Cognitive and noncognitive predictors of success

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When predicting success, how important are personal attributes other than cognitive ability? To address this question, we capitalized on a full decade of prospective, longitudinal data from n = 11,258 cadets entering training at the US Military Academy at West Point. Prior to training, cognitive ability was negatively correlated with both physical ability and grit. Cognitive ability emerged as the strongest predictor of academic and military grades, but noncognitive attributes were more prognostic of other achievement outcomes, including successful completion of initiation training and 4-y graduation. We conclude that noncognitive aspects of human capital deserve greater attention from both scientists and practitioners interested in predicting real-world success.

cognitive ability | grit | achievement | graduation | military

Apart from luck and circumstance, what determines the achievement of personally meaningful goals? One hundred and fifty years ago, Galton (1) conjectured that achievement required intelligence as well as "zeal and the capacity for hard labour" (ref. 1, p. 38). In personal correspondence, Darwin (2) agreed that cognitive ability must matter but added, "I have always maintained that, excepting fools, men did not differ much in intellect, only in zeal and hard work; and I still think this is an eminently important difference" (ref. 2, p. 530).

Subsequent theorizing about the psychology of achievement likewise contrasted cognitive ability with noncognitive factors (3–8). Cox (9), for example, suggested that, in addition to intelligence, unusually successful individuals are characterized by the "tendency not to abandon tasks in the face of changeability" and the "tendency not to abandon tasks in the face of obstacles" (ref. 9, p. 174). Likewise, Wechsler (10) distinguished between "intellective" and "non-intellective" factors.

Nevertheless, the past century of empirical research on human accomplishment has disproportionately focused on cognitive ability. In the military, for example, where predicting success holds potentially life or death consequences, the past century of "research was locked in a paradigm that focused on cognitive tests. . ." (ref. 11, p. 245).* Why? Perhaps because psychologists figured out how to measure cognitive ability earlier, more reliably, and more precisely than most noncognitive attributes (15). It may also be that scholars are drawn to the study of capacities that they themselves exemplify.

The scientific literature is particularly lacking in high-quality, longitudinal studies that assess both cognitive and noncognitive attributes before objectively gauging success outcomes weeks, months, and years later (16). In this investigation, we capitalize on data from more than 10,000 women and men who, on entry to the US Military Academy at West Point, completed measures of grit, cognitive ability, and physical ability and were followed longitudinally through graduation.

Cognitive and Noncognitive Attributes

Cognitive ability is broadly defined as the "ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly, and learn from experience" (ref. 17, p. 13). No construct in psychological science has a longer history, and it is now widely accepted that cognitive ability encompasses aptitudes that are hierarchically organized (e.g., math and verbal ability are distinct but also load on a common factor) and prognostic of many forms of academic and professional success (18).

Research on aptitudes other than cognitive ability is comparatively rare (19). Physical ability, for example, is rarely measured in studies of success (20). The scant literature on physical ability suggests that, like cognitive ability, it is hierarchically organized (e.g., comprising distinct but highly correlated components, such as agility, strength, and speed) (21). To date, little is known about the importance of physical ability, even in the military, a profession in which physical challenges are central to both training and active combat (11).

Grit was recently introduced to the scientific literature on human achievement as a facet of Big Five conscientiousness (22). Defined as passion and perseverance for long-term goals of personal significance, grit is a hierarchically organized trait aligned with Galton's (1) notions of zeal and hard labor and what Cox described as the tendencies not to abandon tasks in the face of either changeability or obstacles (3). Grit seems to

Significance

To examine cognitive and noncognitive predictors of success, we conducted a megaanalysis of prospective, longitudinal data on over 10,000 cadets at the US Military Academy at West Point. Cognitive ability was negatively related to physical ability and grit. While cognitive ability predicted academic and military grades, the noncognitive attributes of physical ability and grit were more prognostic of other achievement outcomes, including successful completion of initiation training and 4-y graduation.

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*One notable exception was Project A, which aimed to identify both cognitive and noncognitive correlates of performance among entry-level personnel in the US Army (12). In cross-sectional analyses, cognitive abilities proved especially predictive of "can do" aspects of job performance, including core technical and general soldiering proficiency (13). In contrast, a noncognitive composite of self-reported self-esteem, work orientation, energy level, conscientiousness, nondelinquency, emotional stability, and physical condition proved especially predictive of "will do" aspects of job performance, including ratings of effort and leadership, personal discipline, and physical fitness and military bearing. More recently, a composite of self-reported dominance, sociability, attention seeking, selflessness, cooperation, achievement, order, self-control, nondelinquency, adjustment, even tempered, optimism, intellectual efficiency, tolerance, and physical conditioning predicted attrition of soldiers from entry-level positions 18 mo later (14).

be independent of cognitive ability (22, 23) and has demonstrated incremental predictive validity, over and above cognitive ability, for achievement (22, 24, 25), particularly for goals of personal significance (26).

West Point

The oldest military academy in the United States, West Point offers a unique opportunity to study personal attributes that predict success. Each year, about 14,000 young women and men begin an admissions process that includes a standardized test of physical ability and standardized academic achievement tests. On arrival at West Point, each class of ∼1,200 cadets completes a variety of self-report questionnaires designed by researchers within and outside the academy.

What follows is a 6-wk initiation training nicknamed Beast Barracks. This experience has been described in the handbook for new cadets as "the most physically and emotionally demanding part of the 4 years at West Point. . .designed to help you make the transition from New Cadet to Soldier" (27). As one cadet put it, "You are challenged in a variety of ways in every developmental area—mentally, physically, militarily, and socially. The system will find your weaknesses, but that is the point—West Point toughens you" (27).

Whether cadets excel at or barely survive Beast Barracks, all are given a fresh start come fall, when they begin earning military, academic, and physical grades (each calculated as a separate grade point average [GPA]) during their subsequent 4 y of West Point training. Cadets who complete all requirements during this period graduate from the academy and go on to serve a minimum of 5 y in the US Army.

This Investigation

To address foundational questions about the respective roles of cognitive and noncognitive predictors of success, we conducted a megaanalysis of data from 9 separate cohorts of cadets entering training at West Point over a full decade. Several affordances of these data are worth noting. First, the internal validity of our conclusions is strengthened by the prospective and longitudinal design of the dataset, objectively measured success outcomes from official records, and a rich set of demographic covariates. In contrast, metaanalyses on this topic have by necessity relied on studies that vary in quality and disproportionately, are cross-sectional in design.

Second, another advantage concerns ecological validity. Put simply, the outcomes examined in this investigation are consequential in a way that laboratory measures of success are not (26, 28). We can assume that West Point cadets care a great deal about how they fare at an institution where the admissions process lasts 2 y and graduation leads to a 5-y commitment to active duty in the military. Indeed, prior research confirms that cadets are strongly motivated for both internal and instrumental reasons to succeed at West Point (29). We cannot plausibly do the same with, say, undergraduate volunteers solving puzzles in a research laboratory.

Third, our sample is 50 times larger than the average sample of studies published in high-impact psychology journals (30, 31). The statistical power of this investigation is sufficient to detect both curvilinear and interaction effects—analyses that are notoriously underpowered for the vast majority of datasets collected in social science yet clearly essential for a nuanced understanding of the mechanics of human achievement (32).

The West Point Exempt Determination Officer reviewed this research protocol and determined that it is human subject research according to 32CFR219 and meets the requirements of exempt status under 32CFR219.101(b)(2). While the study was determined to be exempt, all participants were informed and consented to participate in the data collection efforts. All study data are stored securely at West Point and were fully deidentified prior to use or external sharing.

Results

Our analytic approach was as follows. For the 2 binary outcomes of Beast Barracks completion and 4-y graduation, we standardized all predictors prior to fitting binary logistic regression models. For the 3 continuous measures of military, academic, and physical GPAs, we fit ordinary least squares regression models. To adjust for multiple comparisons (i.e., 5 outcome variables) in this investigation, we used a 2-tailed P value of 0.01 as our threshold for statistical significance. Following recommendations by Ganzach (33), we included quadratic terms for curvilinearity as well as 2-way interactions. In cases of statistically significant quadratic terms, we followed Gillespie et al. (34) in determining inflection points (i.e., values of the predictor where the minimum or maximum occurs as well as the value of the predictor where the curvilinear shape indicates concavity).

Following recommendations by Duncan et al. (35), we completed a series of robustness checks, which are summarized in *SI Appendix*. For example, as shown in *SI Appendix*, Tables S1–S5, final models using the full sample were generally consistent across individual cohorts. Likewise, as shown in *SI Appendix*, Tables S7–S11, conclusions were similar whether pretraining predictors were entered separately, whether passion and perseverance subscores were entered as separate predictors, or when grit was operationalized using the 8 items in a short-form version of the Grit Scale (36).

Cognitive and Noncognitive Attributes Are Distinct. Cognitive ability was negatively related to both physical ability ($r = -0.05$, $P < 0.001$) and grit ($r = -0.07$, $P < 0.001$), which were, in turn, positively related to each other ($r = 0.07$, $P < 0.001$). Differential relations with demographic factors underscored the independence of these 3 predictors. For example, female cadets scored lower than male cadets in both cognitive ability ($d = -0.21$, $P < 0.001$) and physical ability ($d = -0.25$, $P < 0.001$) but scored higher on grit ($d = 0.07$, $P = 0.006$). Additionally, whereas the average cognitive ability of incoming cadets increased slightly ($r = 0.05$, $P < 0.001$) with cohort year, their grit ($r = 0.02$, $P = 0.016$) and physical ability ($r < 0.01$, $P = 0.99$) did not. *SI Appendix*, Table S6 shows descriptive statistics and bivariate correlations.

Quitting Early: Only Grit Predicts Completing Beast Barracks. Across cohorts, an average of 3 of every 100 cadets dropped out of West Point during the first summer of training. As shown in Fig. 1 and model 1 of *SI Appendix*, Table S7, cadets 1 SD higher than their peers in grit had 54% greater odds of completing Beast Barracks training (odds ratio [OR] = 1.54, $P < 0.001$, 99% confidence interval [99% CI]: 1.31 to 1.81). In contrast, cognitive ability (OR = 1.06, $P = 0.33$, 99% CI: 0.91 to 1.24) and physical ability (OR = 1.08, $P = 0.14$, 99% CI: 0.94 to 1.25) did not reliably predict retention during this period.

There was no evidence of curvilinear effects (model 1 of *SI Appendix*, Table S7), 2-way interactions among pretraining predictors (model 5 of *SI Appendix*, Table S7), or 2-way interactions between pretraining predictors and demographic factors (models 9 to 11 of *SI Appendix*, Table S7). *SI Appendix*, Table S1 shows that, although a higher proportion of cadets completed Beast Barracks in later vs. earlier years in our sample, the predictive validity of pretraining predictors did not differ meaningfully across cohort years.

In summary, grittier—but not necessarily more cognitively or physically able—cadets were more likely to complete Beast Barracks and then continue on to their 4 y of West Point training.

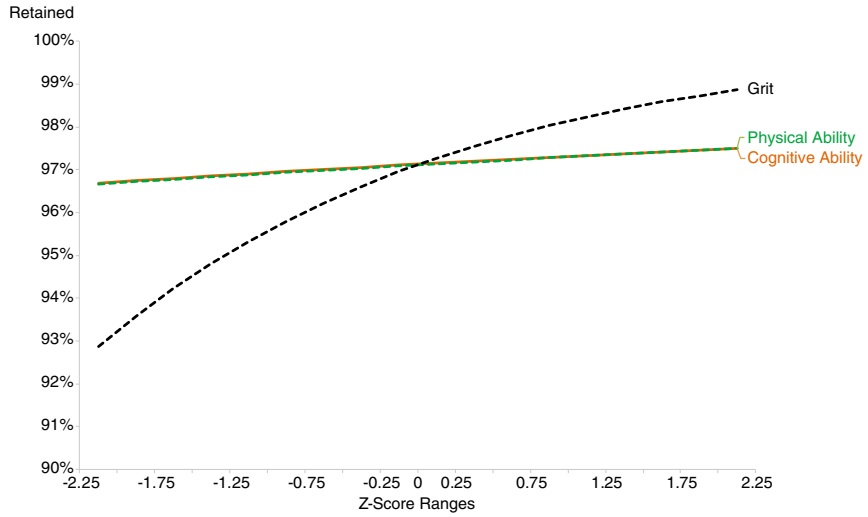

Fig. 1. Estimated probability of completing Beast Barracks training at West Point as a function of grit, cognitive ability, and physical ability controlling for gender, race, age, and cohort year.

Doing Well: Cognitive and Physical Abilities Best Predict Performance. After Beast Barracks, West Point uses coursework and standardized assessments to continuously evaluate the military, academic, and physical performance of cadets (Fig. 2 and model 1 of *SI Appendix*, Tables S8–S10).

Cognitive ability was an especially strong predictor of academic GPA ($\beta = 0.41$, $P < 0.001$, 99% CI: 0.39 to 0.44) and also, the best pretraining predictor of military GPA ($\beta = 0.16$, $P < 0.001$, 99% CI: 0.13 to 0.19). The relationship between cognitive ability and physical GPA was more modest: ($\beta = 0.07$, $P < 0.001$, 99% CI: 0.05 to 0.10).

Likewise, physical ability assessed prior to training was the best measured predictor of physical GPA ($\beta = 0.36$, $P < 0.001$, 99% CI: 0.34 to 0.49) and also predicted military ($\beta = 0.12$, $P < 0.001$, 99% CI: 0.10 to 0.15) and academic ($\beta = 0.07$, $P < 0.001$, 99% CI: 0.05 to 0.09) GPAs.

By comparison, grit predicted a smaller proportion of variance in military ($\beta = 0.10$, $P < 0.001$, 99% CI: 0.08 to 0.13), academic ($\beta = 0.07$, $P < 0.001$, 99% CI: 0.04 to 0.09), and physical ($\beta = 0.06$, $P < 0.001$, 99% CI: 0.04 to 0.08) GPAs.

The handful of reliable quadratic effects observed in these models generally indicated declining marginal returns rather than concave relationships (model 1 of *SI Appendix*, Tables S8–S10). The benefits of grit and abilities did not depend on each other (model 5 of *SI Appendix*, Tables S8–S10) or on demographic factors (models 9 to 11 of *SI Appendix*, Tables S8–S10).

Finishing What You Begin: Grit and Physical Ability Best Predict 4-y Graduation. Across cohorts, about 81 of every 100 cadets graduated from West Point. As shown in Fig. 3 and model 1 of *SI Appendix*, Table S11, both grit (OR = 1.18, $P < 0.001$, 99% CI: 1.10 to 1.26) and physical ability (OR = 1.18, $P < 0.001$, 99% CI: 1.10 to 1.26) were better than cognitive ability (OR = 1.08, $P = 0.011$, 99% CI: 0.99 to 1.16) at predicting graduation. Interactions among these pretraining variables were not significant.

Unlike models predicting other success outcomes, models predicting 4-y graduation showed concave curvilinear effects for both cognitive ability (OR = 0.95, $P = 0.008$, 99% CI: 0.91 to 0.99) and physical ability (OR = 0.89, $P < 0.001$, 99% CI: 0.85 to 0.93). Specifically, increases in physical ability beyond the 89th percentile predicted a decrease in the odds of graduation. Similarly, increases in cognitive ability beyond the 95th percentile predicted a decrease in the odds of graduation. For grit, although the quadratic term was significant (OR = 0.94, $P < 0.001$, 99% CI: 0.90 to 0.99), only increases beyond the 99th percentile predicted a decrease in the odds of graduation. Notably, these inverse U relationships were not symmetric—the odds of graduating were clearly lowest for cadets who entered West Point with the lowest levels of grit, cognitive ability, and physical ability.

Discussion

This investigation underscores the independent roles of cognitive and noncognitive determinants of achievement. In data collected on over 10,000 West Point cadets for a full decade, cognitive ability emerged as the best pretraining predictor of academic and military grades, and physical ability proved the best pretraining predictor of physical performance. Grit, in contrast, contributed only modestly to academic, physical, and military performance but was the only reliable predictor of completing Beast Barracks, the initial summer training during which attrition from the academy peaks. Finally, compared with cognitive ability, both grit and physical ability were more prognostic of graduation.

It is worth noting that, by far, the largest effect sizes were observed for the prediction of academic and physical performance by cognitive and physical ability, respectively. While affirming the benefits of an agile mind, this finding also suggests the need to assess a more expansive array of domain-relevant abilities (e.g., military acumen, artistic talent, emotional intelligence) than is typical in research and practice.

Why did noncognitive factors do a better job of predicting surviving Beast Barracks and ultimately, graduating from West Point? A cadet in the Class of 1854 who later achieved the rank of general observed: "For one to succeed here, all that is required is an ordinary mind and application; the latter is by far the most important and desirable of the two. For men of rather obtuse intellect, by indomitable perseverance, have been known to graduate with honor; while some of the greatest geniuses of the country have been found deficient, for want of application" (ref. 37, p. xiv). More recently, one West Point professor observed: "The real reason for most dropouts is the very nature of the selection process. Every new cadet is among the cream of the crop at his high school. . .Some can cope with this realization and others cannot" (38). These informal observations align with journalistic accounts of the rigors of West Point (39),

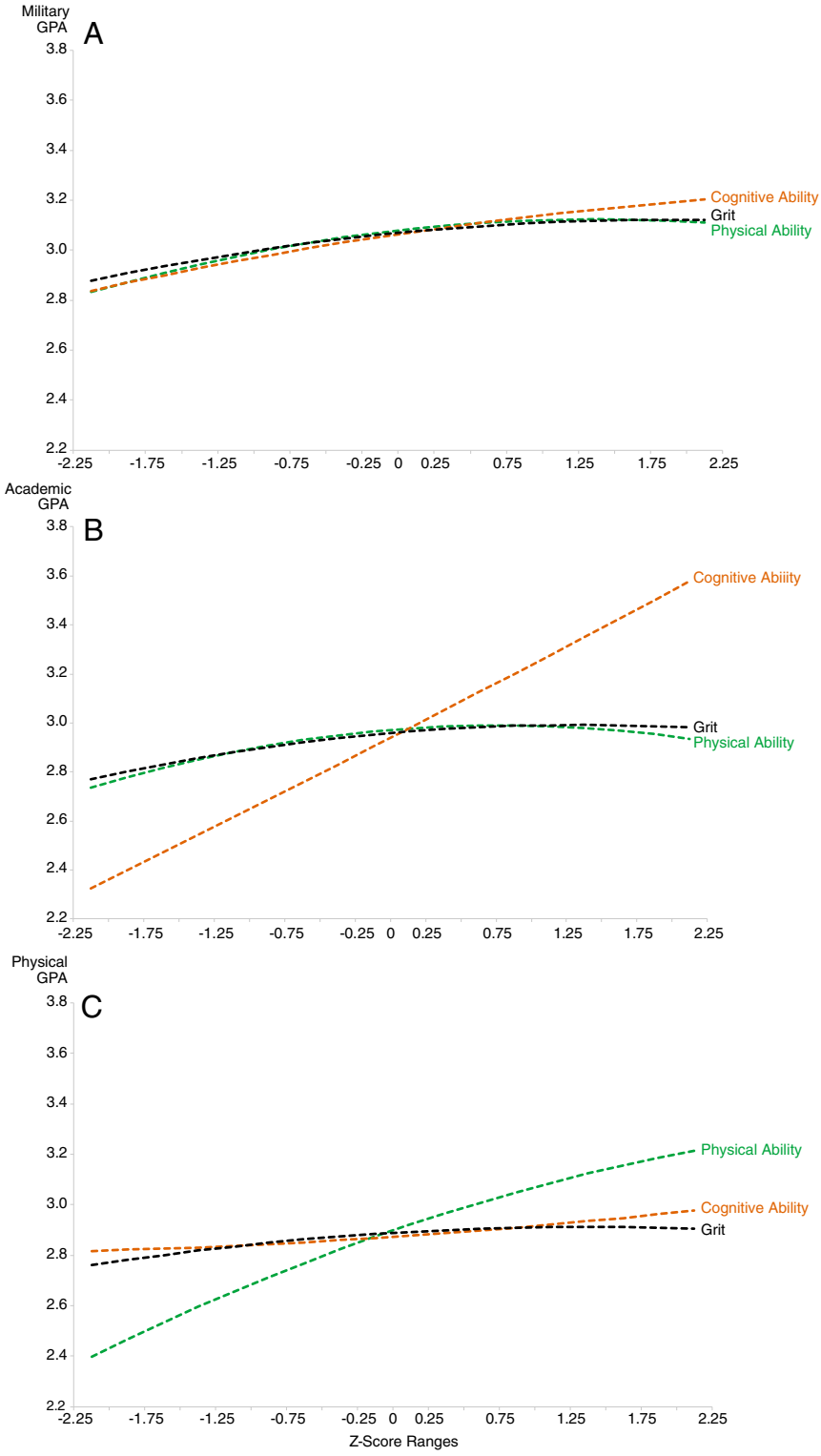

Fig. 2. Estimated (*A*) military, (*B*) academic, and (*C*) physical GPA as a function of grit, cognitive ability, and physical ability controlling for demographic covariates.

but the psychological processes underlying attrition require further study.

To our surprise, we identified no reliable interactions among grit, cognitive ability, and physical ability in any of our predictive models. In theory, cognitive and noncognitive attributes could confer a multiplicative advantage (40–42). Logic suggests that cadets who are both especially intelligent and especially gritty, for example, may excel far beyond their peers. Nevertheless, our findings are consistent with null findings in much smaller datasets examining interactions between cognitive ability and either motivation (43, 44) or physical ability (45). Why? It is certainly possible that, in a more heterogeneous

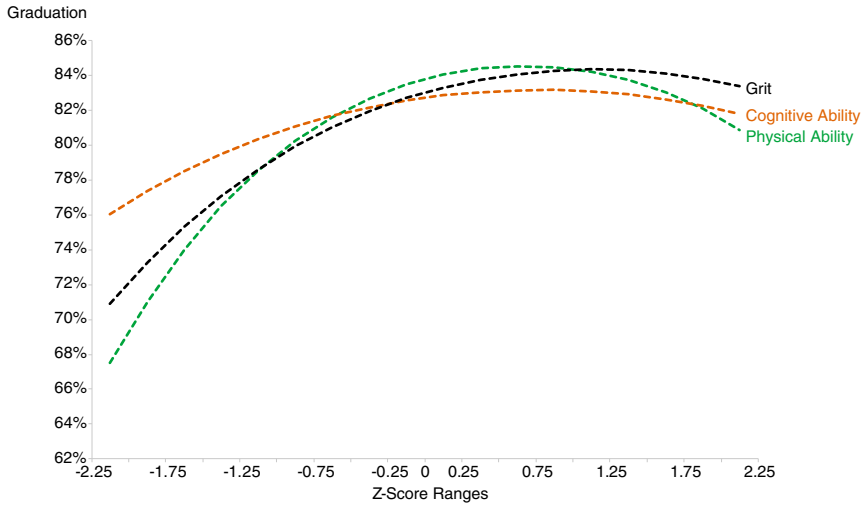

Fig. 3. Estimated probability of graduating from West Point as a function of grit, cognitive ability, and physical ability controlling for demographic covariates.

sample, evidence of complementarity would have emerged. However, it may be that inherent complementarities are negated by a countervailing dynamic. Perhaps most individuals approach achievement by satisficing (i.e., aiming to reach a threshold level of achievement beyond which additional achievement holds little to no value) (46). If so, following cadets longitudinally to predict who reaches the very highest echelons of military leadership (e.g., the rank of general) would provide a more informative test of dependencies among cognitive and noncognitive attributes.

Another finding is that, at the very highest levels of cognitive and physical ability, cadets were less likely to graduate from West Point. Theoretical arguments have been advanced that all virtues are detrimental at both extremes (47, 48). To date, empirical evidence for these suppositions is relatively sparse, in part because of the requirement of extreme values and hence, large datasets. For example, cognitive ability has been found in some samples to be linearly related to academic achievement (49, 50) but among the very brightest, concavely related to both leadership (51) and mental health (52). Despite the enormous statistical power of the this investigation, we found concave curvilinear effects for only one—although arguably, the most important—measure of success: graduation. Whereas deficits of ability clearly impede success, benefits at the uppermost echelons are less clear, and in fact, it may be that individuals with "everything going for them" get up and go elsewhere. This explanation is consistent with laboratory research showing that having multiple alternatives for achieving one's goals can diminish commitment to any particular path (53).

Several limitations of this investigation are worth highlighting. First, the generalizability of our findings cannot be assumed. We look forward to conceptual replications outside of the military, in less structured settings, and with less select samples of women and men. Second, the longitudinal data presented here are correlational rather than experimental, thereby limiting inferences to the prediction, rather than causes, of success. Third, another limitation concerns our reliance on available measures, namely those that were administered by West Point repeatedly over a decade. Future research should explore a broader set of cognitive attributes (e.g., spatial ability) and noncognitive attributes (e.g., Big Five personality traits). Fourth, additional longitudinal research—ideally using repeated measures—would help unpack the mechanisms by which cognitive and noncognitive factors lead to success.

The question of what predicts success is among the most basic in social science. The unique affordances of this longitudinal investigation suggest that both cognitive and noncognitive attributes matter in different ways and at different times. Cognitive and physical abilities each enable progress toward goals in their respective domains. In contrast, grit seems to enable individuals to keep going when the going gets tough. Also, finally, the noncognitive factors of grit and physical ability in this case were more prognostic of the ultimate goal of completing a long-term goal of personal consequence.

We note that our models did not account for the preponderance of variance in objectively measured outcomes. For instance, our battery of cognitive and noncognitive attributes as well as a rich set of demographic covariates collectively explained less than 4% of variance in graduation from West Point 4 y after entry. Why? It is likely that a more comprehensive approach to assessing personal attributes (e.g., a multimethod battery of grit measures or a larger battery of cognitive and physical tests) and a more heterogeneous sample would have yielded higher predictive validities than those reported here. Certainly, our models would have been more powerful if we had included a broader set of personal attributes. However, we suspect that the noise in our predictive models—and so many empirical attempts before ours—hints at something deeper.† There may be severe limits to how well any set of personal attributes can forecast an individual's destiny. People change. Contexts change. And life trajectories are shaped by the whims of chance and path dependency (57, 58).

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†Consider, for example, the magnitude of predictive validities reported in Moffitt et al. (54), which used a multimethod approach to assess the predictive validity of self-regulation, cognitive ability, and background socioeconomic status on outcomes in a birth cohort. More comprehensive reviews are in Almlund et al. (55) and Smithers et al. (16). The work by Funder and Ozer (56) has an illuminating discussion on credible effect sizes in psychological research.

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