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Is there a *g* in gunslinger? Cognitive predictors of firearms proficiency

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ABSTRACT

This study addressed a gap in the research literature by evaluating the validity of general mental ability (*g*) and personality test scores for prediction of firearms proficiency via shooting range performance, an entirely objective task-based criterion. It was hypothesized that mental ability test scores would be positively related to firearms proficiency based on past research in related areas (e.g., *g* predicts skill acquisition and training performance) and conceptual similarities between firearms proficiency and cognitive tasks. Using 4 datasets with a combined sample size of 22,525 individuals, this hypothesis was confirmed: *g* had operational validities ranging from .162 to .188 and logical reasoning had operational validities ranging from .179 to .268 after correcting for range restriction and criterion unreliability. Mental ability test scores predicted an entirely psychomotor criterion task: use of firearms to hit targets at a pre-determined level of accuracy. Most of the validity appears to be attributable to *g*, but a post hoc analysis indicated that writing ability acted as a suppressor (i.e., the validity of *g* increased when writing ability was included in a regression model). Conscientiousness was hypothesized to have a positive relationship with firearms performance and emotional stability was hypothesized to have positive linear and quadratic relationships. In contrast, it was observed that conscientiousness had a negative operational validity (−.079) and emotional stability lacked validity relative to the firearms proficiency criterion. The implications for individual differences research and practice are discussed.

1. Is there a *g* in gunslinger? Cognitive predictors of firearms proficiency

Individual differences in intelligence, especially general mental ability (*g*), have emerged as one of the best predictors of important life outcomes. For example, *g* is a significant predictor of academic course grades (Cucina, Peyton, Su, & Byle, 2016; Roth et al., 2015), training course grades (Salgado et al., 2003; Schmidt & Hunter, 1998), and job performance (Schmidt & Hunter, 1998). These performance domains involve reading, learning new materials, committing information to memory for later recall, solving problems, formulating written responses and essays, addressing novel and complex situations, and other cognitively-loaded activities. When personnel selection researchers devise employment testing programs for jobs, they often analyze the jobs in detail and find that there are a number of cognitively-oriented tasks and abilities needed for effective performance. Indeed, Hunt and Madhyastha (2012) uncovered a *g* factor in job analysis rating data from a large number of jobs.

This study examines the relationship between mental abilities and performance in a purely psychomotor criterion task: firing a pistol at a stationary target at a pre-specified level of accuracy. This criterion is referred to as firearms proficiency and it requires an individual to aim and fire a pistol resulting in a successful hit of a target. Unlike academic, job, or training performance, firearms proficiency does not include activities such as reading, academic learning, and problem solving. Although some firearms training activities involve “shoot-don’t shoot” scenarios, whereby individuals must quickly determine whether a fictitious individual is a threat that must be fired upon or an innocent bystander who should not be fired upon, our study focuses on firing at stationary targets that do not require a “shoot-don’t shoot” decision. Thus, this performance domain approximates the cognitive complexity of many elementary cognitive tests involving choice reaction time. We aim to examine the relationship between firearms proficiency and both mental ability and personality factors in our study.

In many ways, our study serves as test of the boundary conditions of

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practical relevance of *g*. It is well-established that *g* predicts cognitively complex tasks such as overall job performance and learning performance in both academic and job-training programs (Roth et al., 2015; Schmidt & Hunter, 1998). There is also evidence that as the level of cognitive complexity for jobs increases, the validity of *g* for predicting job and training performance increases as do the mean levels of *g* for employees in those jobs (Schmidt & Hunter, 2004). The same can be said for mental abilities measures. Carroll (1993, p. 597) noted that factors for mental ability tests that required higher levels of cognition tended to have higher *g*-loadings. There is also a line of research indicating that *g* correlates with performance on laboratory-based tasks such as simple and choice reaction time (Deary, Der, & Ford, 2001). Our study extends this research by examining the relationship between *g* and a real-life task that is quite removed from academic and complex activities.

The first testing program in recorded history, the Chinese civil service examination, included a test of archery, the precursor to modern firearms (Cohen, Swerdlik, & Phillips, 1996). A sizable number of occupations in the United States require firearms proficiency either at entry or in terms of demonstrating ongoing proficiency. Of the 974 occupations listed in O*NET by the U.S. Department of Labor (2017), 22 require using a handgun, 7 require using rifles, and 8 require using shotguns. These jobs include police officers, sheriffs, detectives, fish and game wardens, bailiffs, security guards, and corrections officers as well as supervisors for these positions. The U.S. Bureau of Labor Statistics (2017) estimates that over 2.7 million individuals are employed in these occupations. Separately, uniformed military personnel often need to use a firearm. The U.S. Army's warrior tasks and battle drills requires qualifying and maintaining proficiency in an assigned weapon. In addition, many individuals obtain proficiency in the use of firearms for recreational reasons. Shooting is an Olympic Games event in both summer and winter.

2. Individual Differences and Firearms Proficiency

Although firearms proficiency has societal importance in a number of jobs, in recreation, and in sport, there is a lack of cumulative research that directly examines individual differences that are related to firearms proficiency. In this study, we investigate whether *g* and personality predict performance in a pistol-shooting course with firearms proficiency as a criterion. We begin with a review of past research on individual differences used to form hypotheses about the relationship between individual differences and firearms proficiency.

2.1. *Rationale for the Correspondences of Mental Ability and Firearms Proficiency*

Researchers have proposed a skill development framework to understand how novices develop expertise (Ackerman, 1988, 1992; Fitts & Posner, 1967). Of particular interest to the development of firearms proficiency, Ackerman (1988, 1992) demonstrated the importance of aptitude during the initial learning stage when trainees are learning the proper procedures and methods of task execution (e.g., body position, breath control, and sight alignment in the case of firearms).

Chung, Nagashima, Espinosa, Berka, and Baker (2009) found that the initial stage of skill development is replete with errors, which is thought to be due to the high cognitive load of learning. A novice is expected to understand the fundamentals and self-correct as necessary. This process involves concentration and conscious thought, which depletes cognitive resources. There is a negative relation between *g* and depletion of cognitive resources (Fink & Neubauer, 2005). Trainees with higher *g* should have greater cognitive resources, resulting in more accurate performance – here, firearms proficiency.

Support for the role of cognitive variables in marksmanship performance was postulated in the early 1900's when Whelen (1918) noted "rifle shooting is almost entirely a matter of intelligent practice, without head work, will not get one very far" (p. 455). He went on to state that accuracy in rifle shooting requires coordination, concentration, and attention to detail when aiming, holding, trigger squeezing, calling the shot (i.e., indicating where on the target the shot is aimed), and adjusting the sight. He also offered anecdotal evidence that intelligence was related to performance in rifle shooting classes. Thompson, Smith, Morey, and Osborne (1980) reported a positive correlation between knowledge of marksmanship fundamentals (e.g., range effects) and record-fire performance. Similarly, Carey (1990) reported a positive correlation ($r = .32$) between *g* and known distance record-fire performance.

Acquisition of skill proficiency also implicates the process of acquiring expertise (Ericsson, 2014; Ericsson, Krampe, & Tesch-Römer, 1993; Gobet, 2016). A meta-analysis of predictors of the acquisition of expertise (Macnamara, Hambrick, & Oswald, 2014; see also Hambrick, Macnamara, Campitelli, Ullén, & Mosing, 2016) showed that deliberate practice is a less important predictor of skilled performance across many domains than previously believed, leaving ample room for individual differences to function as important predictors. Hambrick, Macnamara, and Oswald (2020) also showed that Ericsson's definition of "deliberate practice" was itself inconsistent, which diminishes a standard (e.g., the "10,000 hour rule") by which to apportion variance due to training activity versus individual characteristics. Finally, in a meta-analysis of transfer of training, Huang, Blume, Ford, and Baldwin (2015) showed that the best predictor by far of incorporating training especially in maximal performance situations is *g*. In brief, since *g* is highly predictive of training performance, acquisition of skill, transfer of training, and achievement of expertise, we hypothesize that there is a correlation between cognitive ability and firearms proficiency.

There are several potential reasons why *g* can be hypothesized to predict firearms proficiency. Firearms proficiency is a trained skill and *g* predicts training performance (Schmidt & Hunter, 1998). *g* is also correlated with physical traits and physiological characteristics, with individuals who have a high standing on *g* being more likely to have normal use of their hands, arms, and legs and being less likely to have medical issues such as aching joints and headaches (Lubinski & Humphreys, 1992). *g* has been shown to relate to manual activities; it is negatively related to accidental death (O'Toole, 1990; O'Toole & Stankov, 1992), but not after controlling for reaction time (Deary & Der, 2005).

The process of aiming and shooting at a target resembles *g*-loaded cognitive tasks/tests. Consider the steps in shooting at a target with a handgun. First, individuals must stand in position and raise their arms holding the firearm to face the target. Next, they must align the firearm with the center of the target. This involves scanning the visual field to locate the target. This process has similarities with tests of Spatial Scanning (Ss; Carroll, 1993). Individuals high in Ss are able to quickly explore a visuospatial field as evidenced by tests involving maze and line tracing. There is also some similarity to tests of perceptual speed (P factor; Carroll, 1993).

Next, the firearm must be aimed at the target. Several tests have been developed to measure aiming and there is evidence of a narrow cognitive ability factor for aiming that has a loading of .48 on the Broad Speediness factor (Gs/2S; Carroll, 1993; Fleishman, 1972; French, 1951). At this stage in the process, individuals must coordinate movement of their arms and hands with the location of the target. Invariably, there is some movement of the arms and hands that causes the bullseye of the target to move in and out of alignment with the firearm's sight posts. Since Carroll's (1993) manual dexterity (i.e., coordinating hand and arm movements) and arm-hand steadiness (i.e., positioning and steadying the arm and hand) abilities are unrelated to *g*, these are not relevant to our hypothesis. We suggest that *g* operates in firearms proficiency as individuals must make a quick decision as to when to fire based on the alignment of the target and the firearm, an alignment that is constantly shifting. Individuals must sense when the target is properly lined up and they must act expediently by pulling the trigger before the firearm and the target become misaligned again. This involves inspection time, which is correlated with IQ (meta-analytic $\rho = -.54$); a mix of *g* and other abilities underlies this correlation (Kranzler & Jensen, 1989). Second, individuals must decide when to fire. Carroll (1993) discusses elementary cognitive tasks (ECTs) and reaction time factors. In experiments involving the presentation of a stimulus and an action (e.g., pressing a certain button) on the part of the respondent, reaction time can be divided into two uncorrelated portions. *Decision time* involves the time a respondent takes to decide to respond, while *movement time* involves the time to move a part of one's body to respond. ECTs and measures of reaction time often involve presenting a respondent with stimuli (e.g., the letters L or R indicating a response by the left or right hand). More complicated reaction time tests could involve presenting respondents with words and asking them to indicate whether the word refers to a living or non-living entity. Carroll identified several reaction time factors, including simple reaction time (R1, which require a response to a single stimulus), choice reaction time (R2, which require a different response to each of two or more stimuli), and movement time (R3). He reported that reaction time measures typically had absolute correlations <.40 with *g*. However, in a sample of 900 individuals, simple reaction time was shown to correlate −.31 with *g* (Deary et al., 2001). Thus, it appears that decision time could lead to a correlation between *g* and firearms performance.

Movement time is less related to *g* (Carroll, 1993); however, wrist-finger speed (Peterson & Bownas, 1982), which involves the speed of making discrete finger, hand, or wrist movements, is relevant. Carroll (1993) reported that wrist-finger speed had a loading of .84 on the broad cognitive speediness factor (Gs/2S). We also believe that Gs/2S could be related to firearms performance, in and of itself.

2.2. Rationales for the correspondence of personality and firearms proficiency

Personality variables may also be relevant for firearms proficiency. Conscientiousness has been shown to predict academic, training, and job performance (McAbee & Oswald, 2013; Salgado, 1997; Schmidt & Hunter, 1998) and thus is a likely candidate for predicting firearms proficiency. Individuals who are high in conscientiousness are better at setting and committing to goals (Locke & Latham, 2002) which should relate to the amount of effort put into developing firearms proficiency. Additionally, the attention to detail of highly conscientious people may lead to more accurate decisions when deciding when to pull the trigger to hit a target.

Emotional stability (neuroticism reverse-scored) may have linear and quadratic relationships with firearms proficiency. Individuals who are low in emotional stability may be more likely to have high anxiety, which in turn may lead to lower firearms proficiency via test anxiety. The participants in our study must obtain a passing score in the shooting course in order to continue their employment in the position. They will be removed from their position if they cannot pass the shooting course, which could be anxiety-provoking. The Yerkes-Dodson Law (Yerkes & Dodson, 1908) may also apply, whereby performance is maximal in the middle range of neuroticism since non-neurotic individuals lack the arousal needed to excel at the task.

2.3. Hypotheses

We hypothesize that measures of *g* have a positive predictive relationship with firearms proficiency (H1), that conscientiousness has a positive relationship with firearms proficiency (H2), and that emotional stability has either a positive linear (H3) or quadratic (H4) relationship with firearms proficiency.

3. Method

The hypotheses in this study are tested using four archival datasets. The first dataset includes data from 5614 uniformed Federal law enforcement officer trainees. During the hiring process, as applicants, the trainees took a logical reasoning test, an arithmetic reasoning test, a multiple-choice writing skills test, and a personality inventory. The tests were developed by Personnel Research Psychologists working for the U. S. Federal government. The first two tests measure reasoning, which is considered to be at the "core" of mental ability (Carroll, 1993, p. 196). The logical reasoning test consists of multiple-choice questions presenting applicants with a set of logical premises and then asking them to identify the response option that either can be validly concluded or cannot be validly concluded based on the premises provided. In some instances, applicants also have to determine whether or not there is enough information provided to support a conclusion. This test was developed based on the principles of logic-based measurement (Colberg, 1984, 1985; Colberg, Nester, & Trattner, 1985). The arithmetic reasoning test consists of word problems that require individuals to engage in reasoning and problem-solving using basic mathematical formulas, though this test focuses on reasoning skills more than arithmetic computations. Hayes and Reilly (2002) showed that similarly developed logical reasoning tests and arithmetic reasoning tests have excellent criterion-related validity for job and training performance. The personality inventory measures conscientiousness and emotional stability and was construct-validated against the NEO-PI-R (Costa & McCrae, 1992; see Vasilopoulos, Cucina, & McElreath, 2005).

Students are trained in the use of firearms as part of the training academy curriculum. Although their training consists of firearms safety, use of force policy, and other theoretical topics, the final firearms proficiency numerical grade criterion we used was computed solely on the basis of a practical shooting exercise. During this exercise, trainees must use a pistol to successfully hit a target from varying distances and positions (e.g., standing vs. kneeling). They receive a numerical score ranging from 0% to 100% depending on the number of targets successfully hit.

The second dataset is a subset of the first. Some officers ($n = 254$) completed 10 additional cognitive tests during a criterion-related validation study. These tests included meaningful memory (Carroll, 1993), three other memory tests (MA1: Picture-Number; MV1: Shape Memory; MA3: First and Last Names), three mental visualization tests (CF2: Hidden Patterns; S2: Cube Comparisons; VZ-1: Form Board) and three perceptual speed tests (P3: Identical Pictures; P2 Number Comparisons; P1: Finding A's) all from the ETS Kit of Factor-Referenced Cognitive Tests (Ekstrom, French, Harman, & with Derman, D., 1976a/b).

The third dataset consisted of 14,892 uniformed Federal law enforcement officer trainees from another job who completed a similar (but not parallel) version of the logical reasoning test used in Datasets 1 and 2. Tests of arithmetic reasoning, writing, and personality were not administered. The firearms criterion was similar to that of Dataset 1.

The fourth dataset consisted of 2019 non-uniformed Federal law enforcement investigators who serve as detectives for Federal criminal investigations. As part of the hiring process, they completed different versions of the logical reasoning test, the arithmetic reasoning test, and the multiple-choice writing skills test used in Datasets 1 and 2. Personality tests were not administered. The firearms criterion was similar to that used in Datasets 1, 2, and 3.

3.1. Data analysis strategy

The hypotheses will be tested by correlating predictor tests with the firearms criterion scores. Corrections for range restriction and unreliability will be made as these can artificially reduce criterion-related validity coefficients. Both corrected and uncorrected results will be presented. We used a variety of approaches from the literature for testing the hypotheses and did not give preference for one approach over another. Correlation tests, principal components analysis, exploratory factor analysis, regression analyses, and structural equation modeling will be used to investigate the criterion-related validity of *g* and whether the individual predictor tests and components/factors formed from them add incremental validity over *g*. Note that copies of the SPSS syntax and output files for the focal analyses in this paper are provided as Supplementary Materials.

4. Results

In Datasets 1 and 4, we estimated *g* by computing the first unrotated principal component of the logical reasoning, arithmetic reasoning, and multiple-choice writing test scores using applicant datasets.[2] In Dataset 2, *g* was estimated using the first unrotated principal component of all 13 cognitive tests. The estimation of *g* using this method was supported by analyses indicating evidence that Ree, Carretta and Teachout's (2015) two criteria for defining a dominant general factor in the datasets were met. Specifically, the first component accounted for the largest source of variance and all the variables in the PCA had loadings with the first component. Schmidt, 2012 indicates that the sum of three cognitive tests is "a *de facto* measure" of *g* and Johnson, Bouchard Jr., Krueger, McGue, and Gottesman (2004) report findings that the same *g* is extracted across different test batteries. This provides evidence that our test-based *g* scores were measures of *g*.

Table 1 presents the criterion-related validities of the individual tests and *g* scores for predicting firearms proficiency in Datasets 1, 3, and 4. Corrections for unreliability and range restriction were made using two approaches. First, we corrected for criterion unreliability using formula 6–36 from Nunnally and Bernstein (1994) and then corrected for Thorndike's (1949) Case III incidental range restriction using overall scores for the test batteries[3] that participants took as applicants as part of the hiring process as the third variable. Second, we used Hunter, Schmidt, and Le (2006) seven-step Case IV procedure that corrects for indirect range restriction due to selection on unmeasured variables. Hunter et al. (2006) stated that their procedure provides more accurate estimates of criterion-related validity than applying direct range restriction corrections in situations in which the restriction is indirect and a Monte Carlo simulation by Le and Schmidt (2006) provides support for the approach. Copies of the correction formulas can be found in the Supplementary Materials.

Only one published article was available with criterion reliability data. As cited in Chung et al. (2011), using two samples, McGuigan and MacCaslin (1955) reported test-retest reliabilities of .88 (n = 148) and .84 (n = 200) for a rifle-based firearms grade in the military. The sample-weighted average reliability was computed to be .86 and this value was used in this study as a reliability estimate for the firearms proficiency criterion.

g predicted firearms proficiency with operational (and observed, in parentheses) validities of .162 (r = .118; p < .001; 95% confidence interval: .092 to .144) and .188 (r = .103, p < .001; 95% confidence interval: .060 to .146) in Datasets 1 and 4, respectively. Regression analyses were conducted to determine if the subtests added incremental validity over *g*. In other words, after controlling for *g*, does an individual subtest improve prediction of firearms proficiency[4]? The results indicated that the subtests did not add appreciable incremental validity over *g*, with the possible exception of the writing test which had a significant but negative β-weight when controlling for *g*. The logical reasoning test predicted firearms proficiency in Dataset 3 with an operational validity of .268 (r = .160; p < .001; 95% confidence interval: .144 to .176), indicating that on average, a 1 *SD* increase in logical reasoning is associated with a .268 *SD* increase in firearms proficiency.

The results for Dataset 2 are shown in Table 2. The principal component *g* score computed using all 13 cognitive tests had an observed validity of .130 (p < .05; 95% confidence interval: .008 to .249). Only one subtest (CF2) had statistically significant incremental validity (ΔR = .062, p = .023) over *g* when looking at the regression results. This subtest also had a nominally higher validity (.192) compared to *g* (.130); however, this difference was not statistically significant according to Meng, Rosenthal and Rubin's (1992) test (Z = 1.29; p = .198). Thus, with the exception of CF2, specific abilities did not have a meaningful contribution relative to *g* in predicting firearms proficiency. A series of structural equation models, shown in the Supplemental Materials, revealed similar findings.

Emotional stability did not predict firearms proficiency (r = .006; 95% confidence interval: −.020 to .032). Conscientiousness predicted firearms proficiency in Dataset 1; however, the relation was small in magnitude and opposite of the hypothesized direction (r = −.045, 95% confidence interval: −.071 to −.019; ρ_{ov} = −.079; p < .01). It also added a slight amount of incremental validity over *g* (ΔR = .006; p < .01). A quadratic term for emotional stability was computed and entered into hierarchical regression analyses to determine if this personality variable had a curvilinear relationship with firearms proficiency, controlling for the linear effects. The quadratic term for emotional stability lacked incremental validity. As a post hoc exploratory analysis, we computed a quadratic term for conscientiousness and cubic terms for both conscientiousness and emotional stability. These additional terms lacked incremental validity over the linear terms for their respective personality variables.

The writing ability test score added a small amount of incremental validity but was negatively related to performance when controlling for *g*. It appears that writing scores served as a suppressor, increasing the β-weights for *g* from .118 to .182 in Dataset 1, from .130 to .196 in Dataset 2, and from .103 to .163 in Dataset 3. We decided to conduct further post hoc analyses of the suppressor effect using Hayes' (2018) PROCESS analysis for detecting mediation effects since this approach outperforms other mediation tests in terms of statistical power and accuracy (Hayes, 2009, 2012; MacKinnon, 2017). MacKinnon, Krull, and Lockwood (2000) have described how testing for suppression is statistically equivalent to testing for mediation (see also Cliff & Earleywine, 1994; Davis, 1985; Tzelgov & Henik, 1991). Briefly, in a mediation path model, a predictor variable (X) has both a direct effect (c') on a criterion variable (Y) and an indirect effect (ab) through a mediator (M). The indirect effect (ab) is formed by multiplying the path from X to M (which is labeled a) by the path from M to Y (which is labeled b). When the direct and indirect effects both have the same sign, consistent mediation is said to have occurred. However, if the direct and indirect effects have opposite signs, then inconsistent mediation, also known as suppression, has occurred. MacKinnon et al. (2000) presented a table for interpreting third variable (e.g., mediation, suppression, and confounding) effects. If the third variable effect (i.e., ab) is negative, the direct effect (i.e., c') is positive, and the total effect (i.e., c) is less than the direct effect (i.e., c'), then suppression is said to have occurred.

Accordingly, we ran Hayes' (2018) PROCESS (version 3.1) SPSS syntax using 10,000 bootstrap samples to generate 95% confidence intervals to test for suppression effects using Datasets 1 and 4. In both analyses, the predictor variable (X) was the first unrotated principal component *g* score, the mediator (M) was the writing test, and the criterion (Y) was firearms proficiency. The results of this analysis, which are provided in Table 3, show similar trends for Datasets 1 and 4. There are several things to note from these results. First, none of the confidence intervals included zero, therefore, all the effects were statistically significant. Second, since the indirect effect's confidence intervals did not

[2] *g* scores were also computed using principal axis factoring and Tables S1 and S2 of the Supplementary Materials provide these results.

[3] All three test batteries also included biographical data inventories. For readers unfamiliar with this type of assessment, biographical data inventories typically contain items measuring many different constructs and use empirical keying to maximize prediction of a criterion (Stokes, Mumford, & Owens, 1994). Since the biographical data inventories did not yield interpretable construct-based scale scores and were empirically keyed to predict job performance (rather than firearms proficiency), we did not include these in our study.

[4] A reviewer suggested examining whether the second and subsequent principal components added incremental validity over the first principal component as an alternative to examining the incremental validity of the subtests over the first principal component. In Datasets 1 and 4, only the component with a meaningful positive loading for writing had statistically significant incremental validity (ΔR = .012 and .018, respectively) over the principal component for *g*. In Dataset 2, none of the other components had statistically significant incremental validity over the principal component for *g*.

Table 1
Criterion-Related Validity Results for Datasets 1, 3, and 4 – using Principal Components Analysis to Compute g scores.

Test	r_{obs}	p	ρ_{ov} (Case III)	ρ_{ov} (Case IV)	ρ_{TS} (Case III)	ρ_{TS} (Case IV)	Multiple R	ΔR	Squared Semipartial r or ΔR^2	β-weight	Partial r	Semipartial r	p for ΔR and β-weight
Dataset 1													
g	.118	<.001	.125	.162	.134	.171							
Logic	.124	<.001	.135	.179	.155	.198	.127	.009	.002	.082	.049	.048	<.001
Math	.095	<.001	.105	.112	.114	.121	.118	<.001	<.001	.005	.003	.003	.829
Writing	.064	<.001	.076	.094	.095	.114	.128	.010	.002	−.081	−.050	−.049	<.001
Emtnl. stblty.	.006	.670	N/A[a]	N/A[a]	N/A[a]	N/A[a]	.118	<.001	<.001	−.002	−.002	−.002	.869
Conscientiousness	−.045	.001	−.038	−.079	−.043	−.083	.124	.006	.001	−.038	−.039	−.038	.004
Dataset 3													
Logic	.160	<.001	.210	.268	.246	.302							
Dataset 4													
g	.103	<.001	.125	.188	.143	.203							
Logic	.097	<.001	.119	.213	.150	.239	.106	.003	.001	.040	.025	.025	.266
Math	.103	<.001	.125	.134	.146	.157	.109	.006	.001	.057	.033	.033	.136
Writing	.029	.196	N/A[a]	N/A[a]	N/A[a]	N/A[a]	.120	.017	.004	−.085	−.061	−.061	.006

Notes. [a]Since it is inappropriate to make corrections for variables that lack statistical significance, these cells are labeled as not applicable (N/A). Emtnl. Sblty.: Emotional stability (reverse-scored Neuroticism). r_{obs} = observed bivariate correlation; p = statistical significance for r_{obs}; ρ_{ov} = operational validity; ρ_{TS} = true score validity; Case III: Thorndike (1949) range restriction correction; Case IV: Hunter et al. (2006) correction procedure; Multiple R = multiple correlation obtained from regression equation including *g* and subtest score; ΔR = incremental validity of subtest score over *g*-score (note that this is simply the Multiple R minus the validity of the *g*-score); ΔR^2 = incremental validity expressed as R^2; β-weight = standardized regression weight for subtest in the regression equation including *g* and the subtest score as predictors. Partial r = Correlation of subtest and firearms controlling for *g* score. p for ΔR and β-weight = this is the p-value for the ΔR (i.e., incremental validity), which is the same as the p-value for the β-weight of the subtest score.

Table 2
Criterion-Related Validity Results for Dataset 2 – using Principal Components Analysis to Compute g scores.

Test/Factor	r_{obs}	p	Multiple R	ΔR	Squared Semipartial r or ΔR^2	β-weight	Partial r	Semipartial r	p for ΔR and β-weight
Dataset 2									
g	.130	.038							
Glr									
MA1	.039	.533	.136	.006	.002	−.047	−.039	−.039	.532
MA3	.084	.181	.131	.001	<.001	.014	.011	.011	.860
Meaningful Memory	.010	.874	.147	.017	.005	−.080	−.069	−.068	.274
MV1	.134	.033	.158	.028	.008	.097	.090	.089	.155
Mental Visual.									
CF2	.192	.002	.192	.062	.020	.198	.143	.142	.023
S2	.117	.062	.139	.009	.002	.062	.050	.050	.428
VZ1	.077	.222	.132	.002	<.001	.023	.021	.021	.741
Perceptl. Speed									
P1	.052	.406	.131	.001	<.001	.014	.014	.014	.827
P2	−.023	.718	.150	.020	.006	−.080	−.076	−.075	.231
P3	.098	.121	.133	.003	.001	.034	.028	.028	.654
Reasoning									
Logic	.045	.475	.137	.007	.002	−.053	−.042	−.042	.502
Math	.034	.586	.138	.008	.002	−.056	−.047	−.046	.459
Writing	.006	.928	.158	.028	.008	−.111	−.090	−.089	.154

Note. Per Ekstrom et al., 1976a/b/b, tests included MA1 = Picture-Number, MA3 = First and Last Names, MV1 = Shape Memory, CF2 = Hidden Patterns, S2 = Cube Comparisons, VZ1 = Form Board, P1 = Finding A's, P2 = Number Comparisons, P3 = Identical Pictures.

include zero, mediation occurred in both datasets. Third, since the signs of the direct and indirect effects are opposite, inconsistent mediation occurred. Fourth, MacKinnon et al.'s (2000) criteria for suppression were met since the third variable effects (i.e., the indirect effects, *ab*) were negative, the direct effects (i.e., *c'*) were positive, and the total effects (i.e., *c*) were less than the direct effects (i.e., *c'*) in both Dataset 1 (.9249 < 1.4298) and Dataset 4 (.7793 < 1.2253). Thus, we found that writing acted as a suppressor in both datasets.

5. Discussion

Hypothesis 1, *g* predicts firearms proficiency, was supported in all four datasets. It is a notable finding that *g* predicted a criterion that is entirely objective and does not involve the use of tests or ratings. The remaining specific and broad abilities were largely uncorrelated with firearms proficiency after controlling for *g* (with the exception of CF2 and writing). This is a similar finding to that observed in the job (e.g., Ree, Earles, & Teachout, 1994), training (e.g., Brown, Le, & Schmidt, 2006), and academic (e.g., Zaboski II., Kranzler, & Gage, 2018)

Table 3
Results of Hayes (2018) PROCESS Analysis for Suppression Effects of Writing on the Validity of g in Predicting Firearms Proficiency.

Dataset	Type of Effect	Notation	Unstandardized				Completely Standardized
			Effect	95% Confidence Interval		p	Effect
				Lower Bound	Upper Bound		
1	Total	*c*	.9249	.7209	1.1288	<.001	.1178
	Direct	*c'*	1.4298	1.0948	1.7648	<.001	.1822
	Indirect	*ab*	−.5049	−.7652	−.2397	N/A[a]	−.0643
4	Total	*c*	.7793	.4523	1.1064	<.001	.1035
	Direct	*c'*	1.2253	.7692	1.6814	<.001	.1627
	Indirect	*ab*	−.4459	−.7741	−.1219	N/A[a]	−.0592

Note. Hayes (2018) PROCESS does not output a *p*-value for the bootstrap confidence interval for the indirect effect (*ab*); however, since the 95% confidence interval does not include zero, the result is statistically significant at at least the .05 α level.

performance literature and it provides additional disconfirmation of specific aptitude theory. Our findings provide additional disconfirmation of specific aptitude theory (which hypothesized that prediction is maximized using narrow abilities rather than *g*). Unlike previous studies on this topic, the nature of our criterion was arguably much narrower than overall job performance or grades across multiple tests, courses, and subjects (as is the case for training and academic performance). Based on conceptual work on the bandwidth-fidelity dilemma, albeit primarily for personality predictors, two of three different approaches to prediction described by Salgado (2017) suggest that narrow criteria are best predicted by narrow predictors. Our finding that firearms performance is well-predicted by the broad *g* factor is more in line with the first approach described by Salgado (2017).

The operational validities for *g* and logical reasoning ranged from .162 to .268. These are in the small range according to Cohen's (1992) cutoffs and near the 40th to 60th percentiles for correlation magnitudes between knowledge, skills, and abilities with performance according to Bosco, Aguinis, Singh, Field and Pierce's (2015) summary. The validities of .162 to .268 are similar to Schmidt and Hunter's (2004) meta-analytic operational validity estimate of .23 for *g* with low cognitive complexity positions, which is consistent with our hypothesis that firearms proficiency is approximates the complexity of an elementary cognitive test. Although the operational validities we observed were smaller than Schmidt and Hunter's (1998) meta-analytic operational validities for *g* with job performance (.51) and training performance (.56), values in the .162 to .268 range can have practical significance depending on the selection ratio and base rate for successful performance (Taylor & Russell, 1939).

Hypotheses 3 and 4 regarding emotional stability were not supported. Emotional stability had no relation to firearms proficiency even when curvilinearity was explored. As for Hypothesis 2 regarding conscientiousness, we found a small significant relation in a direction opposite to the one expected. It should be noted that the personality data came from applicants and it is possible that impression management impacted the scores. Alternatively, maybe conscientious trainees take longer to achieve mastery, or perhaps they tended to be more perfectionistic and cautious when firing, which could cause them to be reluctant to fire quickly enough to hit the target with high precision.

5.1. Practical implications

Many positions for which applied psychologists develop testing programs require incumbents to develop and maintain firearms proficiency. Our results show that cognitive ability tests have small but potentially useful implications for predicting firearms proficiency. When incorporated in selection systems targeted at predicting a broad range of task performance and work behavior, cognitive tests contribute to the selection of applicants who are also more likely to employ firearms correctly and accurately when tested objectively.

Data for conscientiousness and emotional stability scales do not provide equal utility to the cognitive measures. Although conscientiousness yielded slight incremental validity over *g*, its negative correlation suggests it would be unwise to select applicants lower on conscientiousness to increase firearms proficiency as criteria aside from firearms proficiency relevant for those who use firearms on the job (e.g., citizenship, lack of counterproductive behavior, supervisor ratings) would probably be related positively to conscientiousness (Ones, Dilchert, Viswesvaran, & Judge, 2007).

We also discovered another case of statistical suppression in the context of personnel selection. Horst (1941) was the first to describe suppression when he observed that the validity of a measure of technical abilities in predicting World War II pilot navigational skills increased when verbal ability was included in the regression equation. Verbal ability itself was uncorrelated with navigational skills; however, it had a negative regression weight in the regression equation. Suppressor effects were also found for personnel selection studies conducted in the insurance industry (Bills & Taylor, 1953; Kellner, 1951, 1960) and Thorndike (1949) discussed the possibility and use of suppressor variables in selection. Kellner (1960) wrote that suppressor variables had "probably not been exploited to the fullest extent" (p. 22). That statement still appears valid 60 years later and additional research on suppressor variables in selection could be fruitful.

5.2. Theoretical implications

The theoretical mechanism for the size of the correlations we report would benefit from further exploration. It is possible that *g* or conscientiousness is more predictive of the rate of acquisition of firearms proficiency than performance on a single occasion. Acquisition of skill with firearms would be a direct determinant of our criterion measures. Personality variables similarly may influence performance outside of the strong situation of the firearms proficiency evaluation criterion. Participants were aware of the level of firearms proficiency they would need to demonstrate to pass the examination and hence is of strong administrative interest.

Our results suggest that a non-trivial amount of firearms proficiency is a function of participants' use of cognitive resources to make real-time decisions about when to shoot and how to factor in environmental conditions that affect ballistics. The results add to the diverse literature on the nomological network of *g* and its relationship to important behaviors. Notably, *g* predicted a rather non-academic and non-complex psychomotor real-world task which some might have thought lies beyond the boundary conditions of its influence. Given the consequences of poor firearms proficiency, especially in law enforcement or security work where firearms proficiency is required and inadequate proficiency is potentially lethal for bystanders, an increased understanding of individual differences associated with success is useful.

As noted by a reviewer, our findings provide additional rebuttals of the myths that cognitive ability tests are measures of book smarts that only predict grades and not real-world outcomes (Sackett & Kuncel, 2018). They also speak to the impact of Spearman's' (1927, p. 197) "theorem of the indifference of the indicator" and the role of *g* in criterion-related validity. The content domain of the predictor tests (i.e., reasoning and writing abilities) is not well-aligned to firearms proficiency and yet the tests did have a meaningful correlation in several large samples. Another reviewer also noted that our results have implications for Ericsson's, (2014; Ericsson et al., 1993) deliberate practice theory, which would predict that at the end of training all participants should have had similar levels of firearms proficiency and their proficiency should not be correlated with individual difference variables such as *g*. In contrast to the theory's prediction, we found that individual differences in firearms proficiency exist and correlate with *g*.

5.3. Limitations

Our reliance on archival data prevented the inclusion of other measures such as reaction time. Dataset 3 did not include measures of arithmetic reasoning or writing for use in creating a *g* score. Dataset 2 had a more diverse array of tests but with a smaller sample size. Our sample personnel were predominantly male and our criterion reliability estimate (McGuigan & MacCaslin, 1955) is both limited and antiquated (nearly 70 years old). Nonetheless, our samples represent a workforce in which firearms proficiency can have critically important implications for employees and the public.

Future research could examine additional indices of firearms proficiency and cognitive ability. The finding that writing served as a suppressor could be replicated using different types of writing tests and other measures from Carroll's (1993) domain of language as well as tests of crystallized intelligence. An understanding of the factors that influence acquisition of firearms skill, proficiency in employing firearms during testing, and on-the-job use of firearms can improve decisions about who is most capable to use these tools in a discretionary capacity.

Author note

The views expressed in this paper are those of the authors and do not necessarily reflect the views of U.S. Customs and Border Protection or any agency of the U.S. Federal Government. Portions of this paper were previously presented at the 2018 meeting of the Society for Industrial and Organizational Psychology.

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Declaration of Competing Interest

None.

Data availability

The data that has been used is confidential.

Appendix A. Supplementary data

Supplementary materials for this article can be found online at https://doi.org/10.1016/j.intell.2023.101768.

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