Investigating the use of alternative predictors of training performance in the Canadian Forces Operator Occupations

Thesis, submitted in partial fulfillment of the Requirement for the Degree of Master of Science in Applied Psychology (Industrial/Organizational)

Sarah K. Campbell

Saint Mary's University

Halifax, Nova Scotia, Canada

Approved: ______________________
V.M. Catano, Ph.D.

Approved: ______________________
A.L. Day, Ph.D.

Approved: ______________________
Shaun Newsome, Ph.D.

Date: May 2001

0-612-65727-2

Table of Contents

APPENDICES

LIST OF TABLES

ACKNOWLEDGMENT

Defending this thesis has been an adventure not just for me but also for my family and friends. I would like to thank those who helped me complete this project. I am grateful for the support I received from the Directorate of Human Resources Research and Evaluation, specifically: Cdr R. Girard. Mr. C. Mombourquette. Maj R. Porter. Maj L. Grandmaison. Maj L. Noonan. LCdr D. Woycheshin. and Capt N. Perron. I would also like to thank Capt D. Scholtz. SLt. J. Balao. Lt. R. Godlewski. and Lt. M. Norris for their administrative assistance.

To my husband: While Greg may not have always known how to help, it was enough that I knew I could count on him for support (& data entry).

To my committee members. Dr. Shaun Newsome and Dr. Arla Day: Shaun for his rigorous reviews. Arla whose scholarly vigilance was welcome. I would also like to thank my external reader. LCdr R. M. MacLennan for her encouragement and valuable contributions.

To my advisor. Dr. Vic Catano: A man of quiet wisdom (and never-ending patience) who helped me to see the forest *despite* the trees.

Finally. I would like to thank the men and women of the Canadian Forces who took the time to participate in this study.

ABSTRACT

The present study examined the predictive validity of information processing measures - Speed of Closure, Flexibility of Closure, Perceptual Speed and Auditory Attention on training performance. The incremental validity of these ability measures beyond general cognitive ability was examined in a military example of Canadian Forces Personnel in the Operator Family.

Trainees engaged in Qualification Level 3 training (n=122) completed the five information processing ability measures; archival data were collected from two general cognitive ability measures: the Canadian Forces' General Classification Test Form 3 Revised (n=72) and the Canadian Forces Aptitude Test (n=98). Criterion data was a global percentage grade taken from course evaluation reports.

Information processing ability measures are valid predictors of training performance for the Operator Family and were expected to improve the predictive validity of selection against training performance when used with measures of general cognitive ability. The only specific ability measure that significantly predicted training performance was the X-A2 battery, a measure of Auditory Attention. The information processing measures did not reach significance but still contributed to the predictive equation. Further research with a larger sample should be completed to replicate these findings.

Investigating the use of Alternate Predictors of training Performance in the Canadian Forces Operator Occupations

Introduction

Selecting employees for jobs or training programs requires valid predictors based on job requirements. Such measures are particularly useful when measuring abilities that have been identified through job analysis (Childs, Baughman, & Keil, 1997; Levine, Spector, Menon, Narayanan, & Canon-Bowers, 1990). General cognitive ability is a valid predictor across jobs (Gottfredson, 1986; Hunter & Hunter, 1984; Schmidt & Hunter, 1998) and may be incremented by specific ability measures in personnel selection (Lubinski & Dawis, 1992; Schmidt & Hunter, 1998; Wise, McHenry & Campbell, 1990).

Different components of job performance show different patterns of relationships with different predictor measures (Campbell, 1990). If optimal prediction is desired in selection, different mixes of skills may be required (Wise et al., 1990). For example, while general cognitive ability was the best predictor of performance across nine different military occupations, adding specific ability tests improved the equation in two narrow criterion areas: Core Technical Proficiency and General Soldiering Proficiency (Wise et al., 1990). Though a large body of research exists outlining the effectiveness of general cognitive ability (i.e., “g”) in predicting performance, psychology has not given sufficient attention to evaluating and applying specific ability measures in selecting applicants for jobs (Ackerman & Cianciolo, 2000). The addition of specific ability measures to general cognitive ability may improve selection systems.

Research conducted by the Canadian Forces (CF) indicates that the Canadian Forces Aptitude Test (CFAT), a paper and pencil test of general cognitive ability, is not predicting performance on initial trades training for the Operator Job Family (Woycheshin, 1999). With reduced training resources and projected increases in job complexity, selection is becoming more valuable (Olea & Ree, 1994). Therefore, as guided by Catano's (1995a) research with the CF, and in conjunction with Fleishman's taxonomy of human abilities, this study will evaluate the feasibility of additional selection measures for the Operator Family.

Background.

The Ability Requirements Approach links descriptions of job tasks to common abilities required to perform them (Fleishman, 1982; Fleishman & Mumford, 1988; Fleishman & Quaintance, 1984). Abilities are considered to influence an extensive range of task performance as well as being relatively stable attributes of an individual (Fleishman, 1982; Fleishman & Mumford, 1988; Fleishman & Reilly, 1992). This approach differentiates between abilities and skills. Abilities refer to a broader capacity of the individual connected to performance in a range of human tasks. An ability can influence performance on a number of specific tasks (Catano, Cronshaw, Wiesner, Hackett & Methot, 1997). Skills, in contrast, are defined as the level of proficiency on an explicit task (Buffardi, Fleishman, Morath, & McCarthy, 2000). Fleishman and Quaintance (1984) have identified 52 separate human abilities which can be categorized into four broad groups: Cognitive, Psychomotor, Physical, and Sensory/Perceptual. One of the primary applications of this methodology is in personnel selection as this approach provides the basis for illustrating the relevance of the ability tests selected and their linkages to critical job tasks (Fleishman & Quaintance, 1984).

In the early 1980s, the US Army undertook Project A, the first large scale cognitive ability testing program for testing recruits since World War I. Project A attempted to expand and validate military selection personnel and classification techniques for entry-level occupations (Campbell, 1990; Hanser, 1997). In 1991, the CF embarked on a similar research vein in an attempt to improve the already existing selection and classification of entry-level Non-Commissioned-Members (NCMs). Common ability requirements were used to group sixty-six entry-level occupations into five job families according to Fleishman's taxonomy of human abilities: **Military** (i.e., Infantry Soldier, Artillery Soldier), **Operator** (i.e., Naval Communicator, Tactical Acoustic Sensor Operator), **Administrative** (i.e., Postal Clerk, Resource Management Clerk) **Technical** (i.e., Land Communications and Information Systems Technician, Aerospace Telecommunications and Information Systems Technician), and **Mechanical** (i.e., Aviation Technician, Aircraft Structures Technician; Catano & Ibel, 1995a; see appendix A for all occupations included in each family). 2501 Subject Matter Experts, NCMs from all entry-level occupations, completed an Occupation Abilities Survey (OAS). Powell, Cunningham, Wimpee, Wilson, & Ballentine (1999) applied this approach in the US Army and determined that it was useful in linking human abilities to taxonomies of work. This method of job analysis is germane to the issues of content and construct validation as it provides the basis for demonstrating the occupational relevance of the ability tests selected and their correlation to critical job tasks (Fleishman, 1982).

Catano (1995a) used Principle Components Factor Analysis to organize the 52 abilities from Fleishman's taxonomy into nine ability composites that were related to the five entry-level occupational families. These dimensions include Strength and Movement, Vision, Audition, Controlled Reaction, Analytical Ability, Information Processing, Cognition, Verbal Ability, and Fine Motor Control (Catano, 1995b). See appendix B for the abilities associated with each dimension. Ability composites that differentiated the Operator Family from other job families were Audition, Information Processing, and Vision (Catano, 1995a). Table 1 presents the primary ability composites for each job family.

Table 1
Abilities that differentiate the occupation families

Military	**Operator**	**Administration**	**Technical**	**Mechanical**
• Strength & Movement • Controlled Reaction • Vision	• Audition • Information Processing • Vision	• No differential predictors for the Administration occupation family	• Fine Motor Control • Analytical Ability • Cognition • Vision	• Strength & Movement • Controlled Reaction • Fine Motor Control • Analytical Ability • Cognition

Audition included the following abilities: Speech recognition, Auditory Attention, Speech Clarity, Hearing Sensitivity, Time sharing, Wrist-finger speed, and Sound Localization. **Information Processing** represented Flexibility of Closure, Speed of Closure, Selective Attention, Perceptual Speed, Spatial Orientation, Manual Dexterity, and Auditory Attention (Catano, 1995b). All of the abilities linked to information processing, with the exception of manual dexterity, are directly related to processing perceptual information (Woycheshin, 1999). **Vision** is represented by Near Vision, Far

Vision, Visual Colour Discrimination, Night Vision, Peripheral Vision, Depth Perception, and Glare Sensitivity.

Six of the nine predictors, Audition, Information Processing, Vision, Strength and Movement, Controlled Reaction, and Fine Motor Control are not measured by the recently or currently used CF selection measures (General Classification 3-Revised (GC3-R), CFAT). These measures of general cognitive ability do not cover the full range of abilities required for the all of these job families. Catano (1995a) suggested that consideration be given to abilities that were not being assessed as part of the selection process (appendix B). Table 1 shows that Audition, Vision and Information processing are primary predictors of the Operator Family. This relationship makes intuitive sense because the occupations in the Operator family involve processing auditory and visual information presented through various computer and radar displays (Catano, 1995b). The probability of correctly classifying applicants into suitable occupations could be improved through the accurate measurement of the ability composites during selection screening (Catano, 1995b). The following abilities, including general cognitive ability, were examined in this study for the Operator Family: Auditory Attention, Flexibility of Closure, Speed of Closure, and Perceptual Speed.

General Cognitive Ability Theory

General mental ability, cognitive ability, and g are often referred to as general cognitive ability. Such measures are effective predictors of performance (Carey, 1994; Ghiselli, 1973; Gottfredson, 1997; Hunter and Hunter, 1984; Jensen, 1984; Jensen, 1986; Lubinski & Dawis, 1992; Olea & Ree, 1994, Ree & Earles, 1991; 1990). Nevertheless, controversy surrounds the theory of a general cognitive factor and whether it adequately predicts training success and job performance (Jensen, 1984; Ree & Earles, 1991). The concept of specific abilities that comprise general cognitive ability (e.g., verbal, mathematical, and spatial abilities) are still being investigated (Childs et al., 1997; Gustafsson & Snow, 1997). Measures of general mental ability or g often measure several of these aptitudes with varying levels of aggregation. General ability is, however, a well-established predictor for entry-level jobs for applicants with no prior experience (Hunter & Hunter, 1984; Ree & Carretta, 1997; Schmidt & Hunter, 1998).

General Cognitive Ability as a Predictor of Performance.

Since the advent of Project A, general cognitive ability has been widely accepted as a predictor of both work and training performance (Carretta, T.R., personal communication, November 15, 2000; Hunter & Hunter, 1984; Jensen, 1984; Ree & Carretta, 1997; Ree & Earles, 1992; Thorndike, 1986). Tests of general mental ability predict training and work performance better than other aptitude tests, including measures of perceptual, spatial, and motor abilities (Ghiselli, 1973; Thorndike, 1986). Meta-analytic research on predictors of job and training performance demonstrate that tests of general ability are the most valid across different job families for training criteria (average validity of .54) and for job proficiency criteria (average validity of .45; Hunter & Hunter, 1984).

General cognitive ability is also the best predictor of training success across jobs (Hunter, 1986; Ree & Earles, 1990; Ree, Carretta, & Teachout, 1995). The average validity of g across all jobs in the workforce varies, generally, between .3 and .5 (Hartigan & Wigdor, 1989). Moreover, Gottfredson (1997) asserted that validities using g vary across different jobs, ranging from .2 to .8, increasing with job complexity. Even in studies where the predictive validity of g declined, it remained an important and significant correlate of performance (Ackerman & Cianciolo, 2000). Conversely, in military settings, where jobs require an array of skills and abilities, tests limited to general cognitive ability may not be able to predict performance as necessary specific abilities are not measured (Carey, 1994; Jackson, 1984).

Selection systems may be improved with the addition of specific ability measures; the possible importance of specific abilities should not be ignored (Carroll, 1993). For example, manual dexterity tests provided incremental validity beyond general cognitive ability in predicting performance for mechanical occupations in the CF (Johnston, 2000). Based upon this review, it is apparent that while general cognitive ability is central in the prediction of performance (Carroll, 1993; Ree, Earles & Teachout, 1994; Schmidt & Hunter, 1998), g may not be sufficient.

Specific Ability Theory

Controversy surrounds the supposition that g is the best predictor of performance (Ackerman & Cianciolo, 2000; Borman, Hanson, & Hedge, 1997; Gustafsson & Snow, 1997; Thorndike, 1985). Some consider g to be the leading predictor of performance (Hunter, 1986; Ree & Earles, 1990; Ree, Carretta & Teachout, 1995) while others accept that specific ability may add significant incremental validity to general cognitive ability (Carey, 1994; McHenry, Hough, Toquam & Ashworth, 1990). Hull (1928) was one of the first researchers to hypothesize that general cognitive ability was not a sufficient predictor of performance in all occupations. He proposed that instead of using measures of g to predict performance, multiple regression techniques should be applied to combine test scores with different weights for different jobs. If different abilities are required for different jobs, and if these abilities could be recognized in employees, then predictive validity beyond g could be improved. Hunter (1986) supported Hull's theory that different jobs require different abilities. Specific ability theory is the idea that personnel selection systems could be improved through the addition of specific abilities (Ree & Earles, 1992). Clearly, if identifiable abilities are essential for successful performance, then advantageous person-job matches could be attained (Hunter, 1986). Hull's idea has obvious potential applications in selection and classification systems.

Multiple–ability theorists led the development of multiple aptitude test batteries. The General Aptitude Test Battery (GATB), The Differential Aptitude Test (DAT) and the Armed Service Vocational Aptitude Test Battery (ASVAB) were designed to measure specific abilities in order to make predictions about performance (Ree & Earles, 1991). Other research has examined the specific ability theory in selection using similar measures. Campbell (1990) found that different ability measures demonstrated different relationships with different factors of job performance through his research with Project A, supporting Hull's (1928) hypothesis.

Prediger (1989) supports the application of specific ability tests in predicting performance but presents no data on incremental validity beyond g. Although the significance of general cognitive ability in personnel selection is important, multiple ability dimensions merit applied and theoretical attention (Lubinski & Dawis, 1992). Some researchers concede that specific abilities may prove essential in predicting job and training performance criteria beyond general cognitive ability (Levine et al., 1996; Prediger, 1989), but only across a limited range of jobs (Gottfredson, 1997). Despite the surrounding controversy, specific abilities may prove valuable in selection if the measurement instruments are properly constructed and validated (Gustafsson & Snow, 1997). Specific abilities afford greater insight into performance than through general cognitive ability alone (Miller, 1999). If intelligence were the best predictor of performance, training results would be predicted through g successfully, regardless of the job (Sternberg & Wagner, 1993).

Specific measures of ability add significant incremental validity beyond g in predicting job performance. Ree & Earles (1990) found that the mean increase in R^2 from adding components beyond general cognitive ability was .02, a small yet practical increase. Adding specific ability tests to a highly g-saturated test battery improved the predictive effectiveness for both training and job performance criteria (Carey, 1994). Ree et al. (1994) found a similar level of predictive incremental validity averaging .02 beyond general cognitive ability. Overall, validity for predicting job performance in skilled trades and clerical occupations is significantly improved by tests of spatial and psychomotor abilities and measures of perceptual speed (McHenry et al., 1990; Jensen, 1984). Specific ability theory continues to gain acceptance but is still unclear (Schmidt, Ones, & Hunter, 1992).

General cognitive ability does not appear to predict performance in nonsupervisory jobs in military settings (Ree, Carretta, & Teachout, 1995). Certainly, the use of specific abilities as predictors in military and occupational settings have established validity (Carroll, 1993). When jobs are more specialized, the scope of individual differences due to g decreases and the demand on more focused or specialized cognitive abilities escalates (Lubinski & Dawis, 1992). The probability that measures with more concentrated content will account for more of the criterion variance (job or training performance) increases. Specialized abilities can reflect both work-relevant ability pattern differences, which g obscures, and overall ability level differences among occupations (Prediger, 1989). Research supports this theory. Johnston (2000) examined the predictive validity of psychomotor ability in the Technical and Mechanical occupation families. Manual dexterity added small yet significant incremental predictive validity to cognitive ability in the CF's Mechanical job family. Validity beyond general cognitive ability was improved in predicting training performance supporting the argument that measures of specific ability provide significant incremental validity beyond g. Although the validity gained from specific ability tests has been small, these improvements economically benefit large organizations such as the Armed Forces (Hunter & Hunter, 1984; Larson & Wolfe, 1995).

The minor gains in validities in these studies may be explained through the method of job clustering. Job complexity is a key dimension in job clustering methodology (Hunter & Hunter, 1984); the more complex the job, the larger the number of activities required to perform it. Grouping jobs on complexity may conceal any similarity among jobs that have been classified into the job family. Fleishman & Quaintance (1984) suggest that this methodology may make it difficult to distinguish one job family from another in terms of necessary abilities. Hartigan & Wigdor (1989) confirm that clustering jobs into job families based on complexity has not resulted in significant predictive composites. Job families in the CF were formed according to common ability requirements; measuring central abilities within these families may improve the selection and classification of personnel.

At the time, Catano (1995a) suggested that the CF examine the feasibility of using specific abilities not measured by the CFAT as alternate predictors for the Operator Family even though there was little research to support the incremental predictive validity of specific ability measures beyond g (Ree & Carretta, 1997; Schmidt, Ones, & Hunter, 1992). Nevertheless, the supposition that g may not be sufficient in predicting performance and that tests of specific ability may improve this prediction equation warrants further investigation. Abilities required for the Operator Family in the CF are listed in Table 2.

Table 2
Abilities required for the Operator Family

Ability	**Mean Ability Score** (Ability scores anchored to 7 point scale)	**Test used**
Auditory Attention	5.38	X-A2 Battery
Selective Attention	5.17	No known test exists
Near Vision	5.05	Not measured by CF – medical issue[1]
Flexibility of Closure	4.97	GATB: Part 5 – Tool Matching GATB: Part 7 – Form Matching
Speed of Closure	4.96	Gestalt Completion Test Concealed Words Test
Glare Sensitivity	4.89	No known test exists
Hearing Sensitivity	4.89	No – medical issue[2]
Speech Clarity	4.75	No known test exists
Far Vision	4.75	Not measured by CF medical issue[1]
Night Vision	4.75	Not measured by CF medical issue[1]
Sound Localization	4.45	No—medical issue[2]
Speech Recognition	4.45	No known test exists
Perceptual Speed	4.39	GATB: Part 1 – Name Comparison
Spatial Orientation	4.17	CFAT (2nd subscale)
Visual Colour Discrimination	3.96	No—medical issue[1]
Depth Perception	3.93	Not measured by CF medical issue[1]
Peripheral Vision	3.81	Not measured by CF medical issue[1]

[1]Vision is measured by a physician's assistant at the recruiting center. All candidates must meet a minimum vision requirement in order to enroll into the Operator family, this includes colour vision. This information is confidential and is part of student's medical file. Further, as the definition of the Vision factor suggests, testing beyond the CF medical tests of visual acuity would not improve the selection system (Woycheshin, 1999).

[2]Hearing sensitivity is measured by a physician's assistant at the CF recruiting center. All candidates must meet a minimum standard in order to enroll into the Operator Family. This information is confidential and is part of the student's medical file.

Appropriate tests do not exist for all of these abilities; as well, some abilities can be measured only through medical examination (i.e., Near Vision, Hearing Sensitivity). In this latter case, human rights requirements require restrictions on the use of such measures. Table 2 demonstrates the tests used to measure the specific abilities that differentiated the Operator Family and provides information on why some abilities were not investigated. Acceptable measures exist for the abilities of Auditory Attention, Flexibility of Closure, Speed of Closure, and, Perceptual Speed. The present study examines the incremental validity of these abilities, beyond g.

Information Processing Abilities as Predictors of Performance.

Information processing, often referred to as Perceptual Ability, includes Auditory Attention, Flexibility of Closure, Speed of Closure, and Perceptual Speed (Catano, 1995b). The ability to focus on a single source of auditory occurrence in the presence of other irrelevant stimuli is defined as Auditory Attention (Fleishman & Reilly, 1992). Flexibility of Closure is the ability to identify a previously specified stimulus configuration, which is set in a more complex sensory field (Ekstrom, French & Harman, 1976; Fleishman & Quaintance, 1984; McCrumley, Pierce, Schwalm, Coke & Brown, 1992). Speed of Closure involves the speed with which a seemingly disparate sensory field can be arranged into a single meaningful pattern (Ekstrom et al., 1979; Fleishman & Quaintance, 1984; McCrumley et al., 1992). This construct also requires speed of perception (Eliot & Czarnolewski, 1999). Perceptual Speed is the speed with which sensory patterns can be compared in order to determine extent of resemblance (Ekstrom et al., 1979; Fleishman & Quaintance, 1984; McCrumley et al., 1992).

Auditory Attention. According to Fleishman and Reilly (1992), auditory attention is required in jobs ranging from stock bidder to sonar operator. Earlier research by Fleishman (1955) addressed the predictive validity of audition among radiotelegraphers. Aural tests, specifically rhythm discrimination, predicted training success ($r=.34$, $p<.01$). Measures of basic auditory perception may generalize to other areas involving auditory attention (Fleishman, 1955).

The X-A2 Battery, an aural code test predicted Qualification Level 3 (QL3) course success for the Communicator Research (291) occupation in the CF ($r=.25$, $p<.01$; Grandmaison, 1992). The Communicator Research occupation is a member of the Operator Family. The X-A2 battery has been used previously for selection in the CF. Similar Aural Code tests, upon which the X-A2 Battery is based, have also been used to select Radio Operators for the US Air Force (Grandmaison, 1992; Fleishman & Friedman, 1957).

Perceptual Speed. Greater understanding of performance may extend from specific abilities, particularly perceptual speed (Ackerman, 1992; 1997; 1999; Ackerman & Cianciolo, 2000). Measures of perceptual speed may provide a critically important supplement to measures of general abilities in the prediction of individual differences in performance (Ackerman, 1999; Ackerman & Cianciolo, 2000; Levine et al., 1990). Perceptual speed predicted pass/fail criterion of US pilots in training; however, incremental validity of perceptual speed beyond g was not examined ($R^2 = .33$, $p<.05$; Kantor & Carretta, 1988). More recently, Ackerman's (1997) research with the US military demonstrates consistent and significant correlations between training performance and perceptual speed. The correlation between performance and Perceptual

Speed ranged from r=.20 to r=.39 for a complex task simulating the job of an Air Traffic Controller (Ackerman, 1999). Clearly, measures of perceptual speed are important predictors of skilled performance.

Perceptual-psychomotor ability tests provided the best prediction of both general task and job-specific proficiency in the US Army when compared to g (McHenry, et al., 1990). Perceptual-Psychomotor Ability predicted a range of job performance factors with validity coefficients ranging from .11 (Physical Fitness and Military Bearing) to .57 (General Soldiering Proficiency). McHenry et al. (1990) found small but significant improvements when using Perceptual-Psychomotor Ability in the prediction of both general soldiering and job specific proficiency over general cognitive ability. Preliminary research conducted by the US Air Force showed that high levels of information processing abilities are required for successful performance in the Air Traffic Control occupation (Siem & Carretta, 1998).

Neither cognitive nor psychomotor ability are good predictors of perceptual abilities (Hartigan & Wigdor, 1989). Levine et al., (1996) found that validity coefficients for perceptual speed tests were lower than those for cognitive tests using training criteria (r =.20, r = .38 respectively). Hartigan and Wigdor (1989) stated that if cognitive and psychomotor ability alone were sufficient to predict performance, then it would be possible to predict all aptitudes for a given job from their validities. Nevertheless, perceptual ability provides incremental validity beyond g in a broad range of jobs (Lubinski & Dawis, 1992; McHenry et al., 1990). Perceptual speed demonstrated small yet significant increases in validity for predicting Air Traffic Controller performance (Ackerman & Cianciolo, 2000). McCrumley et al., (1992) proposed that perceptual speed would predict those soldiers who would detect more targets because they would be able to scan radar and computer screens more rapidly. Perceptual Speed was not related to this specific task (r=-.07). Moreover, perceptual speed is not related to performance at all (r = -.02; Ackerman & Cianciolo, 2000). Ackerman (1999) stated that perceptual speed is one domain of ability assessment that has been insufficiently studied in the last 50 years. On the one hand, perceptual speed predicts performance (Kantor & Carretta, 1988; Ackerman, 1997; 1999), but others have been unable to replicate these results (McCrumley et al., 1992). The relationship between g and perceptual ability requires further research and clarification (Ackerman & Cianciolo, 1999).

Speed of Closure. Few studies have examined the relationship between Speed of Closure and performance. While Speed of Closure is related to Spatial Orientation and Flexibility of Closure (Stanny, 1990; 1991), its status as a predictor of performance is not clear. McCrumley et al. (1992) employed three Speed of Closure tests to examine their relationship with performance of a specific task. The Gestalt Completion Test (Ekstrom et al., 1976) contains items that are similar to the visual tasks involved in identifying camouflaged targets (McCrumley et al., 1992). The Concealed Words Test (Ekstrom et al., 1976) is comparable to the Gestalt Completion Test but also requires some word knowledge. The Snowy Pictures Test (Ekstrom et al., 1976) is similar to many target detection scenarios (McCrumley et al., 1992). The Gestalt Completion, Concealed Words Test and Snowy Pictures Tests were significantly correlated with the target detection tasks: r=.145; r=.145; and r=.263 respectively with performance criteria. McCrumley et al., (1992) determined that the Speed of Closure factor provided predictive validity for the target detection task and suggested more research to determine whether this factor extends to other broader performance criteria.

Flexibility of Closure. Flexibility of Closure strongly differentiated overall performance among US Army personnel (Stanny, 1990; 1991). This, despite the fact in an accompanying job analysis, subject matter experts (SME's) rated this ability as low in terms of its requirement for overall performance. McCrumley et al., (1992) investigated the link between this ability and the detection of items that have a specific shape or pattern but are embedded in other visual material. The relationship between the Flexibility of Closure factor and the specific target detection task was low (r=.14) and non-significant. McCrumley et al., (1992) believed, however, that further research into the Flexibility of Closure factor and performance was needed.

Overall Goals

Personnel selection systems may be improved by measuring information processing abilities in addition to tests of general cognitive ability (Ghiselli, 1973; Hunter & Hunter, 1984; Lubinski & Dawis, 1992; McHenry et al., 1990). The modest increments in validity observed from specific abilities, may be due to the fact that jobs within job families require different abilities. The equation may be improved based on the application of the common ability requirements approach, where jobs are grouped based on the measurement of common abilities. Information-processing abilities are valid predictors of performance across many occupations. Auditory Attention, Flexibility of Closure, Speed of Closure, or Perceptual Speed may add incremental validity beyond measures of g.

Hypotheses

This study will evaluate the feasibility of using information processing tests to improve the CF's existing selection system:

Hypothesis 1: It is hypothesized that the measures of Flexibility of Closure, Perceptual Speed, Speed of Closure, and Auditory Attention will be valid predictors of training performance for the Operator family.

Hypothesis 2: It is hypothesized that measures of Flexibility of Closure, Perceptual Speed, Speed of Closure, and Auditory Attention will provide incremental validity beyond a measure of g (CFAT).

Method

Participants

One hundred and twenty-two members of the CF on QL3 apprentice level training at various CF schools across Canada participated in the study. These respondents were at least 18 years old and all new to the Operator occupations; however, some were new members to the CF while others with several years of military experience were transferred from different occupations within the organization. The majority of the students were male and anglophone. Students included 85 Anglophone Males, 28 Anglophone Females, 7 Francophone Males, and 2 Francophone Females.

Because the low number of francophone students and the unavailability of all study measures in French, only students enrolled in English courses were tested. Francophone students who enroll in English courses must be demonstrate strong English skills in order to study in their second language. Ninety-eight percent of the Anglophone students enrolled in QL3 training in the Operator family voluntarily completed the testing session.

Members who participated represented the Operator Occupations of Aerospace Control Operator (AC Op), Communicator Research (COMM RSCH), Meteorological Technician (MET Tech), Naval Combat Information Operator (NCI Op), Naval Communicator (NAV Comm), Naval Electronic Sensor Operator (NES Op), Signal Operator (SIG Op), and Tactical Acoustic Sensor Operator (TAS Op). Table 3 presents the distribution of students across these occupations.

Table 3
Stratification of Sample by Occupation (N = 122)

Military Occupation Titles	N	(%)
Aerospace Control Operator (AC Op)	12	9.8
Communicator Research (COMM RSCH)	23	18.9
Meteorological Technician (MET Tech)	11	9.0
Naval Combat Information Operator (NCI Op)	13	10.7
Naval Communicator (NAV Comm)	25	20.5
Naval Electronic Sensor Operator (NES Op)	14	11.5
Signal Operator (SIG Op)	19	15.6
Tactical Acoustic Sensor Operator (TAS Op)	5	4.1

Participation in this study was voluntary. Testing was conducted in a classroom setting without course instructors present. Test administrators read verbatim instructions (see appendix C) introducing the purpose behind the study and gave participants the opportunity to leave at any time without penalty. Participants were also told that if they did not wish to complete testing, they could remain in the room to avoid identification as a non-participant by leaving early. Participants read and signed informed consent forms.

Measures

Criterion Measures

Training performance, specifically QL3 level training, is linked to successful job performance in the CF. Training specification (TS) are based on extensive job analyses as well as occupational specifications for each military occupation. The training specifications for the Operator occupations include all aspects of the trade, including information processing which should require considerable levels of Auditory Attention, Flexibility of Closure, Speed of Closure, and Perceptual Speed.

Successful completion of QL3 training is a valid criterion measure. Training failures are expensive, especially when recruiting and training costs are considered. A selection system that could decrease training failures would have a significant positive impact on the Department of National Defense. This sample had relatively few failures (n=3), therefore, training success could not be used as a measure. The criterion measure that was used was a global percentage grade from each QL3 student. This was the only performance data made available for this study. Training criteria, often the criterion measure of choice in the CF (Ibel & Campbell, 1991), are suitable measures for estimating maximum performance (Catano, 1992). Successful completion of training is a necessary condition for employment in the CF (Campbell & Cotton, 1994).

Predictor Measures

Canadian Forces Aptitude Test. The CF has employed the CFAT since October 1997 (Black, 1999). This measure of cognitive ability is administered as part of a selection and classification system of its recruits. Applicants must achieve a preestablished minimum or cut-off score in order to be considered suitable for enrolment into the CF. Items are designed to be fair with respect to both gender and language (Zumbo & Hubley, 1997). This test consists of three subscales: Verbal Skills (VS-15 items), Spatial Ability (SA-15 items), and Problem Solving (PS-30 items) that are aggregated to form a composite score. The total score is then converted into percentile scores for either NCM or officer selection, as applicable (Albert, 1998). The CFAT is a timed test arranged in ascending order of difficulty that requires 45 minutes of testing including administration. Items not completed in the allotted time are scored as wrong.

Internal consistency reliabilities for the VS, SA, and PS scales are .87, .88, and .91 respectively (Black, 1999). These findings suggest that the CFAT is a reliable measure. The CFAT, with some exceptions, is a valid predictor of NCM occupational performance (Ibel & Cotton, 1994; MacLennan, 1997; Woycheshin, 1999). Validity coefficients of the CFAT range from .00 to .15 for the Operator family, (for the AC Op 168 Occupation validities ranged from .43 to .54) and .30 to .48 for the Technical and Mechanical families (Woycheshin, 1999).

General Classification Test. Between 1991 and 1996, the CF employed the General Classification Test, Form 3 Revised (GC 3-R) a paper and pencil measure of general cognitive ability prior to the implementation of the CFAT to select and classify its recruits. Following psychometric analyses of the GC3 and Canadian Forces Classification Battery (CFCB; Spinner, 1991), an aptitude battery that was often used in conjunction with the GC3, it was found that there was a great deal of overlap in the constructs measured. The proposed measured, evolving form Spinner's (1991) research, resulted in the CFAT. The GC3-R is a 75-item test that requires 30 minutes to complete.

It has good reliability (r= .87; Angus & Halliwell, 1987; Spinner, 1991). Woycheshin (1999) validated the GC3-R on training performance for the Technical, Mechanical, and Operator job families where coefficients ranged from .15 to .53. The GC3-R is a valid measure of general cognitive ability.

__Concealed Words Test.__ The Concealed Words Test measures Speed of Closure, which is defined as the ability to unite an apparently disparate perceptual field into a single concept (Ekstrom et al., 1976; Eliot & Czarnolewski, 1999; Fleishman & Reilly, 1992). This test consists of black blotches representing parts of the objects. It takes 8 minutes to complete. This test is part of a Kit of Reference tests for Cognitive Factors (Ekstrom et al., 1976). The Kit of Reference Tests compared findings from 69 factorial datasets (Carroll, 1993). No validity data are available for this test (Buros, 1965). It's published reliability is .85 (Ekstrom, French, & Harman, 1975; Peterson & Bownas, 1982).

__Gestalt Completion Test.__ The Gestalt Completion Test measures Speed of Closure. During the test, words are presented with parts of each letter missing. Respondents are asked to write out the complete word. This test takes 4 minutes to administer and is also part of a Kit of Reference tests for Cognitive Factors. No validity data are available for this test (Buros, 1965). Its published reliability is .85 (Ekstrom et al., 1975).

__GATB.__ The GATB, an established test of general aptitudes measures specific abilities and is used to predict performance in education and employment (Hartigan &

Wigdor, 1989; Pettersen & Turcotte, 1996; Ree & Earles, 1990) counseling (87%), it is also used for selection and promotion of personnel (35%).

The GATB contains 12 separate sub-tests that are combined to form nine aptitude scores within the cognitive, perceptual, and psychomotor domains (Table 4). In the area of perception, the aptitudes measured include spatial aptitude, form and clerical perception. The GATB contains 3 dimensions or factors (Watts & Everitt, 1980; Hunter, 1983). Hunter (1983) categorized the nine aptitudes into 3 dimension (Cognitive, Perceptual, and Psychomotor).

Table 4
GATB Aptitudes, symbols and associated scales by dimension

Aptitude	Symbol	Scales	Dimension
General Intelligence	G	Vocabulary, Arithmetic Reasoning, 3-Dimensional Space	Cognitive (GVN)
Verbal Aptitude	V	Vocabulary	
Numerical Aptitude	N	Computation, Arithmetic Reasoning	
Spatial Aptitude	S	3-Dimensional Space	Perceptual (SPQ)
Form Perception	P	Tool Matching, Form Perception	
Clerical Perception	Q	Name Comparison	
Motor Coordination	K	Mark Making	Psychomotor (KFM)
Finger Dexterity	F	Assemble & Disassemble	
Manual Dexterity	M	Place & Turn	

Part 1 Clerical Perception (or Q) is the ability to perceive pertinent detail in verbal or tabular material and avoid perceptual errors in arithmetic computation. This subtest contains 150 names placed in two columns and measures Perceptual Speed. Respondents are asked to inspect each pair of names, one from each column, and to indicate whether there are any differences (Hartigan & Wigdor, 1989). Convergent validity coefficients for the Q aptitude range from .24 to .76 (Hartigan & Wigdor, 1989).

Test-retest reliability coefficients for Clerical Perception is .80 across periods of up to 3 years (Jaeger, Linn & Tesh, 1989).

Part 5&7 Form Perception Ability (or P) is the ability to make visual comparisons and discriminations and see slight differences in shapes and shadings of figures (GATB Manual Section II, 1983). These subtests are used to measure Flexibility of Closure. Part 5, Tool Matching, asks respondents to indicate which of the four pictures presented is most similar to the stimulus drawing. There are 49 items in this sub-test. Part 7, Form Matching, presents two groups of assorted shaped line drawings and asks the respondent to indicate which figure in the second group is exactly the same size and shape as each figure in the first or stimulus group (Hartigan & Wigdor, 1989). Convergent validity coefficients for the P aptitude range from .38 to .65 (Hartigan & Wigdor, 1989). Test-retest reliability coefficients for Form Perception is .81 across periods of up to 3 years (Jaeger et al., 1989).

The X-A2 Battery. The XA-2 battery was originally developed by the U.S. Air Force, and validated in 1966. Earlier versions of this test have been used in selection since 1952 (Fleishman & Friedman, 1957). It was subsequently introduced to the selection process for CF Communication Operators (Grandmaison, 1992). The XA-2 is a two-part test that measures the ability to judge similarity or difference between rhythmic patterns and the rate at which respondents can learn and respond to three characters of international Morse code. Fleishman and Reilly (1992) proposed a task where subjects identify Morse code as a measure of auditory attention (Wheaton, Eisner, Mirabella, & Fleishman, 1976) as did Woycheshin (1999). Information on the reliability of the X-A2 is not available (Major Mombourquette, C., personal communication, December 1[st], 2000). No reliability information is available for this measure.

Procedure

Cognitive ability data (CFAT and GC scores) were obtained from archival data bases. These tests were administered to individuals prior to enrollment in the CF. The remaining data were collected simultaneously through extensive testing at CF schools at various bases across Canada by qualified military Personnel Selection Officers (PSOs). The testing session, including administration of the Speed of Closure, Flexibility of Closure (GATB Parts 5 & 7), Auditory Attention and Perceptual Speed (GATB Part 1) measures took 75-80 minutes. In all cases, administration of tests followed the procedures outlined in the test manuals. including administration (Ekstrom et al., 1975; United States Department of Labor, 1986). Complete data were available for 122 participants. All tests used were comparable to those listed by Fleishman & Reilly (1992). Table 5 presents the abilities measured.

Table 5
Cognitive Factors and Tests Used

Factors	Tests
A. Speed of Closure	Concealed Words Test Gestalt Completion Test
B. Flexibility of Closure	GATB Part 5 GATB Part 7
C. Perceptual Speed	GATB Part 1
D. Auditory Attention	X-A2 Battery
E. General Cognitive Ability	CFAT / GC3-R

Cognitive Ability Data. Cognitive ability data were obtained for both the CFAT (n=98) and GC3-R (n=72). Data for both tests were available for 48 trainees. These data were provided from archival databases stored at the Director of Human Resources Research and Evaluation with the permission of the Treasury Board of Canada (Mombourquette, C., personal communication, December 01, 2000). The two measures were highly correlated ($r=.70$, $p<.01$, $n=48$). The GC3-R and CFAT scores were combined by standardizing each of them to T-scores, ranging from zero to 100 (mean of 50, standard deviation of 10). The resultant T-scores were employed as an estimate of general cognitive ability.

Criterion Data. Criterion data (final percentage grade) were gathered from QL3 course reports. QL3 marks ranged from 70 to 99 % ($M = 90.81$, $SD = 4.85$). Missing data (n=5) were attributable to early failures. Five cases were deleted due to early removal from training or missing data.

Data Analysis

Assumptions

All necessary assumptions were examined prior to each statistical analysis. For all analyses, the data met the required assumptions.

Descriptive Statistics

Descriptive statistics were used to determine the distribution of the sample and to compare respondents on their sex and language. Cronbach's Alpha's were calculated for all scales. Pearson product-moment correlations were used to compute the relationships between criterion data and predictor scores.

Hierarchical Regression Analyses (HRA)

Hierarchical Regressions were used to assess the predictive validity of the abilities being measured (Perceptual Speed, Flexibility of Closure, Speed of Closure, and Auditory Attention). Percentage Grade was regressed onto cognitive ability and the specific abilities measured (Perceptual Speed, Flexibility of Closure, Speed of Closure, and Auditory Attention) in order to determine the incremental validity added by each specific ability measured.

Results

In all regression analyses, neither language nor sex were significant predictors when entered as controls (See appendix D and appendix E for sex and languages differences respectively). Therefore, all regressions were recalculated without controlling for these variables.

Relationships between Cognitive Ability, Information Processing and Performance

Table 6 presents Pearson Product-Moment Correlations correlations between the measures of cognitive ability, Information Processing abilities and training performance.

Table 6
Correlations among measures (N=122)

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. QL3 % Grade		.13	.00	**.25****	**.17***	**.16***	-.05	.04	**.28****
2. Sex[1]			-.02	-.10	**.36****	**.26****	.00	.01	.01
3. Language[2]				.06	-.01	.03	**-.19***	-.12	-.02
4. Cognitive Ability					**.23****	**.17***	.14	.07	**.33****
5. Perceptual Speed						**.60****	.06	.02	**.34****
6. Flexibility of Closure							.09	.10	**.31****
7. Concealed Words Test								**.37****	.12
8. Gestalt Completion Test									.09
9. X-A2									

** $p<0.01$ (1-tailed).
* $p<0.05$ (1-tailed).

[1] Males coded as 1; Females coded as 2.
[2] Anglophones coded as 1; Francophones coded as 2.

Cognitive ability was significantly related to QL3 performance (percentage grade; r=.25, p<.01). Perceptual ability (r=.17, p<.05), flexibility of closure (r=.16, p<.01), and the X-A2 Battery (r=.28, p<.01) predicted training performance. Speed of closure did not predict training performance. Gender was significantly related to perceptual speed (r=.36, p<.01) as was flexibility of closure (r=.26, p<.01). The Concealed Words Test, a measure of speed of closure, was moderately related to language (r=-.19, p<.05). Francophone students did not fare as well on this measure which requires verbal skills. They were completing these tests in English, their second language. Cognitive ability is significantly related to perceptual speed (r=.23, p<.01), flexibility of closure (r=.17, p<.05), and the X-A2 Battery (r=.34, p<.01).

Hierarchical Regression Analysis

The Hierarchical Regression Analysis assessed the incremental validity provided by information processing abilities beyond general cognitive ability. Cognitive ability was entered at step one, Speed of Closure, Perceptual Speed, Flexibility of Closure, and Auditory Attention were entered on the second step as a block. The entire model accounted for 12% of the variance in QL3 performance. Cognitive ability was a valid predictor of performance accounting for 6% of the variance. Speed of Closure, Perceptual Speed, and Flexibility of Closure did not account for a significant proportion of variance. Auditory Attention, however, made a significant contribution to the model . Table 7 presents the results of the Hierarchical Regression Analysis. Together, these information processing predictors improved R^2 from .06 to .12, an increment of 6%.

Table 7
Hierarchical Regression: Predicting performance beyond cognitive ability

	Predictor	ß	R^2	□R^2
Step 1			.06**	.06*
	Cognitive Ability	.25		
Step 2			.12*	.06
	Speed of Closure (CWT)	-.12		
	Speed of Closure (GCT)	.05		
	Flexibility of Closure	.05		
	Perceptual Speed	.03		
	Auditory Attention	.21*		

** $p<0.01$ (1-tailed).
* $p<0.05$ (1-tailed).

Discussion

The results of this study suggest that information processing improves the predictive validity of general cognitive ability for the CF's Operator Family. In particular, the X-A2, a measure of Auditory Attention, predicted performance and provided significant incremental validity (3%) beyond general cognitive ability. These results are comparable with past research where specific abilities provided small yet statistically significant increases incremental validity beyond g (Carey 1994; Johnston, 2000; Ree & Earles, 1990; Wise et al., 1990).

Information processing abilities (Auditory Attention, Flexibility of Closure, Speed of Closure and Perceptual Speed) were expected to predict QL3 performance for the Operator Family. This was generally, with the exception of Speed of Closure, supported by the data analysis. Information Processing Abilities, particularly Auditory Attention, are valid predictors of training performance for the Operator Family. The results, however, are less conclusive for the remaining abilities - Speed of Closure, Flexibility of Closure, and Perceptual Speed. Information Processing measures were expected to improve the predictive validity of selection against training performance when used with measures of general cognitive ability. These measures did not reach significance but still contributed to the predictive equation (6%).

The importance of g in predicting performance is accepted by researchers (Hunter & Hunter, 1984; Ree & Earles, 1993) although some agree that measures of g should be supplemented by measures more directly related to occupational performance (i.e., specific abilities; Miller, 1999). Specific ability measures augment the ability of general cognitive ability measures (Larson & Wolfe, 1995). If specific ability measures used in conjunction with general cognitive ability can enhance prediction, such measures, where possible, should be included in selection systems.

This study is the first to confirm the predictors derived from Catano's (1995) job analysis of the CF Operator occupations. Subject matter experts (SMEs) rated Auditory Attention as the most important ability for the Operator Family. Correspondingly, the X-A2, a purported measure of Auditory Attention, was the only specific ability measured that significantly contributed to the predictive equation beyond g. These results add credence to Specific Ability theory. Future research should examine whether other specific ability measures enhance the predictive equation beyond g in selection. Where measures of Auditory Attention, may prove promising in selection, other abilities rated as important by SMEs in sound job analyses should be investigated. In cases where no known tests exist, researchers could develop and subsequently validate such measures if they are found to be related with a reliable outcome measure.

Do Specific Abilities Improve Prediction?

These results, demonstrating that specific abilities do provide incremental validity beyond general cognitive ability, are generally consistent with available research (Ackerman, 1999; Ackerman & Cianciolo, 2000; Jensen, 1984; Johnston, 2000; McHenry et al., 1990; Ree & Earles, 1990; Ree et al., 1994; Stanny, 1991). For example, Manual Dexterity improved the prediction equation by 5% (Johnston, 2000) for the Mechanical Job Family in the CF. Additionally, specific abilities from the ASVAB subtests added small (2%) yet statistically significant incremental validity to g (Ree & Earles, 1990) also improving the predictive equation in a military selection setting.

General Cognitive Ability

General cognitive ability was expected to have the largest relationship with training performance. In light of past research findings, it was surprising that general cognitive ability would not be the strongest predictor of performance (Hunter & Hunter, 1984; Ree & Carretta, 1997; Ree & Earles, 1990; Schmidt & Hunter, 1998). Recently, however, Farrell & McDaniel (2001) demonstrated that general cognitive ability is a strong initial predictor of performance but that this relationship weakens with experience gained. When this occurs, psychomotor ability emerges as the best predictor. This shift in predictive ability is attributed to the shift in cognitive abilities that underlies skill acquisition (Farrell & McDaniel, 2001). While general cognitive ability is important in skill acquisition, the demand on higher cognitive resources diminishes as tasks become more routine (Farrell & McDaniel, 2001). The results of this study may reflect the fact that participants were tested in the latter half of their training courses following the skill acquisition phase. As tasks became routine, the importance of specific abilities increased.

Severe range restriction may have caused the results of this study to be underestimated. The sample, QL3 students, is not a perfect representation of the applicant population for the CF; screening and self-selection have already taken place. All applicants meet minimum education requirements, are subjected to a semi-structured interview, and cognitive ability testing (CFAT, GC3-R) before enrollment. Furthermore, this is a specialized population comprised only of military members. This range restriction probably lowered the validity coefficients in the present study. As in previous research (Carretta & Ree, 1994), the reason for the low validity coefficients may be attributed to the extremely low number of students (2.5%) who failed their QL3 training.

Flexibility of Closure

As expected, Flexibility of Closure predicted training performance. These results are consistent with past research (McCrumley et al., 1992). Nevertheless, this measure did not add significant incremental validity to the predictive equation beyond general cognitive ability. This result is not surprising considering the small sample used in this study. The relationship between Flexibility of Closure and general cognitive ability was higher than its relationship with training performance. As such, it would be impossible for this measure to provide incremental validity beyond g.

Perceptual Speed

Consistent with past research, Perceptual Speed predicted performance (Ackerman, 1992; Ackerman & Cianciolo, 1999; McCrumley et al., 1992). Nonetheless, Perceptual Speed did not contribute significantly to the predictive equation. The moderate relationship between Perceptual Speed and performance is not surprising given its relatively low rating by SME's in Catano's (1995) job analysis (Table 2). Due to the small sample, the low power may have precluded any effect, if present, from being detected. As with Flexibility of Closure, Perceptual Speed did not add any incremental validity to the predictive equation beyond general cognitive ability.

Speed of Closure

Speed of Closure failed to predict training performance. These results are not consistent with earlier research that demonstrated a moderate relationship with performance (McCrumley et al., 1992). The discrepancy between past research and the present study may be attributed, not to the measures themselves, as they were identical, but to the differences in outcome measures. The tests used in this study (Gestalt Completion and Concealed Words Tests) are established measures of Speed of Closure (Eliot & Czarnolewski, 1999; Ekstrom et al., 1979). In the current study, performance is measured through an overall percentage grade, whereas in previous research, narrow target detection tasks were used as the outcome measure in a controlled laboratory environment. Farrell & McDaniel (2001) confirm that the use of multiple job performance measures, would be beneficial as they allow the use of more objective criteria, specifically reaction time (RT) and attainment measures.

In previous studies, the correlations between the Gestalt Completion Test and the Concealed Words Test were around r=.30 (Ekstrom et al., 1979; McCrumley et al., 1992). In the current study, these correlations were very similar, r=.37. Furthermore, the scores of these measures in this study are comparable to scores in earlier research. The Gestalt Completion Test scores are almost identical to published norms (M=15.2, SD=3.6) while scores were only slightly higher than the published norms for the Concealed Words Test (M=23.6, SD= 6.4; Ekstrom et al., 1976). These similarities further support the argument that the disparities in the results of this study and previous research may be attributed to the differences in the broad vs. narrow performance criteria.

Auditory Attention

The X-A2 predicted training performance, which is consistent with past research (Fleishman, 1955; Grandmaison, 1992). The X-A2 was expected to provide significant incremental validity beyond general cognitive ability, supporting specific ability theory. Auditory Attention was rated as the most important ability by SME's in Catano's job analysis of the Operator family (Table 2). The relationship between the X-A2 and QL3 performance was larger than the relationship between general cognitive ability and QL3 performance. These results were interesting, especially when general ability theorists purport that g is the best predictor of performance (Carretta, T.R., personal communication, November 15, 2000; Hunter & Hunter, 1984; Jensen, 1984; Ree & Carretta, 1997; Ree & Earles, 1992; Thorndike, 1986). Nevertheless, these results should not be surprising since it is known that in military populations, when jobs are more specialized, the scope of individual differences due to g decreases and the demand on more specialized abilities increases (Lubinski & Dawis, 1992). As tasks become more routine, the importance of g also declines while the importance of specific abilities increase (Farrell & McDaniel, 2001).

Similar to general cognitive ability, the X-A2 was not correlated with sex or language making it an acceptable measure for use in selection. These data suggest that the X-A2 may be a better predictor of QL3 performance than general cognitive ability if it were used in recruiting to select people for Operator jobs. This conclusion cannot be reached in the present study as participants have already been selected for employment in the CF based on their general cognitive ability scores. Participants who scored highly on the X-A2 are more likely to achieve better results on QL3 performance. Adding the X-A2 could, with further research, improve the CF's selection system, saving both time and resources. Each recruit, before reaching their apprentice-level training has already cost the CF $38,000 (Black, 1999).

Validity Issues

The best predictor of training performance in this study was the X-A2, a measure of Auditory Attention (Woycheshin, 1999; Grandmaison, 1992). Closer examination of this measure suggested that it may actually be measuring Speed of Closure or a combination of both Speed of Closure and Auditory Attention. Auditory Attention can be either visual or auditory in nature (Fleishman & Reilly, 1992); consequently, a measure of this construct can also be either visual or auditory. When suggesting relevant measures of human abilities, Fleishman & Reilly (1992) described two separate tasks to measure Speed of Closure and Auditory Attention. Both tasks were similar in nature in that they required individuals to receive Morse Code. For Auditory Attention, however, they added a caveat requiring individuals to receive Morse Code in a "noisy" environment. Fleishman & Reilly (1992) did not quantify or define empirically what they intended by the term "noisy". Apparently, no other tests for measuring Auditory Attention are available. In their description of a suggested task to measure Speed of Closure, however, Fleishman & Reilly (1992) omitted the requirement for individuals to receive Morse Code in a "noisy" room. Accordingly, the X-A2, which requires individuals to receive Morse Code letters, may be capturing Speed of Closure and not Auditory Attention. In the present study, the X-A2 Battery was administered under standardized testing procedures of a silent background as it was not possible to replicate a standardized "noisy" environment in the various testing locations. The testing conditions under which the X-A2 test was administered closely resembles the type of environment in which it would be used by the CF.

Although the X-A2 predicted performance (Fleishman, 1955; Grandmaison, 1992), it could not be compared to other measures of Auditory Attention as no other valid measures could be identified from the research literature. The X-A2 is not related to the Gestalt Completion Test or the Concealed Words Test, both established measures of Speed of Closure (Ekstrom et al., 1976; McCrumley et al.; Wothke, Bock, Curran, Fairbank, Augustin, Gillet & Guerrero, 1991). If it could be determined that the X-A2 is measuring Speed of Closure, then the results of this study are consistent with other research establishing the X-A2's relationship with performance. Until a valid measure of Auditory Attention can be identified or developed, the validity of the X-A2 as a pure measure of Auditory Attention cannot be confirmed. Nevertheless, it is clear that although this measure, which may seem to be outwardly capturing Speed of Closure, is not correlated with the established measures of Speed of Closure (Gestalt Completion or Concealed Words Test) that were used in this study. A standardized test, designed specifically to measure Auditory Attention, should be developed and validated in future selection research. Such a test would likely have to be administered in a tightly controlled environment. Testing conditions are standardized in Canadian Forces Recruiting Centers and rooms are designed to be resistant to outside noise (Captain Doucet, R., personal communication, April 6th, 2001). Aside from time considerations, administering the X-A2 would not prove difficult for the CF as part of its selection procedures.

The Concealed Words Test is also linked to another specific ability. This measure may be assessing Verbal Closure (Ekstrom et al., 1976). Ekstrom et al. (1975), however, determined that these are distinct abilities. This was confirmed in the present study as no relationship emerged between the Concealed Words Test and general cognitive ability (both the GC and CFAT contain verbal ability scales). Verbal ability, however, may be required to complete this measure of Speed of Closure; for example, Anglophones scored higher than Francophones on the Concealed Words Test suggesting that language skills may be a function (appendix E). Although all testing was done in English, the Francophone candidates may not have as well developed English language skills as their Anglophone counterparts. A measure of Speed of Closure should be developed that does not require verbal ability to be used in selection in order to avoid language bias (French vs. English). For example, a content recognizable composite Gestalt completion test, that does not require verbal ability, was recently developed (Eliot & Czarnolewski, 1999) in an effort to update tests from 50 years ago. This measure should be examined in future selection research.

The relationships among the specific ability measures are all consistent with past research with the exception of Speed of Closure. For example, Flexibility of Closure and Perceptual Speed were correlated (r=.57) which is consistent with earlier research (r=23; Eliot & Czarnolewski, 1999; Ekstrom et al., 1979; McCrumley et al., 1992). Similar to past studies, the Concealed Words Test and Gestalt Completion Test, both measures of Speed of Closure, were significantly correlated (r=.37) as they were in previous studies (McCrumley et al., 1992). These relationships confirm the findings from past studies about the interrelationship between these measures.

With the exception of Speed of Closure, the ability measures predicted training performance. Despite the fact that the X-A2 was the only measure providing incremental validity beyond g, the remaining measures added to the predictive equation. The addition of specific ability measures provided incremental validity beyond measures of general cognitive ability. The fact that these relationships were found despite the small sample likely due to the manner in which that job families were developed. Identifying primary ability composites through an abilities requirements approach (Catano, 1995) as opposed to job complexity (Hunter & Hunter, 1984) with ambiguous ability requirements may have uncovered similarities among occupations in the Operator Family. A recent study provides modest support for a similar argument. Farrell & McDaniel (2001) demonstrate that when tasks are clustered by consistency (consistent rules, stimuli and sequences of action) and not complexity (jobs with inconsistent tasks), the validity coefficients support specific ability theory.

Criterion Problem

Training performance is an acceptable means of estimating maximum performance (Catano, 1992), especially when it is considered that junior CF members often must complete two to three years of training to prepare them for their job (Bradley, 1993b). Levine et al., (1990) maintain that training success is a superior measure to job success as there are fewer external factors influencing training outcomes. Borman et al., (1997) propose that job performance be used as a criterion measure as specific ability components account for more variance when criteria is related to job rather than training performance.

The percentage criterion used in this study provides more variability than the letter grade or pass/fail approach commonly used in the CF (Bradley, 1993). The percentage approach is a composite score or index representing the training course outcome. Even though the percentage approach is often preferred over the letter grade and pass/fail approach, it is still less than optimal. There remains a significant loss of valuable performance information as training courses consist of various curriculums (Bradley, 1993). Often, students perform well in certain training aspects and not well in others (Bradley, 1993). This information is lost in a global criterion measure. Multiple job performance measures, also allow the use of more objective criteria in order to provide a metric against which previous findings in variability could be evaluated, for example, in future validation research (Farrell & McDaniel, 2001). Nevertheless, the percentage grade was the best criterion measure available.

Based upon Catano's (1995) job analysis of the Operator Family, in consultation with various levels of CF members, an improved performance measure should include ratings of performance on narrow tasks that require these specific abilities. Such an approach would result in a multi-faceted measure revealing more variability in performance. Recommendations for multi-dimensional performance criteria have been made to the CF (Bradley, 1993; Johnston, 2000). Johnston (2000) recommended that the CF standardize procedures for reporting training evaluations that report percentage grades for all performance objectives as well as an overall or composite score.

Conclusion

The present study found the X-A2 Battery to be an adequate predictor of performance in QL3 training. The incremental validity provided by this measure provides support for the argument that adding the X-A2 to the CF selection system may enhance it predictive validity. This possible measure of Auditory Attention, should be investigated further before being used to supplement the existing measures for predicting performance in the Operator Family. Further research with a larger sample should be completed to confirm these findings with other measures of Speed of Closure, Flexibility of Closure and Perceptual Speed.

Finally, in light of this research and previous recommendations, CF schools should adopt a standard for reporting training results. The present criterion for QL3 training is too broad. Future evaluations should provide multiple more narrow criteria in an effort to provide more variability in the outcome measure.

References

Ackerman, P.L. (1992). Predicting individual differences in complex skill acquisition: dynamics of ability determinants. Journal of Applied Psychology, 77 (5), 598-614.

Ackerman, P.L. (1997). Cognitive modeling and task analysis: basic processes and individual differences. (Technical Report F49620-98-1-0031). Air Force Office of Scientific Research, Arlington, Virginia.

Ackerman, P. (1999). Cognitive modeling and task analysis: basic processes and individual differences. (Technical Report F49620-98-1-0031). Air Force Office of Scientific Research, Arlington, Virginia.

Ackerman, P. L., & Cianciolo, A.T. (1999). Psychomotor abilities via touch-panel testing: measurement innovations, construct, and criterion validity. Human Performance, 12 (3/4), 231-273.

Ackerman, P.L. & Cianciolo, A.T. (2000). Cognitive, perceptual-speed, and psychomotor determinants of individual differences during skill acquisition. Journal of Experimental Psychology: Applied, 6 (4), 259-290.

Albert, J. (1998). Cognitive Measures: Comparison of the Canadian Forces Aptitude Test (CFAT), Raven's Progressive Matrices and the Wonderlic Personnel Test. (Technical Note 98-5). Ottawa, ON: Director Human Resources Research and Evaluation.

Angus, R.J., & Halliwell, S.T. (1987). Psychometric analysis of the general classification test – form 3 (GC3). (Technical Note 13/87). Willowdale, ON: Canadian Forces Personnel Applied Research Unit.

Black, M.S. (1999). The efficacy of personality and interest measures as a supplement to cognitive measures in the prediction of military training performance. Unpublished master's thesis, Saint Mary's university: Halifax, Nova Scotia.

Borman, W.C., Hanson, M.A., & Hedge, J.W. (1997) Annual Review of Psychology, 48, 299-337.

Bradley, J.P. (1993) What's wrong with using pass/fail to report performance on courses? Paper presented at the 35th Annual Conference of the Military Testing Association, Williamsburg, VA.

Bradley, J.P. (1993b). Measuring and reporting performance on Canadian Forces training courses. (Tech Note 93-13). Willowdale, ON: Canadian Forces Personnel Applied Research Unit.

Buffardi, L.C., Fleishman, E.A., Morath, R.A., & McCarthy, P.M. (2000). Relationships between ability requirements and human errors in job tasks. Journal of Applied Psychology, 85 (4), 551-564.

Buros, O.K. (Ed.) (1965). The Sixth Mental Measurements Yearbook. The Gryphon Press, New Jersey.

Campbell, J.P. (1990). An overview of the army selection and classification project (Project A). Personnel Psychology, 43, 231-239.

Campbell, C.A., & Cotton, A.J. (1994). Guidelines for the development and use of selection tests in the Canadian Forces – the ethical, legal and practical issues associated with bias in tests. (Technical Note 94-1). Willowdale, ON: Canadian Forces Personnel Applied Research Unit.

Carey, N. (1994). Computer predictors of mechanical job performance: Marine Corps findings. Military Psychology, 6, 1-30.

Carretta, T.R., & Ree, M.J. (1994). Pilot-candidate selection method: sources of validity. The International Journal of Aviation Psychology, 4 (2), 103-117.

Carroll, J.B. (1993). Human cognitive abilities. Cambridge: Cambridge University Press.

Catano, V.M. (1992). New directions in officer selection: application of criterion theory and measurement to CF selection research. (Working Paper 92-2). Willowdale, ON: Canadian Forces Personnel Applied Research Unit.

Catano, V.M. (1995a). Describing the primary abilities associated with five clusters of entry-level military occupations. (Sponsor Research Report 95-2). North York, ON: Canadian Forces Personnel Applied Research Unit.

Catano, V.M. (1995b). Describing the primary abilities associated with five clusters of entry-level military occupations. (Technical Supplement 95-4). Willowdale, ON: Canadian Forces Personnel Applied Research Unit.

Catano, V.M., & Ibel, R.H. (1995). Clustering Canadian Forces military occupations using statistical analysis of ability profiles. (Technical Note 6-95). Willowdale, ON: Canadian Forces Personnel Applied Research Unit.

Catano, V.M., Cronshaw, S.F., Wiesner, W, H., Hackett, R.D. & Methot, L.L. (1997). Recruitment and Selection in Canada. Toronto: International Thompson Publishing.

Childs, R.A., Baughman, W.A., & Keil, C.T. (1997). Tests of Cognitive Ability. In Whetzel, D.L. & Wheaton, G.R. (Eds.), Applied measurement methods in industrial psychology, (pp. 143-184). Palo Alto, California: Davies-Black Publishing.

Crocker, L., & Algina, J. (1986). Introduction to classical and modern test theory. Fort Worth: Harcourt Brace Jovanovich Publishers.

Eliot, J., & Czarnolewski, M. (1999). A complete Gestalt completion test. Perceptual and Motor Skills, 89, 294-300.

Ekstrom, R.B., French, J.W. & Harman, H.H. (1975). An attempt to confirm five recently identified cognitive factors. (Technical Report No. 8). Princeton, NJ: Educational Testing Service.

Ekstrom, R.B., French, J.W., Harman, H.H., & Dermen, D. (1976). Manual for the Kit of Factor-Referenced Cognitive Tests. Princeton, NJ: Educational Testing Service.

Farrell, J.N. & McDaniel, M.A. (2001). The stability of validity coefficients over time: Ackerman's (1988) model and the General Aptitude Test Battery. Journal of Applied Psychology, 86, 1, 60-79.

Fleishman, E.A. (1955). Predicting code proficiency of radiotelegraphers by means of aural tests. The Journal of Applied Psychology, 39 (3), 150-155.

Fleishman, E.A. (1982). Systems for describing human tasks. American Psychologist, 37 (7), 821-834.

Fleishman, E.A., & Friedman, M.P. (1957). The development of the Air Force aural code test. (Research Report AFPTRC-TN-57-131). Lackland Air Force Base: TX. Operator Laboratory Air Force Personnel and Training Research Center.

Fleishman, E.A., & Mumford, M.D. (1988). Ability requirement scales. In S. Gael, S (Ed.) The job analysis handbook for business, industry, and government Volume 2, (pp. 917-935). New York: John Wiley & Sons.

Fleishman, E.A., & Quaintance, M.K. (1984). Taxonomies of human performance. Orlando, Florida: Academic Press.

Fleishman, E.D., & Reilly, M.E. (1992). Handbook of Human Abilities. Palo Alto, California: Consulting Psychologists Press, Inc.

Ghiselli, E.E. (1973). The validity of aptitude tests in personnel selection. Personnel Psychology, 26, 461-477.

Gottfredson, L. S., (1997). Why g matters: the complexity of everyday life, Intelligence, 24 (1), 79-132.

Gottfredson, L.S., & Snow, R.E. (1997). Ability profiles. In Dillon, R.F. (Ed.), Handbook on testing (pp.107-135). London: Greenwood Press.

Grandmaison, L.J. (1992). Validation of the XA2 test for Morse code training. (Technical Note 92-14). Willowdale, ON: Canadian Forces Personnel Applied Research Unit.

Gustafsson, J.E., & Snow, R.E. (1997). In Dillon, R.F. (Ed.), Handbook on testing (pp.107-135). London: Greenwood Press.

Hanser, L.M. (1997). Criterion Development in project A. In Dillon, R.F. (Ed.), Handbook on testing (pp.256-273). London: Greenwood Press.

Hartigan, J.A. & Wigdor, A.K. (Eds.) (1989). Fairness in Employment Testing: Validity Generalization, minority issues, and the General Aptitude Test Battery. Washington, D.C.: National Academy Press.

Hunter, J.E. (1986). Cognitive ability, cognitive aptitudes, job knowledge and job performance. Journal of Vocational Behavior, 29, 340-362.

Hunter, J.E., & Hunter, R.F. (1984). Validity and Utility of Alternative Predictors of Job Performance. Psychological Bulletin, 99 (1), 72-98.

Hull, C.L. (1928). Aptitude Testing. New York: Yonkers-on-Hudson.

Ibel, R.H. (1993). Revised norms for the general classification tests- forms 2 (R) and 3 (R). (Technical Note 12-93). Willowdale, ON: Canadian Forces Personnel Applied Research Unit.

Ibel, R.H., & Cotton, C.A. (1994). Validation of experimental scales of non-commissioned member applicant selection and classification. (Technical Note 17-94). Willowdale, ON: Canadian Forces Personnel Applied Research Unit.

Jaeger, R.M., Linn, R.L., & Tesh, A.S. (1989). A synthesis of research on some psychometric properties of the GATB. In J.A. Hartigan, & A.K. Wigdor (Eds.) Fairness in Employment Testing: Validity Generalization, Minority Issues and the General Aptitude Test Battery. Washington, D.C.: National Academy Press.

Jackson, D.N. (1984). Multidimensional Aptitude Battery – Manual. Port Huron, MI: Research Psychologists Press.

Jensen, A.R. (1984). Test validity: g versus the specificity doctrine, Journal of Social and Biological Structures, 7, 93-118.

Jensen, A.R. (1986) Major Contributions, g: Artifact or reality?, Journal of Vocational Behaviour, 29, 301-331.

Johnston, P.J. (2000) Investigating the use of psychomotor abilities tests as predictors of training performance in the Canadian forces technical and mechanical occupations. Unpublished masters thesis, Saint Mary's University, Halifax, Nova Scotia.

Kantor, J.E., & Caretta, T.R. (1988). Aircrew selection systems. Aviation, Space, and Environmental Medicine, November, 32-38.

Larson, G.E., & Wolfe, J.H. (1995). Validity results for g from an expanded test base. Intelligence, 20 (1), 15-25.

Levine, E.L., Spector, P.E., Menon, S., Narayanan, L., & Cannon-Bowers, J.A. (1996). Validity generalization for cognitive, psychomotor, and perceptual tests for craft jobs in the utility industry. Human Performance, 9 (1), 1-22.

Lubinski, D., & Dawis, R.V. (1992). Aptitude skills and proficiencies. In M.D. Dunnette, & L.M. Hough, (Eds.) Handbook of Industrial and organizational Psychology Volume 3 (2nd Ed). Palo Alto, CA: Consulting Psychologists Press.

MacLennan, R.N. (1997). Validity generalization across military occupational families. (Technical Note 00-97). Ottawa, ON: Canadian Forces Personnel Research Team.

McCrumley, L M., Pierce, LG., Schwalm, R.C., Coke, J.S., & Brown, J.C. (1992). Predicting target detection performance using the Armed Services Vocational Aptitude Battery Subtests and Cognitive Factor Tests. (ARI Research Note 92-56). Fort Sill, OK: United States Army Research Institute for the Behavioral and Social Sciences.

McHenry, J.J, Hough, L.M., Toquam, J.I, Hanson, M.A., & Ashworth, S., (1990). Project A validity results: The relationship between predictor and criterion domains. Personnel Psychology, 43, 335-354.

Miller, L.T. (1999). Psychometric and information processing approaches to measuring cognitive abilities: paradigms in military testing. Canadian Psychology, 40 (3), 241-254.

Olea, M.M., & Ree, M.J. (1994). Predicting pilot and navigator criteria: not much more than g. Journal of Applied Psychology, 79 (6), 845-851.

Peterson, N.G., & Bownas, D.A. (1982). Skill, task structure, and performance acquisition. In Dunnette, M.D. & Fleishman, E.A. (Eds.) Human performance and productivity, (Volume1). New Jersey: Lawrence Erlbaum Associates.

Pettersen, N., & Turcotte, M. (1996), Utilisation au Canada de la Batterie Generale de Tests d'Aptitudes (BGTA). Canadian Psychology, 37 (4), 182-194.

Powell, T.E., Cunningham, J.W., Wimpee, W.E., Wilson, M.A. & Ballentine, R.D. (1999). Dimensionality of Ability-Requirements for Generic Job Activities. (Technical Note AFRL-HE-BR-TP-1999-0007). Brooks Air Force Base, TX: Manpower and Personnel Division.

Prediger, D.J. (1989) Ability differences across occupations: more than g. Journal of Vocational Behavior, 34, 1-27.

Ree, M.J., & Carretta, T.R. (1997). What makes an aptitude test valid. In Dillon, R.F. (Ed.), Handbook on testing (pp.65-81). London: Greenwood Press.

Ree, M.J., Caretta, T.R., & Teachout, M.S. (1995). Role of ability and prior job knowledge in complex training performance. Journal of Applied Psychology, 80, 721-730.

Ree, M.J. & Earles, J.A. (1990). Relationships of general ability, specific ability, and job category for predicting training performance. (Technical Report AFHRL-TR-90-46) Brooks Air Force Base, TX: Manpower and Personnel Division.

Ree, M.J., & Earles, J.A. (1991). Predicting training success: Not much more than g. Personnel Psychology, 44, 321-332.

Ree, M.J., & Earles, J.A. (1992). Intelligence is the best predictor of job performance. Current Directions in Psychological Science, 1, 86-89.

Ree, M.J., Earles, J.A., & Teachout, M.S. (1994). Predicting job performance: not much more than g. Journal of Applied Psychology, 79 (4), 518-524.

Sackett, P.R. (Ed.) (1990). Personnel Psychology, 43.

Schmidt, F.L., Ones, D. & Hunter, J.E. (1992) Personnel Selection. In Rosenzweig, M.R., & Porter, L.W. (Eds.) Annual Review of Psychology, 43, 627-670.

Schmidt, F.L., & Hunter, J.E. (1998). The validity and utility of selection methods in personnel psychology: Practical and theoretical implications of 85 years of research findings. Psychological Bulletin, 124(2), 262-274.

Siem, F.M., & Carretta, T.R. (1998). Determinants of Enlisted Air Traffic Controller Success. (Technical Note AFRL-HE-AZ-TR-1998-0079). Brooks Air Force Base, TX: Manpower and Personnel Division.

Spinner, B. (1991). A psychometric analysis of the CFCB and GC3 tests. (Technical Note 16-91). Willowdale, ON: Canadian Forces Personnel Applied Research Unit.

Stanny, R.R. (1990). Modeling human performance assessment. (Annual Report). Frederick, MD: US Army Medical Research and Development Command.

Stanny, R.R. (1991). Modeling human performance assessment. (Final Report). Frederick, MD: US Army Medical Research and Development Command.

Sternberg, R.J., & Wagner, R. K. (1993). The g-ocentric view of intelligence is wrong. Current Directions in Psychological Science, 2 (1), 1-5.

Thorndike, R.L. (1985). The central role of general ability in prediction. Multivariate Behavioral Research, 20, 241-254.

Thorndike, R.L. (1986). The role of general ability in prediction. Journal of Vocational Behavior, 29, 332-339.

United States Department of Labor (1986). Manual for the General Aptitude Test Battery (Section 1). Scarborough ON: Nelson Canada.

Wheaton, G.R., Eisner, E.J., Mirabella, A., & Fleishman, E.A. (1976). Ability requirements as a function of changes in the characteristics of an auditory signal identification task. Journal of Applied Psychology, 61 (6), 663-676.

Wise, L.L., McHenry, J., Campbell, J.P. (1990). Identifying optimal predictor composites and testing for generalizability across jobs and performance factors. Personnel Psychology, 43, 355-366.

Wothke, W., Bock, R.D., Curran, L.T., Fairbank, B.A., Augustin, J.W., Gillet, A.H., Guerrero, C. (1991). Factor analytic examination of the Armed Services Vocational Aptitude Battery (ASVAB) and the Kit of the factor-referenced tests. (Final Technical Report AFHRL-TR-90-67). Brooks Air Force Base, TX: Manpower and Personnel Division.

Woycheshin, D.E. (1999). Validation of the Canadian Forces Aptitude Test against QL3 course performance. (Technical Note 99-11). Ottawa, ON: Director Human Resources Research and Evaluation.

Zumbo, B.D., & Hubley, A.M. (1997). Psychometric study of the Canadian Forces Aptitude Test (CFAT). (Technical Report). Ottawa, ON: Personnel Research Team.

Appendix A:

Five Occupational Families Based on hierarchical cluster analysis of standardized ability profiles (Catano & Ibel, 1995) & CF Occupation Assignment Worksheet (01 Jan 01).

Job Family	Military Occupation Code (MOC)	New MOC and Name
Administrative	212 Teletype operator	Deleted
	831 Administrative Clerk	836 Resource Management Support
		836 Resource Management Support
	841 Finance Clerk	
	862 Steward	
	881 Postal Clerk	
	911 Supply Technician	
	933 Traffic Technician	
Military	011 Crewman	011 Armored Soldier
	021 Artilleryman	021 Artillery Soldier (Field)
	022 Artilleryman Air Defence	022 Artillery Soldier (Air Defence)
	031 Infantryman	031 Infantry Soldier
	041 Field Engineer	
	052 Lineman	052 Line Maintainer
	181 Boatswain	
	651 Firefighter	
	811 Military Police	
	935 Mobile Support Equipment Operator	
Mechanical (Technical B)	065 Naval Weapons Technician	
	312 Marine Engineering Technician	312 Marine Engineering Mechanic
	321 Hull Technician	
	332 Marine Electrician	
	411 Vehicle Technician	
	421 Weapons Technician (Land)	
	431 Electro-Mechanical Technician	
	441 Material Technician	
	511 Aero-Engine Technician	514 Aviation Technician
	512 Airframe Technician	514 Aviation Technician
	531 Safety Systems Technician	514 Aviation Technician
	561 Metals Technician	565 Aircraft Structures Technician
	562 Machinist	565 Aircraft Structures Technician
	563 Refinisher Technician	565 Aircraft Structures Technician
	572 Air Weapons Technician	514 Aviation Technician
	611 Construction Engineering Technician	648 Construction Technician
	612 Structures Technician	648 Construction Technician
	613 Plumber Gas Fitter	646 Plumbing and Heating

Mechanical (Technical B)		Technician
	614 Electrician	642 Electrical Distribution Technician
	621 Refrigeration and Mechanical Technician	641 Refrigeration and Mechanical Systems Technician
	622 Electrical Generating Systems Technician	643 Electrical Generation Systems Technician
	623 Stationary Engineer	647 Water Fuels and Environment Technician
	624 Water. Sanitation and POL Technician	647 Water Fuels and Environment Technician
	711 Medical Assistant	
	861 Cook	
	921 Ammunition Technician	
		646 Plumbing and Heating Technician
		648 Construction Technician
Operator	121 Meteorological Technician	168 Aerospace Control Operator
	161 Air Traffic Controller	168 Aerospace Control Operator
	171 Air Defence Technician	278 Tactical Acoustic Sensor Operator
	191 Oceanographic Operator	
	211 Radio Operator	
	262 Naval Signalman	277 Naval Communicator
	273 Naval Acoustics Operator	278 Tactical Acoustic Sensor Operator
	274 Naval Radio Operator	
	275 Naval Combat Information Operator	277 Naval Communicator
	276 Naval Electronic Sensor Operator	
	283 Naval Electronics Technician (Acoustic)	
	284 Naval Electronics Technician (Communications)	
	285 Naval Electronics Technician (Tactical)	
	291 Communicator Research	
Technical (Technical A)	221 Radio Technician	227 Land Communications and Information Systems Technician
	222 Terminal Equipment Technician	227 Land Communications and Information Systems Technician
	223 Teletype and Cipher Technician	227 Land Communications and Information Systems Technician
	231 Radar Technician	226 Aerospace Telecommunications and Information Systems Technician
		283 NE TECH A
		284 NE TECH C
		285 NE TECH T
	521 Integral Systems Technician	
	524 Communications and Radar Systems Technician	526 Avionics Technician
		526 Avionics Technician
	541 Photographic Technician	
	551 Instrumental Electrical Technician	526 Avionics Technician
	722 Dental Clinic Assistant	

Appendix B:

Abilities Associated with the Nine Factor Ability Solution (Catano, 1995)

Composite Ability	Associated Abilities
Strength and Movement	Dynamic Strength Trunk Strength Explosive Strength Dynamic Flexibility Static Strength Stamina Extent Flexibility Gross Body Coordination Gross Body Equilibrium Speed-of-Limb Movement Rate Control Reaction Time Response Orientation Time Sharing Depth Perception
Vision	Near Vision Far Vision Visual Colour Discrimination Night Vision Peripheral Vision Depth Perception Glare Sensitivity
Audition	Speech Recognition Auditory Attention Speech Clarity Hearing Sensitivity Wrist-Finger Speed Sound Localization Time Sharing

Controlled Reaction	Rate Control Response Orientation Multilimb Coordination Reaction Time Control Precision Speed of Limb Movement Perceptual Speed Spatial Orientation
Analytical Ability	Mathematical Reasoning Number Facility Originality Category Flexibility Deductive Reasoning Visualization
Information Processing	Flexibility of Closure Speed of Closure Selective Attention Perceptual Speed Manual Dexterity Auditory Attention
Cognition	Problem Sensitivity Inductive Reasoning Deductive Reasoning Memorization Fluency of Ideas Information Ordering
Verbal Ability	Oral Expression Oral Comprehension Written Comprehension Written Expression
Fine Motor Control	Finger Dexterity Manual Dexterity Arm-Hand Steadiness Near Vision Control Precision Visual Colour Discrimination

Appendix C:

Testing Procedures

Times listed below include instructions. Administration should take 75 minutes. Tests should be administered in the following order:

1) Read Introduction Sheet (3 minutes)

2) GATB (22 minutes)
    -Part 1, NAME COMPARISON (6 Min)
    -Part 5, TOOL MATCHING (5 Min)
    -Part 7, FORM MATCHING (6 Min)

3) Gestalt Completion (5 minutes)

4) Concealed Words (10 minutes)

5) X-A2 (35 minutes)

Testing Instructions:

Please ensure that each examinee has two pencils, scrap paper, and an eraser. Also, a good quality tape recorder is required for the administration of the X-A2.

(Please note: the time limits must be observed precisely as specified for each test.)

Please read the following introduction VERBATIM as with all "boxed" text ensuring that the exact wording is followed.

Good Morning/Afternoon, I am _________ and I will be conducting this testing session. The Directorate of Human Resource, Research and Evaluation (DHRRE) is involved in a long-term project to revise the recruiting test battery currently in use by Canadian Forces Recruiting Centers. This research is being conducted in an effort to improve the ability of the tests to predict who will succeed on QL3 training. This study will require no more than 75 minutes of your time. During this time, you will be asked to complete several tests. Please respond to the best of your ability.

All information obtained in this study will remain strictly confidential. To ensure that your confidentiality is preserved, your service number will only be used to match your test scores to your QL3 grades. Only DHRRE will have access to this information. As such, there are absolutely no career implications. Furthermore, the results of this study will be presented as a group, thus ensuring that no individual participants will be identified.

If you would like to know your individual scores, the researchers will arrange to have your scores sent to you individually in a sealed envelope. Please see me, the test administrator, __________ at the end of the testing session to make these arrangements.

You are responding to this study on a volunteer basis and you may withdraw at any time without pressure or penalty. If you wish to leave, you may do so now.

Please read and sign the informed consent form given to you and keep one for you own records.

Once the informed consent forms have been passed back (please place in a sealed envelope), ensuring participants have kept a copy for their own records, please continue with the GATB.

General Aptitude Testing Battery (GATB)

Read aloud:

You will now be doing the General Aptitude Testing battery (GATB). Please do not open your booklet until told to do so. You will have a limited amount of time to work on each exercise. Do as much as you can before you are told to stop. You will have a chance to practice before we ask you to work on any problems that are timed. It is very important that you pay careful attention to all directions so that you will know exactly what to do at all times. Be sure that you understand the directions before it is time to begin.

You are going to work on some of the exercises in this booklet (*Hold up booklet 1*). Do not write or make any marks in this booklet. Mark all your answers on the answer sheet, which will be given to you in a moment.

Please ensure that all your answer marks are heavy and black and that they fill the answer spaces. Be sure to erase any answer you wish to change. Do not make any additional marks on the answer sheet. Use only the pencils that are provided.

Distribute BOOK 1 (Form A) of the GATB together with the proper answer sheet, scratch paper and two pencils. After test materials, including an answer sheet, have been distributed, proceed with instructions.

Take your answer sheet and hold it so that part 7 appears at the top of the sheet. On the right side of the page, there are sections for you to fill in your name on the top line.

On the line marked Name, please mark your SERVICE NUMBER (*VERY IMPORTANT*), as well as your name. On the line marked Address, please mark your QL3 serial number and on the line marked City, please mark your MOC. Please mark today's date. In the boxes below, please indicate your gender.

In the box for education, blacken the circle that shows the number of years of formal schooling you have completed. If you have had more than four years of university, please darken 17.

In the section for age, notices there are two columns of numbers for years and two columns of numbers for months. First, write your age in the boxes at the top and blacken the appropriate circles below.

Open your booklet to page 2 and the read instructions yourself while I read them aloud.

Be sure to read the instructions so you will know what to do. If you do not understand the practice exercises, ask questions about them.

You will be told when to start and when to start working.
Be sure to begin IMMEDIATELY when you are told to BEGIN!

When you complete a page, read the instructions at the bottom of the page so you will know whether to go on to the next page or to stop and wait for further instructions.

Work as quickly as you can without making mistakes.

Stop IMMEDIATELY when you are told to STOP!

You will probably not be able to finish in the time allowed, so do as much as you can.

You will indicate your answers by making pencil marks on a separate answer sheet. Make sure your answer marks are heavy and black. Erase completely any answer you wish to change. Use only the pencils that are provided.

Make no marks on this booklet.

Proceed with the administration of PART 1 and the tests that follow.
Read the instructions to the examinees as follows:

Now look at the instructions on PAGE 3 of your booklet while I read them aloud. (PAUSE.)
On this page are some exercises in comparing names. Look at exercise 1. (PAUSE.) The two names are exactly the same.

Now turn your answer sheet so that you look at the section that says PART 1 PRACTICE.

Make certain that each examinee has their answer sheet properly placed and is looking at the practice exercise box for Part 1 Practice. Then Say:

Notice that in the row for practice exercise 1, the SPACE under S has been filled in. (PAUSE.)

Now look at exercise 2. (PAUSE)

These two names are different, so in the row for practice exercise 2, the SPACE under D has been filled in. (PAUSE)

Here are some practice exercises. If the numbers are EXACTLY the SAME, make a solid black mark under S. IF they are DIFFERENT in any way, make a solid black mark under D. When you finish these practice exercises, stop and wait for further instructions. DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO. READY? BEGIN!

Allow the examinee sufficient time to finish the practice exercises. Then check the answer sheets to make sure the exercises have been answered correctly: either write them on a blackboard or read them aloud:

#3-D.
#4-S

#5-D
#6-D
#7-D
#8-S

If any examinee made an error, point out why their answer was wrong. Have the examinee rework the problem correctly. Then say:

Now look at the instructions at the bottom of the page in your booklet while I read them aloud.

Do not turn this page until you are told to do so. On the following pages are more exercises like these. Do them in the same way. Make no marks in this booklet. Make heavy black marks on the answer sheet. Works as fast as you can, without making mistakes. You will be allowed 6 minutes. Ready? Turn the page. BEGIN (Start the stopwatch).

Allow exactly **6 minutes**. Then say:

STOP put your pencils down.

Please pick up Booklet 1 and distribute Booklet 2 (Form A). *Examinees already have the answer sheets - different side.*

Proceed with the administration of **PART 5** and the tests that follow.
Read the instructions to the examinees as follows:

Do not open your booklet until I tell you to do so.

Now fold your answer sheet so the PART 5 and PART 6 are face up.

Allow sufficient time for this to be done. Then Say:

Now open your booklet to PAGE 3 and look at the instructions while I read them aloud. (PAUSE.)

On this page are some exercises in comparing figures. Look at EXERCISE 1. (PAUSE.)

Notice that only FIGURE B is exactly like FIGURE 1 at the left. Look at the practice box in PART 5 section of the answer sheet. (PAUSE.) Notice that in the row for practice exercise 1 the space under B has been filled in.

Here are some practice exercises. In each one find the lettered figure which is exactly the same as the numbered figure. Then blacken the space under the correct letter in the Part 5 Practice section of the answer sheet. Do not turn this page when you finish these exercises. Make no marks in this test booklet. READY? BEGIN!

Allow the examinee sufficient time to finish the practice exercises. Then check the answer sheets to make sure the exercises have been answered correctly, either write them on the blackboard or read them aloud.

#2-D
#3-C

If any examinee made an error, point out why their answer was wrong. Have the examinee rework the problem correctly. Then say:

Now look at the instructions at the bottom of the page in your booklet while I read them aloud.

Do not turn this page until you are told to do so. On the following pages are more exercises like these. Do them in the same way. Make no marks in this booklet. Make heavy black marks on the answer sheet. Work as fast as you can, without making mistakes. You will be allowed 5 minutes. Ready? Turn the page. BEGIN (Start the stopwatch).

Allow exactly **5 minutes**. Then say:

STOP put your pencils down.

Proceed with the administration of **PART 7** and the tests that follow.
Read the instructions to the examinees as follows:

Now turn to PAGE 19 in your booklet and look at the instructions while I read them aloud.

On this page are some exercises in matching figures that are exactly the same in size and shape.

Look at FIGURE 1 in the UPPER BOX. (PAUSE) Now look at FIGURE B in the LOWER BOX. Figure B is exactly like figure 1.

Now look at the part of the answer sheet that is labeled PART 7 PRACTICE (below PART 6). Notice that in the row for practice exercise 1, there are ten answer spaces from which to choose. These ten answer spaces are divided into two groups of five each. In this exercise, since B is the correct answer, the answer UNDER letter B has been filled in. (PAUSE)

Now look at FIGURE 2 in the UPPER BOX. (PAUSE) FIGURE G in the LOWER BOX is exactly like FIGURE 2. (PAUSE) Notice that on the answer sheet, in the row for practice exercise 2, the space under the correct answer, G, has been filled in.

Now do the rest of the exercises in the same way. Find the lettered figure exactly like the numbered figure and fill in the space under that letter on the answer sheet. For each exercise, choose the correct one of the ten spaces to indicate your answer. Do not write in this booklet. When you finish these practice exercises, stop and wait for further instructions. READY? BEGIN!

Allow sufficient time for all examinees to finish the practice exercises. *EXAMINEES SHOULD ANSWER IN NUMERICAL ORDER.* Occasionally examinees will mark or cancel completed figures in order to respond more rapidly. If this occurs, the examinee should be instructed to make no marks in the booklet.

Check to see that each examinee's answer sheet to see that the practice exercises have been done correctly.

#3-A
#4-C
#5-F
#6-E
#7-H
#8-D

If any examinee made an error, point out why their answer was wrong. Have the examinee rework the problem correctly. Then say:

Now fold your answer sheet so that PART 7 appears at the top (PAUSE).

Make certain that each examinee has turned over his (her) answer sheet and positioned it properly. Then say:

Now look at the instructions at the bottom of the page in your booklet while I read them aloud.

Do not turn this page until you are told to do so. On the following pages are more exercises like this. Remember to choose one of the ten spaces to indicate your answer to each exercise. For each numbered figure find the lettered figure that is exactly the same a the numbered figure. Then blacken the space on the answer sheet under the letter or letters of that figure. Make no marks in this booklet. Work as fast as you can without making mistakes. You will be allowed 6 minutes. READY? Turn the page. BEGIN! (Start the stopwatch).

Allow exactly **6 minutes**. Then say:

STOP put your pencils down. Close your booklets

Gestalt Completion Tests

Now pass out the Gestalt Completion Tests and read the following instructions aloud:

You will now be doing the Gestalt Completion Tests.

In the line marked Name at the top of the test page, please write your service number as well as your name, MOC, and QL3 serial number.

This is a test of your ability to see a whole picture even though it is not completely drawn. You are to use your imagination to fill in the missing parts.

Look at each incomplete picture and try to see what it is. On the line under each picture, write a word or two to describe it.

Try the sample pictures below: (*wait a few seconds*) Picture 1 is a flag and picture 2 is a hammer head.

Your score on this test will be the number of pictures identified correctly. Even if you are not sure of the correct identification, it will be to your advantage to guess. Work as rapidly as you can without sacrificing accuracy.

You will have two minutes for each of the two parts of this test. Each part has two pages. When you have finished Part 1 (pages 2 and 3), STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

READY? Turn the page. BEGIN! (Start the stopwatch).

Allow exactly 2 minutes. Then say:

STOP put your pencils down. Now we would like you to turn to Part 2. Again, you will have two minutes to complete this part. Do not go back to part 1 and do not go on to any other test until asked to do so. READY? Turn the page. BEGIN! (Start the stopwatch).

Allow exactly 2 minutes. Then say:

STOP put your pencils down.

CONCEALED WORDS TEST

Please read the following aloud:

You will now be doing the Concealed Words Test.

In the line marked Name at the top of the test page, please write your service number as well as your name, MOC, and QL3 serial number.

This is a test of your ability to read a word when parts of the word have been erased. Look at the words printed below. The word north has been completely printed the first time; the second time parts of the letters have been erased.

Now look at the sample item below. Parts of each word have been erased. Try to read what each word is. Write your answers on the lines provided. All the words used in this test will be at least four letters long. No word will contain any capital letters. (Pause)

Did you recognize the words as 1. parents, 2. easy, and 3. giant?

Your score on this test will be the number of correct answers that you write. Work as quickly as you can without sacrificing accuracy. If some words are difficult, skip them, and return to them later if you have time.

You will have 4 minutes for each of the two parts of this test. Each part has 25 items on two pages. Be sure to do the items on both pages if you have time. When you finish Part 1 (pages 2 and 3), STOP. Do not go on to Part 2 until asked to do so.

READY? Turn the page. BEGIN! (Start the stopwatch).

Allow exactly 4 minutes. Then say:

STOP put your pencils down. Now we would like you to turn to Part 2. Again, you will have four minutes to complete this part. Do not go back to part 1 and do not go on to any other test until asked to do so. READY? Turn the page. BEGIN! (Start the stopwatch).

Allow exactly 4 minutes. Then say:

STOP put your pencils down.

X-A2 Battery

The X-A2 aural comprehension test uses a cassette recording and answer sheet.

Please read the following before turning on the cassette.

This is a two part aural code test divided as follows.

Part 1 is a measure of your ability to judge similarity or difference between rhythmic patterns. It is 16 minutes in length.

Part 2 is a measure of the rate at which an examinee can learn and respond to three characters of international Morse code: it is 17 minutes in length.

The test will come out of these speakers (point to the cassette player). **Turn your answer sheet so that part one is at the top of the sheet.**

Please fill in the following information: write your service number on the line called number. Write in your name on the line marked name. Fill in today's date on the line marked date. On the line marked place, fill in your QL3 serial number and your MOC.

Both parts of the test will come from the cassette player with specific directions and examples on how to complete the test. Listen carefully as I will not be able to repeat the directions. Are there any questions? This is the last test.

Play the cassette ensuring that the sound quality is satisfactory. On completion of the test, stop the cassette and collect the answer sheets. Thank -you!

Appendix D:

Gender Differences.

The table below presents the means and standard deviations by male and female participants. There were no significant differences of Cognitive Ability (males, M = 50.99; females, M = 48.77), Concealed Words Test (males, M = 27; females, M = 27.07), Gestalt Completion Test (males, M = 15.75; females, M = 15.8), X-A2 (males, M = 120.84; females, M = 122.11), and percentage grade (males, M = 90.45; females, M = 91.92). Females (M =62.02) scored higher than males (males, M = 51.87) on the Perceptual Speed measure, (GATB Part 1; $t = -4.191$, $p < .001$). Females (M = 68.63) also scored higher than males (M=62.06) on a measure of Flexibility of Closure (GATB Parts 5 & 7; $t = -3.00$, $p < .01$).

Descriptive Statistics for male vs. female

	Males (N= 92)		Females (N=30)	
Measure	**Mean**	**SD**	**Mean**	**SD**
Cognitive Ability	50.99	9.99	48.77	9.88
Concealed Words Test (Speed of Closure)	27	8.30	27.07	5.76
Gestalt Completion Test (Speed of Closure)	15.75	2.19	15.8	1.94
Flexibility of Closure (GATB Parts 5 & 7)	62.06	10.51	68.63	10.04
Perceptual Speed (GATB Part 1)	51.87	10.4	62.02	15.13
Auditory Attention	120.84	62.96	122.12	61.39
% Grade	90.45	4.70	91.92	5.21

Appendix E:

Language Differences.

The Table below presents means and standard deviations by Anglophone and Francophone participants. There were no significant differences between Anglophones and Francophones on Cognitive Ability (Anglophones, M = 50.21; Francophones, M = 52.45), Speed of Closure, (Gestalt Completion Test; Anglophones, M = 15.83; Francophones, M = 14.88), Flexibility of Closure, (GATB Part 5 &7; Anglophones, M = 63.59; Francophones, M = 64.77), Perceptual Speed, (GATB Part 1; Anglophones, M = 54.46; Francophones, M = 53.77), XA-2 (Anglophones, M = 121.62; Francophones, M = 115.22), and percentage grade (Anglophones, M = 90.81; Francophones, M = 90.83). Anglophones (M = 27.43) did score significantly higher than Francophones (M = 21.78) Concealed Words Test, (t=2.14, p<. 05).

Descriptive Statistics for Anglophone vs. Francophone

	Anglophones (N= 113)		Francophones (N=9)	
Measure	Mean	SD	Mean	SD
Cognitive Ability	50.22	10.06	52.45	8.86
Concealed Words Test (Speed of Closure)	27.43	7.73	21.78	5.74
Gestalt Completion Test (Speed of Closure)	15.83	2.11	14.88	2.20
Flexibility of Closure (GATB Part 5)	32.74	6.08	32.88	5.10
Flexibility of Closure (GATB Part 7)	30.85	6.52	31.88	4.80
Perceptual Speed (GATB Part 1)	54.46	12.55	53.77	12.54
Auditory Attention	121.62	61.86	115.22	71.62
% Grade	90.81	4.74	90.83	6.42

Appendix F:

Information Processing Abilities (Fleishman & Reilly, 1992)

Fleishman & Reilly (1992) provide a list of the abilities, accompanying tasks, tests, and jobs associated with each. The following is a summary of the information provided for the abilities associated with information processing.

Auditory Attention is defined as the ability to focus on a single source of auditory information in the presence of other distracting auditory stimuli. Tasks that would require this ability include receiving Morse Code in a noisy environment and listening for broadcasts in a busy airport. Jobs that require high levels of this ability include sonar operator.

Selective Attention is defined as the ability to concentrate on a task over a period without being distracted by external stimuli. Tasks requiring this ability include studying a technical manual in a noisy room. Jobs that require high levels of this ability are air traffic controller, radio transmitter operator, and lifeguard.

Near Vision is defined as the capacity to see close environmental surroundings. Details, including, number of objects and patterns should be in focus. Tasks associated with near vision include reading books, watching a computer monitor and watching gauges on a control panel. Jobs that necessitate high levels of this ability include secretary, meter reader, and proofreader.

Flexibility of Closure is the ability to detect a known pattern that is hidden in other material. Tasks that require this ability include picking out a camouflaged vehicle in the forest, and looking for a golf ball on the green. Jobs that require high levels of this ability include pilot, radar operator, and microbiologist.

Speed of Closure is the capacity to quickly make sense of information, which may, initially, seems to be without organization. All the pieces presented in the pattern are relevant, but the pattern is not known ahead of time. Tasks that require this ability include receiving Morse Code, making sense out of unfamiliar handwriting, and recognizing a melody from only a few notes. Jobs that require high levels of this ability include those of a navigator and radio telegrapher.

Glare Sensitivity is defined as the ability to see objects in the presence of glare. Tasks that involve this ability include watching swimmers on a bright day, and identifying ships on the horizon. Jobs that require high levels of this ability include fisherman, Navy midshipman, and bus driver.

Hearing Sensitivity is defined as the ability to detect and discriminate among sounds over a wide range of pitch and/or loudness. This ability is thought to underlie more specific abilities such as auditory attention, sound localization, and speech recognition. Tasks that involve this ability are receiving Morse Code under poor reception conditions, and monitoring electronic equipment at a nurse's station. Jobs that require high levels of this ability include music critic, sonar operator, and acoustics engineer.

Speech Clarity is defined as the ability to communicate orally in a clear manner that an observer is able to understand. A task that requires this ability is being able to give oral presentations. Jobs that require this ability include air traffic controller, teacher, and telephone operator.

Far Vision is defined as the capacity to see distant environmental surroundings including details of things at a distance. Tasks requiring Far Vision include seeing streetcars while driving a car and standing watch on a ship. Jobs that require high levels of this ability include astronomers, ship captain and rifleman.

Night Vision is defined as the ability to see under low-light conditions. Tasks involving this ability include standing watch in a ship at night, and recognizing someone in an open field at night. Jobs that require high levels of this ability include scuba diver, night watchman, and bus driver.

Sound Localization is defined as the ability to identify the direction from which an auditory stimulus originates relative to the observer. This ability requires that the observer possess hearing in both ears. Typical tasks include tracing the source of noise in an engine. Jobs requiring this ability include lifeguard and auto mechanic.

Speech Recognition is defined as the ability to identify and comprehend the speech of another individual. Typical tasks include comprehending oral instructions, identifying a spoken foreign accent. Jobs requiring this ability include interpreter, air traffic controller, and telephone operator.

Perceptual Speed is defined as the ability to compare letters, numbers, or patterns quickly and accurately. Tasks that involve this ability include rapid identification of enemy aircraft and rapid scanning of manuscripts for typographical errors. Jobs that require high levels of this ability include telephone operator and proofreader.

Spatial Orientation is defined as the ability to know one's location in relation to the environment one is in. It is also the ability to know where an object is in relation to oneself. Tasks that involve this ability include aircraft piloting and using a roadmap in a city. Jobs that require high levels of this ability include taxi driver and pilot.

Visual Colour Discrimination is defined as the capacity to match and/or discriminate between colours. Tasks that involve this ability include tracing colour coded wires and painting portraits. Jobs that require high levels of this ability include interior designer and chemist.

Depth Perception is defined as the ability to evaluate the distance of an object from the observer. Tasks that involve this ability include estimating whether or not two aircraft are approaching a collision course, and threading a needle. Jobs that require high levels of this ability include crane operator, pilot, and artillery gunner.

Peripheral Vision is defined as the ability to perceive objects or movement located in the edges of the visual field. Tasks that involve this ability include piloting a plane and playing basketball. Jobs that require high levels of this ability include astronomer and fighter pilot.