Predicting Educational Attainment: Does Grit Compensate for Low Levels of Cognitive Ability?

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Abstract: This study examined the role of cognitive ability in moderating grit's predictive effect on educational outcomes. Using a large, representative sample of young adults, we estimated multivariate regression models for the probability of graduating from high school, enrolling in college, earning any college degree, and earning a college degree. For each outcome, the effect of grit (and, alternatively, consistency of interest and perseverance of effort) was allowed to differ for students in each quartile of the cognitive ability distribution. We found that the predicted effect of grit—which is dominated by the effect of perseverance—is almost entirely concentrated among students at both the high *and* low ends of the cognitive ability distribution. We also found that grit's predictive power increases with each successive educational outcome for high-ability students, but not for low-ability students. The findings are consistent with the notion that high-ability students adopt self-regulated learning processes that exploit their grit, especially as educational tasks become more challenging. For low-ability students, it appears that grit plays a compensatory role. Relatively few low-ability students attain each educational outcome, but those who do appear to benefit from the effective substitution of grit for cognitive ability.

As part of a broad effort to identify factors that explain individual difference in success, researchers have begun to compile evidence that grit is predictive of a range of educational outcomes (Bowman et al., 2015; Datu et al., 2016; Duckworth et al., 2007; Duckworth & Quinn, 2009; Eskreis-Winkler et al., 2014; Rimfeld et al., 2016; Strayhorn, 2014; West et al., 2016). Recent meta-analytic evidence suggests grit's predictive power might be small and subsumed by other factors (Credé et al., 2017), yet the topic demands further attention because grit—defined as “passion and perseverance for long-term goals” (Duckworth et al., 2007)—has the potential to be instilled in individuals at relatively young ages (Duckworth & Gross, 2014). As a result, grit might prove to be a useful mechanism for improving rates of high school and college completion as well as grades, test scores, and other measures of educational achievement.

In this study, we contributed new evidence on the grit-education relationship by determining whether grit's predictive power is moderated by cognitive ability. Credé et al. (2017) conjectured that the adaptive effect of grit found for many domains might hold only for individuals with high levels of cognitive ability or metacognition. We incorporated this idea to hypothesize that high-ability students might be better equipped than their low-ability counterparts to adopt learning processes that leverage their grit, and that such synergistic learning processes are particularly likely to be used when educational tasks are challenging. We also considered the alternative, non-competing hypothesis that grit might play a *compensatory* role in the learning process of low-ability students. That is, students who successfully attain educational milestones despite their low levels of cognitive ability might do so by substituting grit (and other traits) for ability.

One reason the potentially moderating influence of cognitive ability had not been explored prior to the current study is because the literature often focused on genius, or eminence. Building on the work of Galton (1892), samples of high achievers were used to obtain seminal evidence that grit is predictive of success (Duckworth et al., 2007; Duckworth & Quinn 2009) and that increased deliberate practice is a mechanism by which grit affects achievement (Duckworth et al., 2011; Ericsson et al., 1993). Those samples—which included West Point cadets, National Spelling Bee participants, and Ivy League undergraduates—were not suited to learning whether grit is equally predictive for low-ability and high-ability individuals. In contrast, a small number of subsequent studies of educational outcomes used large samples spanning the population-wide cognitive ability distribution (Eskreis-Winkler et al., 2014; Rimfeld et al., 2016; West et al., 2016). While those data *could* be used to explore the grit-education relationship across a non-truncated cognitive ability distribution, we were the first to ask: Is grit more strongly predictive of educational outcomes among low-ability, medium-ability, or high-ability students?

Cognitive Ability as a Moderator of Grit's Relationship to Educational Outcomes

We drew from the educational psychology, personality psychology, and economics literatures to hypothesize that grit can potentially enhance educational outcomes at both the high end *and* the low end of the cognitive ability distribution. Turning first to educational psychology, the interdependence of grit and cognitive ability can be considered in the context of self-regulated learning models that describe metacognitive, feedback, motivational, and other processes by which students affect their own learning (Zimmerman, 1986, 1990). In describing self-regulated learners as “self-starters who display extraordinary effort and persistence during learning” (p. 5), Zimmerman (1990) effectively characterized them as gritty. Therefore, it was unsurprising that Wolters and Hussain (2015) found empirical evidence that grit—especially perseverance of effort which, along with consistency of interest, is one of its two lower-order facets—was strongly,

positively related with a host of observed indicators of self-regulated learning. Their evidence suggests that adoption of self-regulated learning is a mechanism by which perseverance promotes academic achievement.

The question remains: Does the link between grit and learning processes depend on students' cognitive ability levels and, if so, how? Wolters and Hussain (2015) were unable to address this question empirically with their sample of 213 college students. Others have suggested that grit is more likely to promote self-regulated learning (and, in turn, academic achievement) among *high*-ability students because, relative to their low-ability peers, they have better metacognition, are better able to recognize value and respond to feedback, and are better able to employ learning strategies productively (Credé and Kuncel, 2008; Credé and Phillips, 2011; Zimmerman, 1990). If this hypothesis holds, then cognitive ability not only has a direct effect on academic performance, but it also enables students to engage in self-regulated learning and deliberate practice (Duckworth et al., 2011; Ericsson et al., 1993) that fully utilize their grit.

Recent studies in the economics of education made similar arguments in the context of production functions (Almlund et al., 2011; Borghans et al., 2008; Cunha and Heckman, 2007; Cunha and Heckman, 2008). For our purpose, we can envision a simple production process in which students combine inputs that include cognitive ability and persistence to learn a concept or complete a homework assignment. A key aspect of the “technology,” or learning process, by which inputs convert to output is that inputs can be complements *or* substitutes. Complementarities between inputs imply, for example, that increased levels of cognitive ability increase the efficiency with which persistence leads to output. Proponents of this production function framework did not elaborate on the precise reasons for such complementarity, but it could arise for the reason we already provided: high-ability students know how to adopt self-regulated learning processes that make full use of their persistence. Regardless of the reason for the complementarity, the production function approach supports the hypothesis that grit enhances learning and educational achievement relatively more for high-ability students than for low-ability students.

The production function framework also yields the opposite prediction: in some scenarios, grit and ability can serve as *substitutes* in the learning process. Students are assumed to behave optimally (given their current information and the extent to which they are forward-looking) in deciding how to combine inputs, and students with a relative paucity of cognitive ability must choose between intensifying their use of other inputs, including persistence, or failing to achieve. This argument is closely related to the idea of “resource substitution” invoked by Damian et al. (2015) and Shanahan et al. (2014), who found empirical evidence that children from low-SES households were able to improve educational outcomes by substituting Big 5 personality traits for the resources they lacked. Whether substituting conscientiousness and agreeableness for family resources or substituting persistence for cognitive ability, the hypothesis is that students who lack a given input exploit their comparative advantage as a means of achieving success (Almlund et al., 2010).

It is important to understand that complements and substitutes can exist side by side. High-ability students can synergistically combine their ability and persistence in the service of highly effective learning processes, while low ability students can compensate for their lack of cognitive ability by relying on persistence in their “constrained” learning processes. There is little question that students who possess high levels of both cognitive ability and grit will be the most productive, and will typically surpass minimal educational milestones such as graduating from high school and attending college. Low-ability students will invariably be less productive than their high-ability

peers no matter how much grit they possess, but those who achieve a given educational milestone are likely to do so *because* they made good use of their grit. An analogy can be made to farming, where farmers who employ both rich land *and* good laborers will produce large crops, while farmers with poor soil will often experience crop failure. However, those farmers who produce moderate crop levels despite having poor soil will succeed *because* they found a way to compensate for their land deficiency by effectively substituting labor.

A final issue is that the moderating effect of ability on the grit-outcome relationship might depend on the educational outcome being considered. Complementarities between ability and grit will enable many high-ability students to be highly productive; e.g., to master the most difficult concepts, complete the most challenging assignments, and graduate from the most competitive schools. High-ability students are likely to attain more modest milestones (e.g., graduating from high school) with or without the implementation of productive learning processes, so grit might not be predictive of these outcomes; a similar argument is made by MacNamara et al. (2014) regarding the effect of deliberative practice on outcomes that differ in task predictability. In contrast, low-ability students might find it necessary to substitute grit for cognitive ability to attain even modest educational outcomes. As the outcomes become more challenging, fewer low-ability students will meet with success and the predictive role of grit will increase in magnitude relative to the unconditional success rate. In summary, there are reasons to believe the grit-performance relationship might be enhanced at high levels of ability or low levels of ability or both, and that the role of grit and the moderating effects of ability might depend on the educational level.

The Current Study

The primary goal of this study was to identify the moderating effect of cognitive ability on the grit-education relationship for a range of educational outcomes. Specifically, we sought to determine whether two hypotheses received empirical support: (1) grit's positive effect on educational outcomes is concentrated among both low-ability *and* high-ability students; and (2) the latter effect (a positive grit-outcome relationship among high-ability students) is more pronounced for relatively challenging educational outcomes.

To achieve these goals, we used data from the 1997 National Longitudinal Survey of Youth (NLSY97) to construct a sample of 4,488 individuals for whom we had measures of grit, Big 5 personality traits, cognitive ability, and multiple schooling outcomes: completion of a high school diploma, enrollment in any college, completion of any (associate's or bachelor's) degree, and completion of a bachelor's degree. In contrast to studies that examined the grit-education relationship for small, select samples (Duckworth et al., 2007; Duckworth & Quinn 2009), our analysis used a representative sample of students with ability levels spanning the population-wide distribution. In addition, our analysis used a uniform sample of individuals as they advanced through successive educational levels, thus eliminating problems of noncomparability across studies that focus on a single educational institution (Bowman et al., 2015; Datu et al, 2016; Duckworth et al., 2007; Duckworth & Quinn, 2009; MacCann & Roberts, 2010; Strayhorn, 2014) or a single public school district (Eskreis-Winkler et al., 2014; West et al., 2016).¹

¹Mendolia and Walker (2015) is a rare example of a prior study that examined the predictive power of grit with large-scale survey data. They used data from the Longitudinal Study of Young People in England to analyze the relationship between grit and being "NEET" (neither in education, employment nor training).

For each educational outcome, we used multivariate regression models in which the predictors included grit scores, indicators of the quartile in which each student's cognitive ability test score fell, and interactions between grit and ability quartile. This specification allowed grit's predicted effect on each outcome to differ in a flexible manner across the cognitive ability distribution.

In further refining our analysis, we brought to bear arguments made by both proponents and critics of grit's role as a predictor of educational outcomes. The first issue concerns the value of replacing overall grit scores with subscale scores for consistency of interest and perseverance of effort (hereafter referred to as consistency and perseverance) to improve predictive power. Duckworth et al. (2007) and Duckworth and Quinn (2009) provided theoretical and empirical support for the notion that grit is a high-order construct and, as noted in Credé et al. (2017), the majority of grit-related studies used overall grit scores as predictors. This practice was criticized by Credé et al. (2017), whose meta-analysis demonstrated that perseverance is more predictive than grit in predicting a wide range of outcomes. Studies showing perseverance to be a stronger predictor than consistency for educational outcomes include Bowman et al. (2015), Datu et al. (2016), West et al. (2016) and Wolters & Hussain (2015). We pursued this issue by using, in turn, grit, consistency, and perseverance as the key predictor for each educational outcome, and comparing the predictive strength of all three measures at each cognitive ability quartile.

Another point of contention in the grit literature concerns the extent to which grit and its subscales are distinct from conscientiousness and other Big 5 personality traits. While Credé et al. (2017) concluded from their meta-analysis that grit is so highly correlated with conscientiousness as to have virtually no independent, predictive power, several studies demonstrated that grit's relationship with the outcome of interest was maintained even after measures of Big 5 personality traits were included among the controls (Duckworth & Quinn, 2009; Eskreis-Winkler et al., 2014; West et al., 2016). The extent to which grit and Big 5 traits have independent predictive power has also been explored for noneducational outcomes (Eskreis-Winkler et al., 2014; Reed et al., 2012). We demonstrated that grit, consistency, and perseverance are far more strongly correlated with conscientiousness among high-ability individuals than among their low-ability peers, and explored the implications of that pattern by comparing grit's predictive power at each cognitive ability quartile with and without controls for Big 5 traits.

A final aspect of the grit debate that we brought to bear is how best to assess the magnitude of one's estimates. Credé et al. (2007) criticized Duckworth et al. (2007) and Duckworth and Quinn (2009) for overstating the magnitude of their findings by presenting (large) odds-ratios in a manner that did not identify the (small) increase in the predicted probability of success that can be attributed to grit. Credé et al. (2007) also noted that "it should be remembered that variables that exhibit small to moderate effect sizes can still be very useful in high-stakes settings because even marginal improvements in individuals' performance. . . can have very meaningful positive effects" (page 11). Rather than presenting odds-ratios, we reported increments to the predicted probability of each educational outcome associated with a one-unit change in grit for a representative sample member, along with unconditional probabilities of each outcome and the ratio of the former predicted probability to the latter. Stated differently, we determined whether grit's predicted effect on the likelihood of attaining each educational milestone is large or small relative to the overall likelihood of attaining the given milestone. Because graduation and enrollment rates vary dramatically across cognitive ability quartiles, this small innovation in the reporting of findings proved to be a critical aspect of our analysis.

Method

Participants

Our data source was the 1997 National Longitudinal Survey of Youth (NLSY97), which is a large-scale, longitudinal survey sponsored by the Bureau of Labor Statistics of the U.S. Department of Labor. The NLSY97 began in 1997 with a sample of 8,984 males and females born in 1980-84 (age 12-17 in 1997). This sample combined two independent probability samples: one designed to be representative of the 1980-84 birth cohort residing in the U.S. in 1997 ($n=6,748$) and an oversample of black and Hispanic individuals in this birth cohort ($n=2,236$).² Respondents were interviewed annually from 1997 through 2011 (rounds 1-15) and biennially from 2013 to the present. Interviews were completed for 7,141 respondents in 2013, yielding a 79.5% retention rate over the first 16 interview rounds.

The NLSY97 obtained detailed, longitudinal records of individuals' educational activities, employment experiences, family formation and fertility, household income and assets, geographic mobility, criminal activity, substance use, and much more. It has been widely used in the social sciences to study a myriad of topics, including educational outcomes. However, we are unaware of prior studies that used the self-reported grit measures for *any* purpose, let alone as predictors of educational outcomes.

Most of our analysis was based on a sample of 4,448 respondents who satisfied four selection criteria. First, they must have been administered the Armed Services Vocational Aptitude Battery (ASVAB), which provided our cognitive test scores; 7,093 of the original sample of 8,984 (79%) met this criterion. In addition, they must have been administered the Grit-S ($n=5,323$ of 7,093 respondents) and the Ten-Item Personality Inventory (TIPI) of Big 5 personality traits ($n=4,828$ of 5,323 respondents). Finally, we required that respondents report their enrollment and degree attainment in sufficient detail that their achievements could be identified at ages 20 and 26 ($n=4,448$ of 4,828 respondents). Although respondents were as old as 33 when last interviewed in 2013 (the last year for which data were available when the analysis was conducted), an age 26 cutoff gave us the largest possible sample of individuals who had largely (albeit not entirely) completed their education.

We used this uniform sample of 4,448 individuals to identify the effect of grit on the probability of completing several educational outcomes. Because individuals who did not receive a high school diploma (or GED) are typically ineligible to pursue post-secondary education, we also examined college-related outcomes for a subsample of 3,632 high school graduates.

Measures

Grit. NLSY97 respondents were administered the Grit-S scale in 2013, at ages 28 to 33, as part of the self-administered portion of the regular interview. While we cannot rule out the possibility that perceived grit at those ages reflected earlier educational experiences, most respondents were far removed from school by 2013. Moreover, respondents with recent or ongoing schooling activities to report in 2013 did so near the start of the interview, whereas the Grit-S scale was

²The NLSY97 is one of several cohorts collectively referred to as the National Longitudinal Surveys. See <https://www.nlsinfo.org> for information about the NLS and the NLSY97. The NLSY97 Technical Sampling Report can be viewed at <https://www.nlsinfo.org/sites/nlsinfo.org/files/attachments/121221/TechnicalSamplingReport.pdf>

administered toward the end. As a result, it is unlikely that respondents were thinking about their educational experiences when self-reporting their grit.

We used all four items for the consistency subscale (4 items; $\alpha=0.74$) but only three items from the perseverance scale (3 items; $\alpha=0.61$) to obtain a seven-item overall grit score (7 items; $\alpha=0.75$). Following Bowman et al. (2015), we dropped “setbacks don’t discourage me” from the perseverance scale because its inclusion caused a substantial reduction in reliability. All three alphas are virtually identical to comparable statistics reported for samples of West Point cadets in Duckworth and Quinn (2009), and within the ranges reported in the meta-analysis of Credé et al. (2017). In our sample of 4,448 individuals, the two subscales were moderately correlated with each other ($r=0.41$, $p<0.001$) and highly correlated with the overall grit score ($r=0.92$, $p<0.001$ for consistency; $r=0.74$, $p<0.001$ for perseverance).

Table 1 contains summary statistics for the grit, consistency, and perseverance scores for the total sample of 4,448 individuals (bottom row) as well as for each ability quartile described below. Table 1 reveals differences in mean grit, consistency, and perseverance scores across ability quartiles that are statistically insignificant; it also reveals a pronounced increase in alpha as ability quartile increases. Table 1 used “raw” point scores for grit, consistency, and perseverance, but for our regression analysis we used standard scores (mean=0, SD=1) for all three measures.

Cognitive Ability. We used an age-adjusted, percentile achievement test score computed by NLSY97 staff as our measure of cognitive ability. This test score was based on the arithmetic reasoning, mathematical knowledge, paragraph comprehension, and word knowledge components of the ten-item Armed Services Vocational Aptitude Battery (ASVAB), which was administered to NLSY97 respondents in 1997 (when respondents were ages 12-17) following Department of Defense procedures. The ASVAB was not a high-stakes test for NLSY97 respondents, but each individual received a \$75 participation fee for completing the test. The four-item score that we used was designed to correspond to an Armed Forces Qualification Test (AFQT) score, and is hereafter referred to as an AFQT score.

AFQT scores reflect achievement as much as innate ability (Borghans, et al. 2016; Cascio and Lewis, 2006), but have been found to be highly predictive of numerous academic and labor market outcomes (Almlund et al., 2011; Altonji et al., 2012; Castex and Dechter, 2014; Gazach, 2014; Kearney and Levine, 2016). We further validated its predictive capability by computing its correlation with a range of achievement test scores drawn from NLSY97 respondents’ college transcripts. For each correlation, we used a sample consisting of *all* respondents for whom an AFQT score and the given achievement test score were available. We found correlations of $r=0.74$ ($p<0.001$, $n=1,193$) for AFQT and SAT math scores, $r=0.76$ ($p<0.001$, $n=1,192$) for AFQT and SAT verbal scores, $r=0.82$ ($p<0.001$, $n=1,132$) for AFQT and ACT scores, $r=0.75$ ($p<0.001$, $n=869$) for AFQT and PSAT verbal scores, and $r=0.74$ ($p<0.001$, $n=868$) for AFQT and PSAT math scores.

For regression analysis, we assigned each of our 4,448 sample members to an AFQT category based on the quartile in which his or her AFQT score fell. Quartile cutoffs were determined using the distribution for all 7,093 NLSY97 respondents who completed the ASVAB. We used this “out of sample” determination of quartiles for two reasons. First, our sample had a slightly higher mean AFQT score (mean=49.07, SD=29.06) than did the larger, more representative sample (mean=45.32, SD=29.17). Second, it enabled us to maintain uniform definitions of high ability and low ability when switching to a smaller sample of 3,632 high school graduates for

confirmatory analyses. As shown in table 1, we placed 911 individuals (20.5% of the sample) in the lowest quartile (quartile 1), 1,076 (24.2%) in quartile 2, 1,178 (26.5%) in quartile 3, and 1,283 (28.8%) in quartile 4.

Big 5 personality traits. For select specifications, we added measures of the Big 5 personality traits (conscientiousness, emotional stability, agreeableness, extroversion, and openness) to our baseline controls to determine the effect on the predictive power of grit, consistency, and perseverance scores. Scores were based on the ten-item personality inventory (TIPI) developed by Gosling et al. (2003), which was administered to NLSY97 respondents as part of the regular interview in 2008, when they were ages 23-28. “Raw” TIPI scores were used for summary statistics in table A1, but standard scores (mean=0, SD=1) were used for the regression analysis.

Additional controls. The remaining controls in our regression models included binary indicators of whether the individual was male (mean=0.48), black (mean=0.26), and Hispanic (mean=0.19). It was unnecessary to control for age because all outcomes were defined with respect to a fixed point in the lifecycle (age 20 for high school completion, and age 26 for the college-related outcomes).

Educational outcomes. We considered four educational outcomes representing increasingly challenging achievements: receiving a high school diploma by age 20, enrolling in a two-year or four-year college by age 26, receiving any college degree (associate’s or bachelor’s) by age 26, and receiving a bachelor’s degree by age 26. We required that enrollment and educational attainment be reported through age 26 for inclusion in our sample, so all four outcomes were observed for all 4,448 sample members. Sample members who did not receive a high school diploma would typically be ineligible to enter college and complete a college degree, so we performed regression analysis for the three college-related outcomes for a sub-sample of 3,632 high school graduates as well as for the full sample.

For each outcome, we created a binary indicator equal to one if the educational milestone was attained and zero otherwise. See tables 4-5 for sample means for each outcome for the full sample and by AFQT quartile; these means can be interpreted as the “baseline” probability of attaining the outcome. Summary statistics for all outcomes and regressors, for both samples, were also summarized in appendix table A1.

Analysis

Before performing our regression analysis, we examined correlations to learn how grit, consistency, and perseverance are related to cognitive ability, the Big 5 personality traits, and each educational outcome. Pearson correlation coefficients were computed for the full sample of 4,448 individuals and for each subsample defined by AFQT quartile.

Our primary analysis used multivariate regression to model the probability of each binary outcome (graduate from high school by age 20, enroll in college by age 26, etc.). We used probit models, which are identical to logistic regression (logit) models except that the distribution of errors is assumed to be normal rather than logistic. Probit and logit models are known to deliver virtually identical estimates except in extreme tails of the distributions (Maddala, 1986), which we confirmed for our findings. We used four alternative specifications for the probit model:

Specification 1a included indicators for female, black, Hispanic, and AFQT quartile, and a standard score (z-score) for, alternatively, grit, consistency, or perseverance. This specification identified the grit-output (or consistency-output or perseverance-output) relationship *conditional*

on ability, but did not allow that relationship to differ with ability.

Specification 2a also included indicators for female, black, Hispanic, and AFQT quartile, and a standard score for either grit, consistency, or perseverance. In contrast to Specification 1a, it also included interaction terms between AFQT quartile indicators and grit (or consistency or perseverance) scores. This specification identified the moderating effects of ability on the grit-outcome (or consistency-outcome or perseverance-outcome) relationship by allowing those predicted effects to differ flexibly for students in each of the four ability quartiles.

Specifications 1b-2b were identical to Specifications 1a-2a except that TIPI scores for each of the Big 5 personality traits were added to the set of controls. These specifications were used to determine whether predicted effects of grit, consistency, and perseverance were simply due to their correlations with conscientiousness and other Big 5 traits.

We estimated 12 different versions of Specification 1a-2a, given that we had three alternative predictors to consider (grit, consistency, and perseverance) for each of four alternative outcomes (high school graduation, college enrollment, any college degree completion, and bachelor's college degree completion). We also estimated 12 different versions of Specifications 1b-2b, but to streamline the presentation we only tabulated estimates with perseverance as the key predictor, given that it proved to be more predictive of outcomes than consistency or grit. We also reestimated specifications for the three college-related outcomes with a subsample of individuals who completed high school.

As with logit models, a characteristic of probit models is that estimated coefficients are difficult to interpret directly. To skirt this difficulty, we focused discussion on estimated *marginal effects* of our key predictors (grit, consistency, and perseverance). For Specification 1a, we computed the predicted probability of the outcome for a “representative” sample member: a nonblack, non-Hispanic woman with mean levels of grit (or consistency or perseverance) and mean levels for each AFQT quartile.³ For Specification 1b, the representative person was also assigned mean values for each Big 5 personality trait. We then recomputed the predicted probability of the same outcome for the same representative individual after increasing her grit (or consistency or perseverance) score by one standard deviation (from 0 to 1). The difference between these two computations represents the predicted marginal effect of a one-unit increase in grit on the probability of success for a typical sample member. Specifications 2a-2b, which allowed the grit-outcome effect to differ by AFQT quartile, required four sets of computations. Instead of assigning the representative sample member mean values for each AFQT quartile we assigned her, in turn, $Q1=1$ (and $Q2=Q3=Q4=0$), $Q2=1$ (and $Q1=Q3=Q4=0$), and so forth, where $Q1$ - $Q4$ represent the four quartile indicators. That is, we computed the predicted marginal effect of a one-unit increase in grit (or consistency or perseverance) for four otherwise representative sample members with AFQT scores in *each* of the four quartiles.

If we were to find, for example, that a one-unit increase in perseverance raised the predicted

³Male=0, Black=0, and Hispanic=0 are the modal values for each demographic indicator; had we assigned a different race, ethnicity, or sex, the predicted probabilities would change in magnitudes but the substance of our findings would remain the same. Sample means for AFQT quartiles 1-4 are 0.205, 0.242, 0.265, and 0.288, respectively (see table 1). No individual can have an AFQT score that is 20.5% in quartile 1, 24.2% in quartile 2, etc., but this assignment is equivalent to a “mean” level of ability.

probability of college completion by 2.5 percentage points for a student in the bottom quartile of the ability distribution and by the same amount for an otherwise identical student in the top quartile, we would face the following difficulty in interpreting our findings: Individuals in the bottom quartile might have an unconditional graduation probability of only 0.025, while those in the top quartile might have an unconditional probability that is 20 times higher. Because unconditional probabilities of educational outcomes differ so dramatically across ability quartiles, for each specification and for each outcome we reported both the predicted marginal effect and that predicted effect divided by the unconditional probability of success. In our example, this would reveal that a one-unit increment in perseverance raised the predicted graduation rate 100% relative to the baseline (0.025/0.025) for the bottom-quartile student, but only 5% relative to the baseline (0.025/0.50) for the top-quartile student.

Results

We computed correlations between key variables used in our analysis to gain a preliminary overview of patterns in the data. To begin, we established that grit has a small, negative correlation with AFQT scores ($r=-0.05$, $p<0.01$, $n=4,848$). A similar negative correlation was found for the consistency and AFQT scores ($r=-0.07$, $p<0.001$, $n=4,848$) while no significant correlation was found for perseverance and AFQT scores ($r=0.02$, $p\geq 0.05$, $n=4,848$). These findings indicate that grit and its lower-order facets—especially perseverance—are largely unrelated to cognitive ability and can be viewed as independent predictors of educational outcomes.

Next, we considered how grit, consistency, and perseverance scores are correlated with each of the four educational outcomes. These correlations were summarized in table 2. Focusing first on high school graduation (outcome 1), we found that grit has a small, statistically insignificant correlation with this outcome ($r=0.03$, $p\geq 0.05$, $n=4,848$) for the sample that includes students in all AFQT quartiles. However, a positive, significant correlation ($r=0.09$, $p<0.01$, $n=911$) exists among students in the lowest ability quartile. This “quartile 1” correlation does not exist for consistency, but it is strengthened ($r=0.14$, $p<0.001$, $n=911$) for perseverance. For college enrollment, completion of any college degree, and completion of a bachelor’s degree (outcomes 2-4), table 2 shows a positive, statistically significant correlation with grit ranging from $r=0.09$ to $r=0.13$ among students in both the lowest *and* the highest ability quartiles. A similar pattern is seen for correlations between outcomes 2-4 and consistency, although the correlations are smaller in magnitude and not uniformly significant for quartile 1. In contrast, perseverance is correlated with outcomes 2-4 not only among students in quartiles 1 and 4, but to a lesser degree at the intermediate quartiles as well. The correlations in table 2 provide preliminary evidence that the grit-outcome, consistency-outcome, and perseverance-outcome relationships differ from each other, and do not hold uniformly for students with different levels of cognitive ability.

In table 3, we summarized correlations between the three key predictors (grit, consistency, and perseverance) and TIPI scores for the Big 5 personality traits. The rows marked “all,” based on samples of 4,448 individuals in all four ability quartiles, show that grit is particularly strongly correlated with conscientiousness ($r=0.37$, $p<0.001$), followed by emotional stability ($r=0.22$, $p<0.001$); moreover, consistency and perseverance have nearly identical correlations with each trait. When correlations were computed for ability quartile subsamples, additional patterns emerged: First, grit, consistency, and especially perseverance are much more positively correlated with conscientiousness among high-ability students (quartile 4) than among low-ability students (quartile 1). Second, correlations between persistence and both agreeableness and extroversion

also increase with ability quartile, but a similar pattern is not seen for consistency. Third, the opposite pattern holds for openness, in that correlations with grit, consistency and perseverance are larger for low-ability students than for high-ability students. These patterns suggest that grit's predictive power might be more independent of Big 5 personality measures at some ability levels than at others.

We now turn to table 4, which summarizes predicted “marginal effects” for the sample of 4,448 students.⁴ To clarify how the numbers should be interpreted, consider the prediction of 0.014 in the “all” column of the first row. This prediction was based on Specification 1a (described in the analysis subsection), with high school graduation as the outcome and grit as the predictor. The reported marginal effect indicates that a one-unit (i.e., one standard deviation) increase in grit raises the predicted graduation probability by a statistically significant 1.4 percentage points. The number in parentheses (0.017) is $0.014/0.82$, where 0.82 is the baseline probability of high school graduation. This indicates that the 1.4 percentage point marginal effect represents a 1.7% increase relative to the baseline probability. The remaining four columns in the first row were based on Specification 2a, which augments Specification 1a by adding interactions between grit and each AFQT quartile indicator. The prediction of 0.045 in the quartile 1 column indicates that a one-unit increase in grit *for an individual whose AFQT score falls in the first (lowest) quartile* increases the predicted probability of high school graduation by 4.5 percentage points, or by 8.0% relative to the baseline graduation probability of 0.56 for individuals with bottom-quartile ability levels. Estimates in the next two rows of table 4 were obtained in identical fashion, except consistency scores or perseverance scores replaced overall grit score in each regression. Estimates in the fourth row were based on Specifications 1b-2b, in which TIPI scores for the Big 5 personality traits were added as controls.

The first four rows of table 4 reveal a distinct pattern regarding grit's effect on high school graduation: The “all” column, based on a specification that does not allow the predicted effect of grit to be moderated by ability, reveals that (a) a one-unit increase in grit raises the predicted graduation probability by 1.4 percentage points, or 1.7% relative to the baseline; (b) a comparable increase in consistency has an insignificant, near-zero effect on the outcome; (c) the grit effect is *entirely* due to perseverance which, when used in place of grit, yields a statistically significant predicted marginal effect of 0.019, or 2.3% relative to the baseline; and (d) due to modest correlations between perseverance scores and Big 5 personality traits (see table 3), the predicted effect of perseverance falls by almost half, to 0.010, when Big 5 measures are added to the specification. However, the remaining columns of estimates—based on specifications that allow effects of grit, consistency, and perseverance to differ across ability quartiles—show that grit's predicted effect is *wholly* concentrated among students with AFQT scores in the lowest quartile. For those students, a one-unit increase in grit raises the predicted graduation probability by 4.5 percentage points (8.0% relative to the baseline), while a comparable increase in perseverance raises the predicted probability by 6.4 percentage points (11.4% relative to the baseline). Moreover, because correlations between perseverance scores and most Big 5 measures are smaller at low ability than at high ability (see table 3), the predicted marginal effect of perseverance only falls to 0.054 (9.6% relative to the baseline) when Big 5 traits are included as controls. Estimates for the “earn high school diploma” outcome are consistent with the hypothesis that a subset of low-ability students succeed by relying on their grit to compensate for limited cognitive ability.

⁴Probit model estimates used to compute predicted marginal effects for table 4 appear in appendix tables A2-A5.

When we analyzed college-related outcomes (college enrollment, earning any college degree, and earning a bachelor's degree), the patterns seen for high school graduation changed in two distinct ways. First, predicted effects of consistency are no longer uniformly insignificant, although each is smaller in magnitude than the corresponding predicted effect of perseverance (seen by comparing rows 2 and 3 for each outcome). For example, a one-unit increase in consistency increases the predicted probability of college enrollment by a statistically significant 3.0 percentage point for students in quartile 1, versus 6.9 percentage points for a comparable increase in perseverance. Second, the predictive power of grit and perseverance are no longer concentrated entirely among low-ability students. Instead, the predicted marginal effects of grit, perseverance, and consistency tend to be larger (and also more precisely estimated) at both quartiles 1 and 4 than at quartiles 2-3.⁵ For example, a one-unit increase in perseverance (in the absence of controls for Big 5 traits) increases the predicted probability of receiving any college degree by 0.046 among individuals with AFQT scores in the bottom quartile, and by a similar amount (0.049) among individuals with AFQT in the top quartile; the predicted marginal effect falls to 0.033-0.036 for individuals with intermediate AFQT scores. With Big 5 traits among the controls, these effects decline far more at quartiles 2-4 than at quartile 1 because conscientiousness, agreeableness, and extroversion are more highly correlated with perseverance at high ability levels than at low ability levels: now the predicted marginal effect is 0.040 at quartile 1 and 0.31 at quartile 4, but statistically insignificant at quartiles 2-3.

The patterns highlighted in the preceding paragraph are consistent with the hypotheses that (a) grit is predictive of success for both low-ability and high-ability students; and (b) grit's predictive power for high-ability students is confined to the more challenging milestones, where complementarities between grit and ability in the learning process are particularly valuable. On the latter issue, the right-most column of table 4 reveals that among students in the highest ability quartile, the predicted effects of grit, consistency, and perseverance usually increase in magnitude as the outcome changes from high school graduation to college enrollment to earning any college degree to earning a bachelor's degree. To illustrate, the predicted marginal effect of grit increases from an insignificant 0.006 for high school graduation to 0.020 for college enrollment, to 0.049 for earning any college degree, and to 0.056 for earning a bachelor's degree.

A final conclusion to draw from table 4 is that it is important to compare each predicted marginal effect to the baseline probability of success. The last row of predictions (with earning a bachelor's degree as the outcome, perseverance as the predictor, and Big 5 traits included) corresponds to the example we provided in the methods discussion: a one-unit increase in perseverance raises the predicted probability of graduation by 2.3 percentage points among students in quartile 1, and by a similar 2.8 percentage points among their counterparts in quartile 4. This similarity masks the fact that the low-ability students have a much lower baseline probability of college graduation than do the high ability students (3% versus 58%). When this difference is brought to bear, we learn that 2.3 percentage points represent a 76.7% increase in the unconditional probability of graduating for students in quartile 1, while 2.8 percentage points represent only a 4.8% increase for students in quartile 4. These estimates demonstrate that it is important to allow grit's effect to vary with cognitive ability and, in doing so, it is *essential* to assess predicted effects relative to ability-

⁵The only exception to this u-shaped pattern is seen in the second to last row of predicted marginal effects, where "earn bachelor's degree" is the outcome, perseverance is the predictor, and Big 5 measures are excluded from the controls. In this specification, the estimated marginal effects increase from 0.028 for quartile 1 to 0.036-0.037 for quartiles 2-3 to 0.053 for quartile 4.

specific baseline probabilities.

The advantage of using a uniform sample of 4,848 individuals for all specifications summarized in table 4 is that estimates are comparable across all four outcomes. A disadvantage is that the sample included high school dropouts who were ineligible to attend college and earn college degrees. To determine whether the inclusion of high school dropouts systematically affected the estimates in table 4, we reestimated all specifications for the three college-related outcomes for a sample of 3,632 high school graduates. These estimates were summarized in table 5. Baseline probabilities are higher in table 5 than in table 4, especially for the lowest ability quartile, so estimated marginal effects are often smaller when expressed relative to the baseline. Using Specification 2b with college graduation as the outcome for comparison, in table 4 we found that perseverance has a predicted marginal effect of 0.023 for students in the lowest ability quartile, which is 76.7% relative to the baseline probability of 0.03. In table 5, the comparable marginal effect is 0.037, which is only 61.7% relative to the much larger baseline probability of 0.06. Aside from these differences in magnitudes, the key patterns described with respect to table 4 continue to hold for table 5.

Discussion

We hypothesized that grit's predictive effect on educational outcomes might be concentrated among low-ability and high-ability students for two distinct reasons. At the low end of the ability distribution, grit is likely to compensate for cognitive ability—or, stated differently, those low-ability students who succeed in reaching educational milestones might do so by overcoming their cognitive disadvantage via the effective substitution of grit. At the high end of the ability distribution students are likely to adopt learning processes that synergistically combine ability and grit, especially when trying to attain relatively challenging educational outcomes.

Our findings supported both hypotheses. For high school graduation, which was the “lowest” educational outcome we considered, grit is predictive of success *only* among students with ability in the lowest quartile of the distribution. For the three higher-level educational outcomes (enrolling in college, earning any college degree, and earning a bachelor's degree), grit is strongly predictive of success for students in the bottom quartile *and* in the top quartile of the ability distribution, with smaller and/or insignificant effects for students in the middle two quartiles. Moreover, among students in the top quartile of the distribution, grit's predictive power increases in magnitude for each successive educational milestone. In short, we found strong, consistent evidence that the effect of grit on educational outcomes is moderated by cognitive ability in a manner that is entirely consistent with learning models: grit complements ability in the learning process among high-ability students, while playing a compensatory role among their low-ability peers.

Our analysis contributed additional evidence relevant to ongoing debates about grit's predictive power. First, we found that perseverance is a stronger predictor than consistency for each educational outcome we considered, at all points in the cognitive ability distribution. This is consistent with evidence reported by Bowman et al. (2015), Datu et al. (2016), West et al. (2016) and Wolters and Hussain (2015). However, for all outcomes except high school graduation, consistency proved to have a nontrivial degree of predictive power, *especially* among students at the high end of the ability distribution. Second, we found that conscientiousness is not only more strongly (positively) correlated with grit, consistency, and perseverance than is any other Big 5 personality trait (as found in numerous earlier studies, including Duckworth et al., 2007; Duckworth and Quinn, 2009), but that its correlation with all three scores—but especially

perseverance—is stronger among high-ability individuals than among their low-ability counterparts. As a result, perseverance’s predictive effect on the educational outcomes of low-ability students was reduced only slightly when Big 5 traits were added as control variables.

Our findings highlight the merits of allowing grit’s predictive effects to depend on cognitive ability. They also reveal the importance of assessing those effects relative to unconditional, baseline probabilities of success. We found that a one-unit increase in perseverance increases the predicted probability of receiving a bachelor’s degree (conditional on Big 5 traits) by approximately 2.5 percentage points for low-ability *and* for high-ability students. However, that modest-sized effect represents a 77% increase in graduation probabilities relative to the baseline at the low end of the ability distribution, but only a 5% increase at the high end. Students with limited cognitive abilities are the least likely to attain each educational milestone, but arguably the most worthy of policy interventions that might enhance their outcomes. Our findings suggest that efforts to instill grit—and especially perseverance—in low-ability students could have substantial payoffs with respect to educational attainment.

Limitations of our analysis

Large-scale surveys offer numerous advantages for the analysis of grit’s predictive power, but they also impose limitations. We believe limitations of the NLSY97 were three-fold. First, the Grit-S scale was administered in the 16th interview round, when survey respondents were ages 28-33. While there might be advantages to temporal separation between administration of the grit scale and educational activities, the concern is that self-reported grit at this stage in the lifecycle might be conditioned on earlier educational experiences. Additional evidence on the extent to which self-reported grit changes over time is needed to determine whether the survey’s relatively “late” collection of grit scores posed problems for our analysis. Second, measures of the Big 5 personality traits were obtained via the administration of the Ten Item Personality Inventory in the 12th interview round, when survey respondents were ages 23-28. Although researchers have found that core personality traits evolve throughout early adulthood (Roberts and DelVecchio, 2000), evidence based on a large-scale, longitudinal survey in Germany suggests that changes in personality traits over adulthood are not substantial enough to affect research findings (Cobb-Clark and Schurer, 2012). Overall, it is unclear whether the timing of the NLSY97 TIPI administration imposed limits on our analysis. Third, although NLSY97 data enabled us to define a sequence of educational outcomes for a large, representative sample, the survey did not provide details on college engagement and satisfaction, time allocation, institutional support, and other aspects of educational experiences that previous studies (e.g., Bowman et al., 2015; Datu et al., 2016; Eskreis-Winkler et al., 2014) brought to bear.

Additional limitations of our analysis could be addressed in future research. The NLSY97 collected high school and college transcripts for subsets of respondents, so future studies could explore grit’s relationship to grades, test scores, and other dimensions of educational achievement, albeit for smaller samples than the ones used in the current study. The current study did not explore the extent to which grit-educational relationships depend on individuals’ demographic characteristics, nor did it consider the many noneducational outcomes reported in the NLSY97 related to family formation, labor market experiences, asset accumulation, and much more.

Conclusions

In this study, we used data from the 1997 National Longitudinal Survey of Youth to determine

whether cognitive ability moderates grit's predictive power. Our analysis had the following key features: (a) we analyzed a sequence of increasingly challenging educational outcomes for a large, uniform, representative sample of individuals; (b) grit's effect on each outcome was allowed to differ for individuals in each quartile of the cognitive ability distribution; (c) predicted effects of grit (for each outcome and at each quartile in the ability distribution) were compared to those for consistency of interest and, alternatively, perseverance of effort; and (d) predicted effects were compared with and without measures of Big 5 personality traits among the controls.

The analysis produced three key findings. First, the predictive effect of grit—which is largely due to perseverance—is almost entirely concentrated among students at both the high *and* low ends of the cognitive ability distribution. Second, for high-ability students, grit's predicted effect on the probability of success increases as the educational outcome becomes more challenging, and is effectively zero for high school graduation (the “lowest” outcome we considered). Third, estimated marginal effects of grit on the probability of earning a college degree are modest (on the order of 3-6 percentage points in response to a one standard deviation increase in grit) for both low-ability and high-ability students, but are *substantial* (50% or even higher) for low-ability students when expressed relative to their low baseline probabilities of success.

The finding that grit is positively associated with college-related outcomes among high-ability students is consistent with the notion that high-ability students adopt self-regulated learning processes that leverage their grit. For these students, grit and cognitive ability complement each other in the learning process, especially when tasks are relatively challenging. The finding that grit is also positively associated with (all) educational outcomes at the opposite end of the ability distribution is perhaps more surprising, and is consistent with the hypothesis that low-ability students substitute grit for ability in the learning process. This does not imply that grit is as valuable as ability: relatively few low-ability students succeed in attending college and earning college degrees, but among those who *do* attain success, grit might an important factor. These findings suggest that interventions designed to augment grit among low-ability students could have substantial benefits—and that additional evidence on the moderating effects of cognitive ability is well worth pursuing.

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Table 1

Descriptive Statistics for Grit and its Subscales, by Cognitive Ability Quartile

Ability Quartile	N	Grit			Consistency of Interest			Perseverance of Effort		
		α	M	SD	α	M	SD	α	M	SD
1	911	.66	26.87	4.22	.69	14.41	3.30	.52	12.46	1.96
2	1,076	.75	27.51	4.18	.76	14.75	3.11	.60	12.75	1.82
3	1,178	.79	27.14	4.31	.77	14.47	3.11	.70	12.68	1.85
4	1,283	.80	26.43	4.31	.76	13.84	3.09	.72	12.58	1.87
All	4,448	.75	26.97	4.28	.74	14.35	3.16	.61	12.62	1.87

Note: α =Cronbach's Alpha. Ability quartiles are assigned using the distribution of scores for the Armed Forces Qualification Test (AFQT) for the full sample of respondents (N=7,093) who took the 10-battery Armed Services Vocational Aptitude Battery in 1997-98.

Table 2
*Correlations Between Grit and its Subscales, and
Alternative Educational Outcomes by Cognitive Ability
Quartile*

Predictor	Ability Quartile	Educational Outcome			
		1	2	3	4
Grit	1	.09**	.13***	.13***	.09**
	2	.04	.05	.05	.04
	3	.00	.02	.03	.05
	4	.05	.09***	.12***	.12***
	All	.03	.04**	.04*	.03*
Consistency	1	.03	.07*	.10**	.05
	2	.03	.00	.02	.00
	3	-.01	-.00	.00	.02
	4	.05	.07**	.09***	.10***
	All	-.00	-.00	.00	-.00
Perseverance	1	.14***	.15***	.12***	.10**
	2	.03	.11***	.07*	.08**
	3	.02	.06*	.07*	.07*
	4	.04	.09***	.12***	.12***
	All	.07***	.10***	.08***	.08***

Note. See table 1 for sample sizes and description of cognitive ability quartiles. Educational outcomes: 1=earn high school diploma by age 20; 2=enroll in college by age 26; 3=earn any college degree by age 26; 4=earn bachelor's degree by age 26.

*p<.05, **p<.01, ***p<.001

Table 3
Correlations Between Grit and its Subscales, and the Big 5 Personality Factors by Cognitive Ability Quartile

Predictor	Ability Quartile	Big 5 Personality Trait				
		C	ES	A	E	O
Grit	1	.27***	.26***	.08*	.12***	.17***
	2	.36***	.22***	.09**	.13***	.11***
	3	.37***	.24***	.08**	.10***	.09**
	4	.43***	.21***	.12***	.11***	-.00
	All	.37***	.22***	.09***	.12***	.09***
Consistency	1	.22***	.22***	.10**	.10**	.12***
	2	.31***	.20***	.08**	.09**	.08*
	3	.39***	.21***	.05	.06*	.05
	4	.36***	.19***	.09***	.07*	-.05
	All	.31***	.19***	.08***	.08***	.05***
Perseverance	1	.21***	.19***	.01	.09**	.16***
	2	.30***	.17***	.08**	.16***	.13***
	3	.36***	.19***	.09**	.13***	.14***
	4	.39***	.16***	.11***	.14***	.08**
	All	.32***	.18***	.08***	.14***	.13***

Note. See table 1 for sample sizes and description of cognitive ability quartiles. C=conscientiousness, ES=emotional stability, A=agreeableness, E=extroversion, and O=openness.

*p<.05, **p<.01, ***p<.001

Table 4

*Predicted Change in the Probability of Alternative Educational Outcomes by Cognitive Ability Quartile**(Predicted Change Relative to the Baseline Probability in Parentheses)*

Predictor	Cognitive Ability Quartile				
	All	1	2	3	4
Outcome: Earn High School Diploma by Age 20					
Grit ^a	.014 (.017)	.045 (.080)	.013 (.016)	-.000 (.000)	.006 (.006)
Consistency ^a	.006 (.008)	.016 (.029)	.010 (.013)	-.004 (-.005)	.006 (.006)
Perseverance ^a	.019 (.023)	.064 (.114)	.014 (.018)	.006 (.007)	.006 (.006)
Perseverance ^b	.010 (.013)	.054 (.096)	.001 (.001)	-.003 (-.003)	.002 (.002)
Baseline prob.	.82	.56	.79	.88	.97
Outcome: Enroll in College by Age 26					
Grit ^a	.030 (.047)	.057 (.204)	.023 (.042)	.006 (.008)	.020 (.022)
Consistency ^a	.013 (.020)	.030 (.107)	-.003 (.005)	-.005 (.007)	.016 (.018)
Perseverance ^a	.048 (.074)	.069 (.246)	.059 (.107)	.022 (.029)	.021 (.023)
Perseverance ^b	.035 (.054)	.059 (.211)	.045 (.082)	.010 (.013)	.014 (.016)
Baseline prob.	.65	.28	.55	.76	.90
Outcome: Earn Any College Degree by Age 26					
Grit ^a	.042 (.118)	.050 (.714)	.027 (.129)	.015 (.039)	.049 (.075)
Consistency ^a	.029 (.080)	.036 (.514)	.015 (.071)	.002 (.005)	.040 (.062)
Perseverance ^a	.050 (.140)	.046 (.657)	.036 (.171)	.033 (.087)	.049 (.075)
Perseverance ^b	.031 (.088)	.040 (.571)	.022 (.105)	.013 (.034)	.031 (.048)
Baseline prob.	.36	.07	.21	.38	.65
Outcome: Earn Bachelor's Degree by Age 26					
Grit ^a	.039 (.139)	.023 (.767)	.018 (.138)	.024 (.080)	.056 (.097)
Consistency ^a	.026 (.093)	.014 (.467)	.003 (.023)	.012 (.040)	.049 (.084)
Perseverance ^a	.047 (.170)	.028 (.933)	.037 (.285)	.036 (.120)	.053 (.091)
Perseverance ^b	.027 (.096)	.023 (.767)	.024 (.185)	.013 (.043)	.028 (.048)
Baseline prob.	.28	.03	.13	.30	.58

Note: N=4,448. Estimates in bold are statistically significant at $p < .05$. Each estimate represents a change in the predicted probability of the outcome due to a one-unit change in the predictor; the ratio of that change to the baseline probability is in parentheses.

^aEstimates in the “all” column are for Specification 1a; estimates in the remaining columns are for Specifications 2a.

^aControls also include measures of Big 5 personality traits. Estimates in the “all” column are for Specification 1b; remaining columns are for Specifications 2b.

Table 5

Predicted Change in the Probability of Alternative Educational Outcomes by Cognitive Ability Quartile, For a Sample of High School Graduates
(Predicted Change Relative to the Baseline Probability in Parentheses)

Predictor	Cognitive Ability Quartile				
	All	1	2	3	4
Outcome: Enroll in College by Age 26; conditional on high school diploma					
Grit ^a	.023 (.031)	.048 (.107)	.019 (.029)	.010 (.012)	.019 (.021)
Consistency ^a	.008 (.011)	.019 (.042)	-.004 (.006)	.000 (.000)	.014 (.015)
Perseverance ^a	.038 (.051)	.071 (.158)	.054 (.083)	.022 (.027)	.022 (.024)
Perseverance ^b	.030 (.040)	.058 (.129)	.044 (.068)	.014 (.017)	.018 (.020)
Baseline prob.	.76	.45	.65	.82	.92
Outcome: Earn Any College Degree by Age 26; conditional on high school diploma					
Grit ^a	.045 (.104)	.070 (.583)	.028 (.104)	.019 (.044)	.049 (.073)
Consistency ^a	.031 (.072)	.050 (.417)	.015 (.056)	.005 (.012)	.040 (.060)
Perseverance ^a	.052 (.120)	.066 (.550)	.039 (.144)	.035 (.081)	.050 (.075)
Perseverance ^b	.035 (.081)	.058 (.483)	.027 (.100)	.017 (.040)	.034 (.051)
Baseline prob.	.43	.12	.27	.43	.67
Outcome: Earn Bachelor's Degree by Age 26; conditional on high school diploma					
Grit ^a	.042 (.090)	.035 (.583)	.020 (.125)	.028 (.082)	.053 (.088)
Consistency ^a	.029 (.085)	.020 (.333)	.001 (.006)	.017 (.050)	.046 (.077)
Perseverance ^a	.051 (.151)	.044 (.733)	.043 (.269)	.037 (.109)	.051 (.085)
Perseverance ^b	.031 (.112)	.037 (.617)	.031 (.194)	.016 (.047)	.029 (.048)
Baseline prob.	.34	.06	.16	.34	.60

Note: N=3,632 individuals who earn a high school diploma by age 20. Estimates in bold are statistically significant at $p < .05$. Each estimate represents a change in the predicted probability of the outcome due to a one-unit change in the predictor; the ratio of that change to the baseline probability is in parentheses.

^aEstimates in the “all” column are for Specification 1a; estimates in the remaining columns are for Specifications 2a.

^aControls also include measures of Big 5 personality traits. Estimates in the “all” column are for Specification 1b; remaining columns are for Specifications 2b.

Appendix Table A1
Sample means and standard deviations

	Full Sample		HS Graduates	
	Mean	SD	Mean	SD
Outcomes				
Earn high school diploma	0.82	—	1.00	—
Enroll in college	0.65	—	0.76	—
Earn any college degree	0.36	—	0.43	—
Earn Bachelor's degree	0.28	—	0.34	—
Covariates				
1 if male	0.48	—	0.47	—
1 if black	0.26	—	0.24	—
1 if Hispanic	0.19	—	0.17	—
AFQT score	49.07	29.06	54.10	28.00
1 if AFQT quartile 1	0.21	—	0.14	—
quartile 2	0.24	—	0.23	—
quartile 3	0.27	—	0.28	—
quartile 4	0.29	—	0.34	—
Grit score ^a	26.97	4.28	27.03	4.21
Consistency score ^a	14.35	3.16	14.35	3.09
Perseverance score ^a	12.62	1.87	12.68	1.84
Conscientiousness ^a	5.68	1.11	5.70	1.08
Emotional Stability ^a	5.01	1.31	5.09	1.26
Agreeableness ^a	4.99	1.11	5.04	1.09
Extroversion ^a	4.70	1.35	4.76	1.35
Openness ^a	5.50	1.07	5.51	1.04
Sample size	4,448		3,632	

Note. Predictions in table 4 used estimates from regressions based on the full sample; predictions in table 5 were based on the high school graduation sample.

^aMeans and standard deviations for raw scores were reported in this table; standard scores (mean=0, SD=1) were used in all regressions.

Appendix Table A2

Probit estimates for the “earn high school diploma” outcome used to compute predicted marginal effects in table 4

	Specification									
	1a	2a	1a	2a	1b ^a	2b ^a	1a	2a	1b	2b
	—Grit ^b —		—Consistency ^b —				—Perseverance ^b —			
Male	-.154	-.154	-.152	-.152	-.135	-.136	-.153	-.153	-.137	-.135
	(.048)	(.048)	(.048)	(.048)	(.050)	(.050)	(.048)	(.048)	(.050)	(.050)
Black	.095	.096	.104	.105	.104	.105	.094	.093	.093	.092
	(.059)	(.059)	(.059)	(.059)	(.060)	(.060)	(.059)	(.059)	(.060)	(.060)
Hispanic	-.033	-.034	-.028	-.028	-.036	-.036	-.031	-.035	-.041	-.045
	(.064)	(.064)	(.064)	(.064)	(.064)	(.065)	(.064)	(.064)	(.064)	(.064)
AFQT quartile 2 (Q2)	.644	.643	.651	.651	.632	.632	.640	.633	.623	.615
	(.061)	(.061)	(.061)	(.061)	(.062)	(.062)	(.061)	(.061)	(.062)	(.062)
AFQT quartile 3 (Q3)	1.049	1.046	1.055	1.056	1.024	1.025	1.044	1.034	1.017	1.005
	(.066)	(.066)	(.066)	(.066)	(.067)	(.067)	(.066)	(.066)	(.067)	(.067)
AFQT quartile 4 (Q4)	1.723	1.733	1.724	1.745	1.691	1.708	1.713	1.704	1.690	1.678
	(.084)	(.088)	(.084)	(.089)	(.086)	(.090)	(.084)	(.086)	(.086)	(.087)
Key predictor (P) ^{bc}	.064	.115	.032	.042	-.019	-.005	.089	.165	.049	.138
	(.025)	(.043)	(.025)	(.041)	(.027)	(.042)	(.023)	(.042)	(.025)	(.042)
P·Q2 ^{bc}		-.067		-.007		-.010		-.116		-.135
		(.062)		(.061)		(.062)		(.061)		(.061)
P·Q3 ^{bc}		-.118		-.064		-.070		-.134		-.156
		(.066)		(.067)		(.068)		(.062)		(.062)
P·Q4 ^{bc}		-.008		.060		.045		-.079		-.104
		(.084)		(.088)		(.088)		(.078)		(.076)
Conscientiousness ^c					.069	.069			.053	.057
					(.026)	(.026)			(.026)	(.027)
Emotional Stability ^c					.119	.120			.112	.111
					(.027)	(.027)			(.027)	(.027)
Agreeableness ^c					.052	.052			.053	.056
					(.026)	(.026)			(.026)	(.026)
Extroversion ^c					.075	.074			.070	.072
					(.025)	(.025)			(.025)	(.025)
Openness ^c					-.051	-.050			-.054	-.056
					(.026)	(.026)			(.026)	(.026)
Constant	.195	.197	.185	.184	.213	.212	.200	.210	.224	.234
	(.063)	(.063)	(.063)	(.063)	(.066)	(.066)	(.063)	(.064)	(.066)	(.066)

Note: N=4,448. Standard errors are in parentheses.

^aPredicted marginal effects based on this specification are *not* summarized in table 4.

^bThe key predictor (P) is either grit, consistency, or perseverance as indicated in the column heading.

^cScores for P (grit, consistency, or perseverance) and Big 5 traits are standardized to have mean=0 and SD=1.

Appendix Table A3

Probit estimates for the “enroll in a 2 or 4-year college” outcome used to compute predicted marginal effects in table 4

	Specification									
	1a	2a	1a	2a	1b ^a	2b ^a	1a	2a	1b	2b
	—Grit ^b —		—Consistency ^b —				—Perseverance ^b —			
Male	-.329 (.043)	-.329 (.043)	-.328 (.043)	-.327 (.043)	-.341 (.045)	-.341 (.046)	-.329 (.043)	-.331 (.043)	-.345 (.046)	-.345 (.046)
Black	.230 (.055)	.234 (.055)	.245 (.055)	.253 (.055)	.231 (.055)	.238 (.056)	.230 (.055)	.227 (.055)	.216 (.056)	.213 (.056)
Hispanic	.098 (.060)	.098 (.060)	.105 (.060)	.108 (.060)	.095 (.060)	.097 (.061)	.102 (.060)	.099 (.060)	.089 (.060)	.086 (.061)
AFQT quartile 2 (Q2)	.709 (.060)	.713 (.061)	.718 (.060)	.726 (.060)	.689 (.061)	.696 (.061)	.705 (.060)	.703 (.061)	.677 (.061)	.675 (.061)
AFQT quartile 3 (Q3)	1.352 (.063)	1.354 (.063)	1.358 (.063)	1.363 (.063)	1.320 (.064)	1.324 (.064)	1.350 (.063)	1.346 (.063)	1.313 (.064)	1.309 (.064)
AFQT quartile 4 (Q4)	2.019 (.073)	2.039 (.075)	2.016 (.073)	2.044 (.075)	1.973 (.074)	2.002 (.076)	2.013 (.073)	2.013 (.074)	1.973 (.074)	1.973 (.075)
Key predictor (P) ^{bc}	.089 (.022)	.166 (.047)	.038 (.022)	.088 (.044)	-.008 (.023)	.043 (.045)	.141 (.021)	.204 (.045)	.106 (.022)	.171 (.046)
P·Q2 ^{bc}		-.108 (.062)		-.096 (.059)		-.097 (.060)		-.054 (.060)		-.057 (.061)
P·Q3 ^{bc}		-.147 (.063)		-.106 (.061)		-.106 (.062)		-.128 (.061)		-.136 (.061)
P·Q4 ^{bc}		-.017 (.067)		.034 (.067)		.035 (.068)		-.052 (.064)		-.056 (.064)
Conscientiousness ^c					.055 (.024)	.055 (.024)			.025 (.024)	.027 (.024)
Emotional Stability ^c					.113 (.025)	.113 (.025)			.103 (.025)	.103 (.025)
Agreeableness ^c					.005 (.023)	.004 (.023)			.005 (.023)	.007 (.023)
Extroversion ^c					.058 (.022)	.058 (.022)			.050 (.022)	.050 (.022)
Openness ^c					.032 (.023)	.034 (.023)			.026 (.023)	.026 (.023)
Constant	-.544 (.062)	-.547 (.062)	-.555 (.062)	-.561 (.062)	-.515 (.063)	-.521 (.064)	-.540 (.062)	-.537 (.062)	-.500 (.063)	-.497 (.064)

Note: N=4,448. Standard errors are in parentheses.

^aPredicted marginal effects based on this specification are *not* summarized in table 4.

^bThe key predictor (P) is either grit, consistency, or perseverance as indicated in the column heading.

^cScores for P (grit, consistency, or perseverance) and Big 5 traits are standardized to have mean=0 and SD=1.

Appendix Table A4

Probit estimates for the “earn any college degree” outcome used to compute predicted marginal effects in table 4

	Specification									
	1a	2a	1a	2a	1b ^a	2b ^a	1a	2a	1b	2b
	—Grit ^b —		—Consistency ^b —				—Perseverance ^b —			
Male	-.296	-.296	-.297	-.297	-.308	-.309	-.294	-.294	-.309	-.308
	(.042)	(.043)	(.042)	(.042)	(.046)	(.046)	(.043)	(.043)	(.046)	(.046)
Black	-.056	-.052	-.047	-.040	-.066	-.060	-.050	-.051	-.070	-.072
	(.056)	(.057)	(.056)	(.056)	(.057)	(.057)	(.056)	(.056)	(.057)	(.057)
Hispanic	-.200	-.202	-.196	-.195	-.199	-.198	-.193	-.196	-.200	-.204
	(.061)	(.061)	(.061)	(.061)	(.062)	(.062)	(.061)	(.061)	(.061)	(.062)
AFQT quartile 2 (Q2)	.651	.694	.657	.687	.651	.685	.650	.676	.646	.672
	(.078)	(.081)	(.078)	(.080)	(.079)	(.081)	(.078)	(.080)	(.079)	(.081)
AFQT quartile 3 (Q3)	1.146	1.188	1.150	1.178	1.142	1.174	1.143	1.169	1.137	1.164
	(.076)	(.079)	(.076)	(.078)	(.077)	(.080)	(.076)	(.078)	(.077)	(.079)
AFQT quartile 4 (Q4)	1.862	1.908	1.861	1.898	1.850	1.889	1.851	1.875	1.845	1.870
	(.078)	(.082)	(.078)	(.081)	(.079)	(.082)	(.078)	(.080)	(.080)	(.082)
Key predictor (P) ^{bc}	.110	.300	.076	.210	.022	.171	.131	.277	.082	.241
	(.021)	(.070)	(.021)	(.068)	(.023)	(.071)	(.022)	(.060)	(.023)	(.062)
P·Q2 ^{bc}		-.220		-.166		-.179		-.168		-.175
		(.082)		(.080)		(.083)		(.077)		(.078)
P·Q3 ^{bc}		-.261		-.206		-.223		-.193		-.209
		(.079)		(.078)		(.080)		(.072)		(.073)
P·Q4 ^{bc}		-.155		-.090		-.112		-.131		-.149
		(.079)		(.078)		(.080)		(.071)		(.072)
Conscientiousness ^c					.122	.123			.103	.105
					(.024)	(.024)			(.024)	(.024)
Emotional Stability ^c					.091	.092			.088	.088
					(.025)	(.025)			(.024)	(.025)
Agreeableness ^c					-.007	-.008			-.007	-.006
					(.023)	(.023)			(.023)	(.023)
Extroversion ^c					.021	.021			.015	.016
					(.022)	(.022)			(.022)	(.022)
Openness ^c					-.003	-.003			-.007	-.008
					(.023)	(.023)			(.023)	(.023)
Constant	-1.268	-1.307	-1.272	-1.299	-1.264	-1.295	-1.269	-1.292	-1.259	-1.283
	(.075)	(.078)	(.075)	(.077)	(.077)	(.079)	(.075)	(.077)	(.077)	(.079)

Note: N=4,448. Standard errors are in parentheses.

^aPredicted marginal effects based on this specification are *not* summarized in table 4.

^bThe key predictor (P) is either grit, consistency, or perseverance as indicated in the column heading.

^cScores for P (grit, consistency, or perseverance) and Big 5 traits are standardized to have mean=0 and SD=1.

Appendix Table A5

Probit estimates for the “earn a Bachelor’s degree” outcome used to compute predicted marginal effects in table 4

	Specification									
	1a	2a	1a	2a	1b ^a	2b ^a	1a	2a	1b	2b
	—Grit ^b —		—Consistency ^b —				—Perseverance ^b —			
Male	-.287 (.045)	-.287 (.045)	-.288 (.045)	-.287 (.045)	-.274 (.049)	-.274 (.049)	-.285 (.045)	-.287 (.045)	-.276 (.049)	-.277 (.049)
Black	-.044 (.061)	-.037 (.061)	-.034 (.061)	-.024 (.061)	-.037 (.062)	-.028 (.062)	-.037 (.061)	-.039 (.061)	-.043 (.062)	-.045 (.062)
Hispanic	-.198 (.066)	-.199 (.066)	-.194 (.066)	-.192 (.066)	-.185 (.067)	-.184 (.067)	-.191 (.066)	-.194 (.066)	-.188 (.067)	-.192 (.067)
AFQT quartile 2 (Q2)	.687 (.097)	.727 (.102)	.693 (.097)	.713 (.099)	.695 (.098)	.719 (.100)	.687 (.097)	.733 (.101)	.689 (.098)	.737 (.103)
AFQT quartile 3 (Q3)	1.294 (.093)	1.330 (.098)	1.297 (.093)	1.312 (.095)	1.305 (.095)	1.324 (.097)	1.294 (.093)	1.345 (.097)	1.300 (.095)	1.354 (.099)
AFQT quartile 4 (Q4)	2.060 (.094)	2.101 (.099)	2.058 (.094)	2.083 (.096)	2.072 (.097)	2.099 (.099)	2.052 (.094)	2.100 (.098)	2.068 (.096)	2.119 (.101)
Key predictor (P) ^{bc}	.114 (.022)	.254 (.093)	.077 (.023)	.140 (.086)	.009 (.025)	.096 (.092)	.140 (.023)	.325 (.080)	.080 (.025)	.286 (.082)
P·Q2 ^{bc}		-.181 (.105)		-.127 (.098)		-.146 (.104)		-.175 (.097)		-.189 (.099)
P·Q3 ^{bc}		-.189 (.100)		-.107 (.095)		-.128 (.100)		-.228 (.089)		-.251 (.091)
P·Q4 ^{bc}		-.102 (.100)		-.008 (.094)		-.040 (.099)		-.181 (.088)		-.210 (.090)
Conscientiousness ^c					.161 (.026)	.160 (.026)			.138 (.026)	.140 (.026)
Emotional Stability ^c					.078 (.026)	.078 (.026)			.073 (.026)	.072 (.026)
Agreeableness ^c					.027 (.024)	.026 (.024)			.025 (.024)	.026 (.024)
Extroversion ^c					.035 (.023)	.035 (.023)			.029 (.023)	.029 (.023)
Openness ^c					-.034 (.025)	-.033 (.025)			-.038 (.025)	-.039 (.025)
Constant	-1.665 (.093)	-1.701 (.098)	-1.668 (.093)	-1.684 (.095)	-1.700 (.095)	-1.719 (.098)	-1.671 (.093)	-1.718 (.097)	-1.694 (.095)	-1.744 (.100)

Note: N=4,448. Standard errors are in parentheses.

^aPredicted marginal effects based on this specification are *not* summarized in table 4.

^bThe key predictor (P) is either grit, consistency, or perseverance as indicated in the column heading.

^cScores for P (grit, consistency, or perseverance) and Big 5 traits are standardized to have mean=0 and SD=1.