 formally used since 1965 as part of the medical screening program (Convey, 1984) for Air Traffic Controllers. An empirical key using 38 items from the Sixteen Personality Factor Questionnaire (16PF) was designed to target potential anxiety disorder and used to refer screened applicants for more extensive psychiatric and psychological evaluation. Importantly, Pickrel (1984) reported between one and two percent of all applicants warranted closer examination and that subsequently half of these were medically disqualified from service. Collins, Schroeder, and Nye (1989), using the State-Trait Personality Inventory (STPI), found that scores on the STPI scales measuring anxiety were inversely related to successful training and good on-the-job performance. Non cognitive measures are being used successfully in the selection of air traffic controllers because of their criterion validity with performance measures and as a "flag" for those who might have difficulty succeeding in an occupation where stress levels can be high. Research suggests personality may prove valuable in additional areas. Where cognitive abilities may be more predictive of core technical competence, personality may be more relevant to what Borman and Motowildo (1993) termed "contextual performance." Over the past decade, there has been increased interest in determining the role of Non cognitive factors in attracting and retaining individuals in various occupations.

II. Significance of the Study

ATC system is an important factor in achieving the goals of aircraft safety and efficient airport and air management. The development and validation of psychological test will play a critical role in reducing costs associated with attrition from air traffic control training. Using a valid selection test also ensures that those who are hired have the potential to develop the necessary knowledge, skills, and abilities to become a successful Air Traffic Controller.

III. Plan of Research and Sequence of Studies

This research involves two studies and two samples designed to examine, as comprehensively as possible, the psychometric properties of the Non Cognitive Test(NCT). Study 1 focuses on creating the NCT, assessing its dimensionality, confirming the factor structure and construct dimensionality, gender differences among non cognitive dimensions and internal consistency reliabilities of the extracted factors and intercorrelations of the NCT with Criterion scales (Sample 1). Finally, Study 2 attempts to demonstrate

convergent and discriminant validity, including additional measures of personality, polychronicity, and sensory sensitivity (Sample 2).

STUDY 1

Non Cognitive Test:Item Development

IV. Sample & Procedure

The sample for Job analysis Study consists of Eighty seven ATC controllers (N = 87). The controllers were from different level of hierarchy like the junior level (23%), the middle level (42.5%) and senior officer level(34.5%). Their mean age was 35.7(SD=6.1) years, and mean year of service were 11 years. The educational level of the controllers ranged from graduate (N= 36) to post graduate (N=51). The sample for the development of Non Cognitive Test (NCT) consists of 902 military aspirants. The mean age of the participants was 21.3 years (SD = 2.34), out of which 690 (76%) were males and 212 (24%) were females.

Job analytic interviews of the currently employed air traffic controllers were conducted individually and with the senior training instructors.Performance Improvement Characteristics (P I C)(J. Hogan &Rybicki, 1998)and Work Style Rating Scale of O*NET (US Department of Labor/Employment and Training Administration) were used to identify the personal characteristics and work styles needed to successfully execute the air traffic controller job. The job analysis results revealed high ratings for personality characteristics like Adjustment, Prudence and Ambition and Work Styles like Cooperation, Achievement, Self-Control, Persistence, Leadership, Social Orientation, Innovation, Stress Tolerance, Adaptability, Depend-ability, Attention to Detail and Integrity . Visits to the Air fields and observations lead to identify dimensions like Sensory Sensitivity and Polychronicity. Based on the above identified dimensions, 200 non cognitive items were developed.

V. Initial Item Selection

The initial 200 items with six expected dimensions Adjustment, Ambition, Prudence, Extraversion, Social Potency and Orienting Sensitivity were given to 10 Subject Matter Experts (SME). According to DeVellis (2003) one should enlist between 6 and 10 experts on the measure content to review items for a newly constructed test. SME were asked to rate the non cognitive statements on a 5 point rating scale ranging from 'to a very small extent' to 'to a very great extent' of the defined constructs. Each dimension was operationally defined.The dimension of Adjustment, Ambition, Prudence and extraversion consisted of 40 items each and the dimension of Social Potency and Orienting Sensitivity consisted of 10 items each.

Once the results of the expert review were obtained, the process of item clarification and elimination was carried out. Items were rated for the appropriateness for the domain, and results were analyzed to determine if certain items were better suited for any other domain included in the test.Mean analysis was conducted on the subject matter experts' ratings. The mean values of the ratings on items measuring adjustment was 3.5, items measuring ambition was 4, items measuring extraversion was 4, items measuring prudence was 4, items measuring social potency was 4.1and items measuring orienting sensitivity was 4.The Subject Matter Experts' opinions lead to select 100 items. 20 items measuring adjustment, 20 items measuring ambition, 20 items measuring extraversion, 20 items measuring prudence, 10 items measuring social potency and 10 items measuring orienting sensitivity were finally retained. This questionnaire was administered to 902 military aspirants.

VI. Data Preparation and Screening

After the data was collected, data preparation was done by coding the results as per the scoring key. The questionnaire included certain negatively worded statements. These items were given reverse scores so that a higher score corresponded to a higher indication of trait factor. In few instances unanswered items were replaced with the mean scores. In this way the raw data was made appropriate for further statistical analyses.

VII. Results

a) Item analyses

To select the most appropriate items from a total of 100 items, Item Analysis was conducted. All the assumed dimensions were subjected to item total correlation.The value of the coefficient of item total correlation for adjustment ranged from .02 to .45, for Ambition ranged from .05 to .38, for Prudence ranged from .01 to .55, for Extraversion ranged from .03 to .49, for Social Potency ranged from .42 to .62 and ranged from 06 to .49 for Orienting Sensitivity respectively. Items with coefficient of inter-item correlation less than .4 were not selected. The value of Cronbach's alpha was .78 for Adjustment, .78 for Ambition, .84 for Prudence, .82 for Extraversion, .82 for Social Potency and .77 for Orienting Sensitivity respectively. If the omission of any item increased the value of Cronbach's alpha, the item was not selected.

The selection of items on the basis of inter-item correlation and the value of Cronbach's alpha lead to selection of 23 items. Out of these, 02 items measuring adjustment, 08 items measuring prudence, 03 items measuring extraversion, 03 items measuring orienting sensitivity and 07 items measuring social potency were retained.

b) Factor Analysis

An exploratory factor analysis was accom-plished to select the most appropriate items from the items retained after Item Analysis. A principal

component analysis was conducted. The idea behind principal component analysis is to be able to reduce variables from a larger set of observed variables (Hatcher, 1994). Principal component analysis can be used to identify item loadings on the factor and also to clarify the internal structure of a factor.The value of Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was found to be 0.88, which indicated that adequate number of samples was taken in the development of the test.

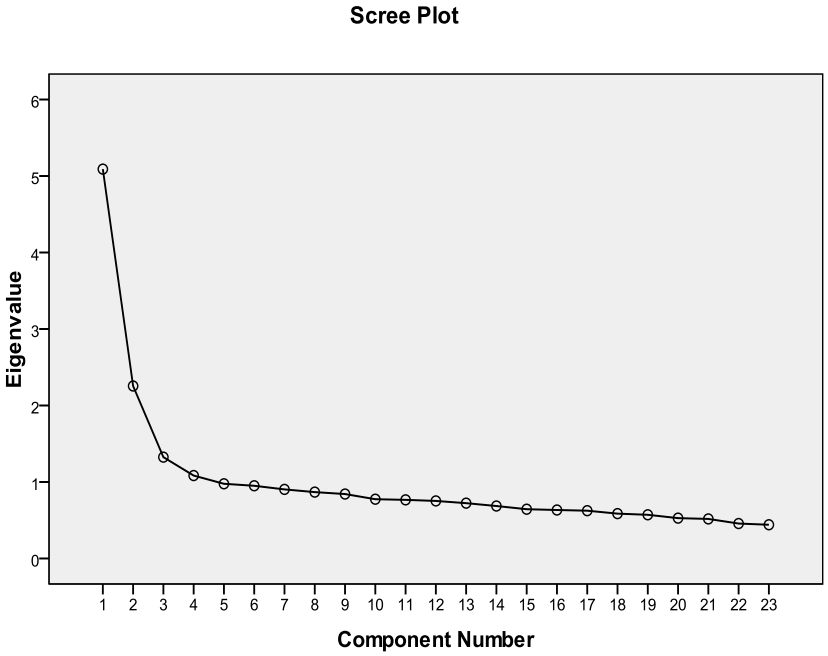

Figure 1 : Scree Plot for the ATC Non Cognitive Test (N=902)

The scree plot (Figure 1.) demonstrated that a four factor solution fit the data; however, the scree plot did not indicate a dramatic increase in variance explained occurred by using more than three factors.

To determine the extent to which the factor structure of the test revealed a four factor solution, principal component analysis and a varimax rotation were performed on the scores of the sample. The four extracted factors accounted for 45% of the total variance.

Table 1 : Principal Component Analysis (After Varimax Rotation)

Item no.	Factor 1	Factor 2	Factor 3	Factor4
41	**.56**	.25	.12	.01
8	**.70**	.23	.03	.01
94	**.60**	-.07	.30	.27
85	**.56**	.27	.12	.06
58	**.52**	-.10	.25	.17
21	**.53**	-.00	.15	.22
97	**.74**	.19	-.08	.08
87	.08	**.65**	.10	.01
4	.27	**.46**	-.14	.02
42	.11	**.64**	-.14	.11
98	.13	**.56**	.13	-.07
91	.06	**.61**	.07	.07
92	.03	**.59**	.01	.27
86	.08	**.52**	.33	.20
7	.09	-.08	**.76**	.06
66	.29	.23	**.54**	.03
59	.39	.20	**.45**	-.12
93	.03	.33	-.19	**.55**
96	.19	.07	.00	**.58**
74	.13	.05	.18	**.714**

Eigen values	4.67	2.03	1.20	1.06
Variance explained	23.39	10.17	6.01	5.29

Note. Factor 1= Social potency, factor 2= Prudence, factor 3= Sensitivity, factor 4= Extraversion

Table 1 shows that the first factor accounted for23.39 % of variance (Eigen value =4.67), the second factor accounted for 10.17% of variance % (Eigen value =2.03), the third factor accounted for 6.01% of variance (Eigen value =1.20), and the fourth factor accounted for 5.29% of variance (Eigen value =1.06). The table also demonstrates the rotated component matrix indicating the factor loadings for each item. The value less than .40 were eliminated. Factor loading of each item was examined from the rotated component matrix and three items were eliminated. Two items were eliminated due to non-loading and one item due to cross loading. No secondary loadings (>.40) occurred. This leads to the selection of final 20 items for the test. The rotated component matrix further demonstrated that factors were easily distinguishable and identifiable.

Each item had its highest loading on the targeted factor. After studying the items that comprised each construct, appropriate names were given to each factor. The four extracted factors were finalized as Social Potency, Prudence, Sensory Sensitivity and Extraversion. The items were resorted and item numbers were changed in order to format the final test.

a) Gender Differences Among Non-Cognitive Dimensions

Table 2 : Mean, SD and Gender Differences among Non- Cognitive Dimensions (N=902)

Dimensions	Males (N=690)		Females(N=212)		t
	M	SD	N	SD	
Social Potency	24.81	5.142	25.54	3.712	-1.92
Prudence	25.84	5.037	27.85	3.749	-5.36**
Sensitivity	10.53	2.415	11.11	1.902	-3.20**
Extraversion	11.55	1.929	11.62	1.634	-.48

*** p< .01*

Table 2 reports the means and standard deviations of the four factors of the non cognitive test for males and females separately. Significant differences were found between males and females on the factors prudence (t [900] = -5.36, p = .000) and sensitivity (t [900] = -3.20, p =.000). In all cases, the females reported higher scores than males. No signifdifferences were found on Social Potency and Extraversion.

Table 3 : Means, SD, correlation coefficients and reliability of extracted factors

Factors	M	SD	1	2	3	4
Social Potency	24.98	4.853	1.00(.77)			
Prudence	26.32	4.840	.390**	1.00(.72)		
Sensitivity	11.57	1.862	.489**	.261**	1.00(.77)	
Extraversion	10.67	2.317	.339	.344	.155	1.00(.82)

Note. 1= Social potency, 2= Prudence, 3= Sensitivity, 4= Extraversion.

Table 3 provides the means, standard deviations, correlation coefficients and internal consistency reliabilities of the extracted factors of the non cognitive test. It was observed that the coefficient alpha for the scales were high. Coefficient alpha measures the internal consistency of a scale (Cronbach, 1951). The coefficient alpha value ranges from zero to one. The higher the score, the higher is the internal consistency. Nunnally (1978, p. 245) and Hatcher (1994, p. 339) recommended that, in basic research, coefficient alpha should be at .70. However, the acceptable level of alpha depends on the context of the research. In personality research, lower alphas are acceptable. Robinson et al. (1991, p.13) indicate that in personality psychology, the alpha levels from .60 to .70 can be rated as moderate. In short personality inventories, alphas are typically in the .60 to .90 range (Parker et al. 2008; Tokar et al. 1999). According to Segal and Coolidge (2004), coefficient alpha values around .90 can be expected with scales of 30 or more items, while

alphas will be lower for scales with fewer items. Here, the reliabilities ranged from .72 (Prudence) to .82 (Extraversion), indicating that it is a reliable test since all coefficients were found to be above the minimum requirement of 0.7 (Nunnally& Bernstein, 1994).

The data also indicated a positive significant correlation between social potency and sensitivity ($r = 0.49$, $p<.01$), followed by prudence ($r = 0.39$, $p<.01$) and extraversion ($r = 0.34$, $p<.01$). A significant positive correlation was also observed between prudence and extraversion ($r = 0.34$, $p<.01$) followed by sensitivity ($r = .26$, $p<.01$) and also between extraversion and sensitivity ($r = 0.16$, $p<.01$).

STUDY 2

Non Cognitive Test : Validation

Validity is one of the key issues in the assessment of the quality of research. Hair et al. (2010, p.3) defined validity as the "extent to which a measure or set of measures correctly represent the concept of study." In other words, validity can be understood as an indicator of whether the research measures what it is supposed to measure (McGivern, 2006, p.79). In the validation of the present Non Cognitive Test , two types of validity were studied, Convergent validity and Discriminant validity.

a) Participants

102 candidates from the Officer's Training Academy voluntarily participated in the validation test of the present test. The mean age of the participants was 23.3 years, out of which 60 were males and 42 were females.

b) Measures

The following scales were used as criterion measures for the present test:

The HEXACO– 60 Personality Inventory-Revised: The 60 item HEXACO - PI – R was developed by Ashton & Lee (2009) to measure six major dimensions of personality including Honesty-Humility (H), Emotionality (E), Extraversion (X), Agreeableness (A), Conscientiousness (C), and Openness to Experience (O). Participants were asked to indicate their agreement on a series of items ranging from 1 (strongly disagree) to 5 (strongly agree). Each of the six HEXACO scales had acceptable internal reliability (H: $\alpha=.82$; E $\alpha=.75$; X $\alpha=.78$; A $\alpha=.78$; C $\alpha=.80$; O $\alpha=.66$).

Multitasking Preference Inventory: The 14-item Multitasking Preference Inventory (MPI) was developed by Poposki and Oswald (2010) to measure an individual's preference to engage in multiple tasks simultaneously. The scale was developed and validated on multiple samples, in which the scale demonstrated adequate internal consistency, with the Cronbach's alpha reliability estimates ranging from .88 to .91. Items were scored on a five point Likert scale with the response options ranging from 1 (Strongly disagree) to 5(Strongly agree).

Sensory Sensitivity Scale from the Formal Characteristics of Behavior- Temperament Inventory (FCB-TI): The 20 item sensory sensitivity scale from the Formal Characteristics of Behavior- Temperament Inventory (FCB-TI) was developed by Fruehstorfer (2010) to measure the ability to react to low-intensity physical stimuli. Participants were asked to respond to the items as "yes" (this is characteristic of me) or "no" (this is not characteristic of me). The scale was found to be internally consistent with Cronbach's alpha .72.

VIII. Procedure

All participants were asked to complete a questionnaire consisting of three scales, namely, The HEXACO– 60, the Multitasking Preference Inventory, and Sensory Sensitivity Scale. The Hexaco-60 was used to correlate the dimensions of personality with the factors of the present test. Sensory Sensitivity scale was correlated with the Sensitivity dimension of the present test. The Multitasking Preference Inventory was used to find whether the scale was inversely related to the factor Prudence, which could establish discriminant validity.

IX. Results

Convergent validity is shown when a group of indicators that are designed to measure the same (or closely related) constructs are moderately or strongly correlated with one another (Hatcher, 1994, p.255).

Table 4 : Inter-Correlations of the ATC Non Cognitive Test with Criterion Scales

Criterion Scales	Social Potency	Prudence	Sensitivity	Extraversion
HEXACO 60				
Emotionality	-.03**	-.12**	.03	-.12**
Extraversion	.32**	.21**	.17**	.22**
Agreeableness	.20**	.19**	.13**	.10**
Conscientiousness	.27**	.36**	.15**	.21**
Openness	.27**	.20**	.24**	.16**
MPI	.08*	-.12**	.05	-.02
Sensory Sensitivity	.17**	.17**	.21**	.09**

Note. MPI=Multitasking Preference Inventory

Table 4 shows that there is a significant relationship between social potency and extraversion, and the correlation coefficient (r=.32, p<.01) between the scores of the two constructs confirms the relationship, at the same time showing convergent validity. Similarly the factor prudence is significantly correlated with conscientiousness, the correlation coefficient being (r=.36, p<.01). The factor sensitivity is significantly correlated with openness to experience with a coefficient of (r=.24, p<.01). The fourth factor extraversion is significantly correlated with extraversion of the HEXACO-60 scale with a coefficient of (r=.22, p<.01), showing convergent validity.

Discriminant validity can be defined as the degree to which two concepts are distinct (Hair et al., 2006, p.137). In order to evaluate the discriminant validity, the compared constructs should be similar in the structural sense, for example, for two personality factors. Correlation analysis is used in the discriminant validity test. For concepts, to present discriminant validity, they should not correlate strongly with each other. Discriminant validity can be observed, for example, social potency is not correlated with emotionality (r=-.03) and social desirability (r=.20). The factor prudence has no significant correlation with preference to multitasking (r=-.12). Orienting sensitivity has no significant correlation with emotionality (r=.03). The factor extraversion has no significant correlation with emotionality (r=-.12) and social desirability (r=.10).

In general, the above findings certify both convergent and discriminant validity for the present test. Where the first is corroborated by high correlations with homologous dimensions, the second one is corroborated by the absence of high correlations with dimensions tapping into different aspects of personality. Indeed, no scales showed correlations higher than .25 with scales other than the corresp

X. Discussion

This study aims to develop and validate a non–cognitive test for the selection of the air traffic controllers. A Personality Based Job Analysis was conducted on 87 air traffic controllers. The job analysis identifies the personal characteristics and work styles needed to execute successfully the air traffic controller job. Job analytic interviews of the currently employed air traffic controllers were conducted individually and with the senior training instructors. They were also assessed on Performance Improvement Characteristics and Work Style Rating Scale. The results of job analysis revealed high ratings for the personality characteristics of Adjustment, Prudence, Ambition, leadership and openness to experience. On the basis of job analysis 200 non cognitive items were developed with six expected dimensions of adjustment, ambition, prudence, extraversion, social potency, and orienting sensitivity. Subject Matter Expert's opinion reduced the number of items to 100. This initial 100 item questionnaire was administered to 902 military aspirants. Item Analysis was conducted and items were further reduced to 23 items. Factor Analysis was conducted and finally 20 items were retrieved. Four extracted factors were obtained: Social potency, Prudence, Sensitivity and Extraversion. 45% of the total variance was covered by these four extracted factors.

Cronbach alpha reliability for extracted factors in ranged from .72 to .82, indicating that it is a reliable measure. In the validation of the present non cognitive test, Convergent validity and Discriminant validity were studied. The present tool was correlated with scales like The HEXACO-60, Multitasking Preference Inventory and Sensory Sensitivity for convergent validity and discriminant validity. The convergent validity of the present tool ranged from .25 to .40. Finally gender differences were also found on the present scale. Significant differences were found for the factors of prudence and sensitivity with females having higher average score than males. There were no significant differences in the factors extraversion and social potency.

In summary, from the viewpoint of developing a psychological test for the selection of air traffic controllers, the present measure can be a suitable to obtain reliable and valid self-ratings of personality. The results also indicate that this is a short, reliable and valid personality measurement scale. The psychometric of ATC Non-Cognitive test is very strong. The scale is highly internally consistent and reliable. Convergent and discriminant validity are high and appropriate. The construction of this test has been highly rigorous and the statistics are highly supportive for its utility. The Non Cognitive Test being developed specifically after a thorough personality based job analysis, it serves to identify individuals with job specific personality attributes ideal for a successful air traffic controller.

The present Non-Cognitive test was developed to assess the personality traits of the Air Traffic Controllers. Further implications of this test can be functional at two levels. First, this test can be utilized for the purpose of screening air traffic controllersfor recruitment of Air Traffic Controllers. Secondly, it can also be used as a screening device at ATC Training institutes for evaluation of Air Traffic Controllers at the training phase. This Non-Cognitive test being developed and validated on military aspirants will be advantageous to measures ATC Job specific personality traits.

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