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# Moving Ahead by Thinking Backwards

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# Moving Ahead by Thinking Backwards:

## Cognitive Skills, Personality, and Economic Preferences in Collegiate Success

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## Abstract

Although some research exists regarding collegiate GPAs, little is known about which individual student characteristics predict college graduation. We study 100 students from the University of Minnesota Morris. Information collected includes demographics, standard personality traits (known in Psychology as the "Big Five"), two economic preferences (risk aversion and patience), and three cognitive skills (numeracy, non-verbal IQ, "Hit15")."Hit 15" is a game played against the computer in which each player must add 1, 2, or 3 on each turn. Winning is exactly hitting fifteen first; players take turns going first and the starting point total varies (game theory calls solving this "backward induction").

Using standardized versions of our variables in multivariate models, we analyze their power to predict three student success measures—timely graduation (≤ 4 years), graduation at all (≤ 6 years), and GPA. Controlling for other measured characteristics the "Hit 15" measure weakly predicts 4-year graduation and strongly predicts 6-year graduation. Interestingly, "Hit 15" is more powerful than other cognitive skills in a combined multivariate model.

We compare these findings to results from parallel models run on a cohort of 1,065 trainee truckers, from whom identical initial measures were collected. Similar to the student cohort, "Hit 15" is strongly associated with trucking success over time—defined as completing a one-year training contract. This suggests "Hit 15" deserves further investigation as it captures something above our other measures in both settings: the ability to think backwards from future goals to determine the best current action to take under varying circumstances.

## Study Design

Our pool of 100 UMM students was followed from Spring 2007 to Spring 2013 and divided into groups based on graduation success during this time period: graduation in 4 years or less (n=57), in 6 years or less (n=80), or not at all (n=20). 1,065 trucking trainees were also followed to see if they completed a one-year training contract, which then made the training free.

Demographic data (age, sex, income, and race) were collected from all subjects. These variables will be referred to as "Demographics".

All participants took the Multidimensional Personality Questionnaire (MPQ); MPQ scores were translated into standardized scores for each of the "Big Five" personality traits (Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism).

Collected through incentivized experiments, intellect and economic preferences variables included:

- **Non-verbal IQ** – As determined by Raven's Standard Progressive Matrices, this measures non-verbal intelligence.
- **Numeracy** – This intellect variable was collected using standard adult quantitative literacy tests.
- **Hit 15** – The "Hit 15" game tests participants' ability to plan ahead. The subject and computer take turns adding 1, 2, or 3 points trying to be the player to add the 15th and final point. After a trial game, each participant played four times and was assigned a "Hit 15" score representing the number of times they won against the computer (ranging from 0-4).
- **Economic preferences** – Using subjects' experimental choices, estimates for two of delay of gratification parameters ("Beta" and "Delta") and a risk aversion parameter ("Sigma") were determined.

## Analytic Methods

Our analyses focus on the predictive role of the cognitive skills and economic preference measurements. First we determined the predictive power of these variables separately for each of our four success outcomes. Controlling for the Big 5 personality traits and subject demographics, we ran a series of five multivariate regression models for each success outcome (20 in total) following a uniform pattern of variable insertion. The five models were as follows:

- 3 separate models for the individual placement of each cognitive skill. (Models 1,2, & 3)
- 1 model containing all three economic preferences—Beta, Delta, and Sigma. (Model 4)
- 1 Full model containing all cognitive skill and economic preference variables. (Model 5)

To properly interpret the model coefficients, it is important to note all predictors are standardized in "z-score" format (measured as sample standard deviations units from the sample mean) within their respective student or trucking cohort.

Using logit models, we report our graduation and trucker success results in odds ratio form, meaning that each coefficient gives the change in the odds of a given success outcome resulting from a one standard deviation change in the predictor. For GPA, we used a version of ordinary least squares that accounts for the upper and lower bounds of GPA ("Tobit" models).

## Results

We analyzed the coefficients and their related p-values for both the "single-predictor" models and full model to determine the effects and robustness of the cognitive skill and economic preference variables. Table 1 lists the dependent variables across the top and shows the results from the "single-predictor" models (Models 1-4). Thus, the coefficients measure the effect of the variable while acting alone in the model, except for the three economic preferences which were placed into Model 4 together. While controlling for personality traits and subject demographics, the results show that individually:

- Hit 15 and IQ are significant predictors of all success measurements
- Numeracy is positively associated with GPA and Trucking success
- Beta and Delta are positively associated with 4-yr graduation and GPA.

**Table 1. "Single Predictor Set" Model Results**

| | 4-yr Grad | 6-yr Grad | GPA | Training |
|---|---|---|---|---|
| Model 1: Hit 15 | **2.036**** | **3.153***** | **0.152***** | **1.398***** |
| Model 2: IQ | **1.881**** | **2.668**** | **0.200***** | **1.416***** |
| Model 3: Numeracy | 0.945 | 1.279 | **0.116**** | **1.312***** |
| Model 4: Beta | **1.737*** | 1.512 | **0.180***** | **1.187**** |
| Delta | **2.274**** | 1.522 | **0.117**** | 0.999 |
| Sigma | 0.894 | 0.957 | -0.057 | 0.956 |

*$p < 0.1$ ** $p<0.05$ *** $p<0.01$

Note: Each model controls for Demographics & Big 5 personality traits.

We then ran the full models for each student success outcome and trucker success to determine which variables remained significant when fighting for predictive power.

- Hit 15 maintains predictive power for 6-yr graduation and trucker success
- IQ no longer predicts any student success outcome, only weakly predicts trucker success (10% level)
- Delta remains as a predictor of 4-yr graduation and GPA, while Beta loses predictive power for graduation in 4 years, but still predicts GPA

**Table 2. "Full" Model Results**

| Model 5: Variables | 4-yr Grad | 6-yr Grad | GPA | Training |
|---|---|---|---|---|
| Hit 15 | 1.708 | **2.741**** | 0.074 | **1.300***** |
| IQ | 1.208 | 1.974 | 0.079 | **1.197*** |
| Numeracy | 0.683 | 1.028 | 0.050 | 1.010 |
| Beta | 1.676 | 1.130 | **0.126**** | 1.151 |
| Delta | **2.086**** | 1.979 | **0.112**** | 0.946 |
| Sigma | 0.912 | 1.407 | -0.040 | 0.960 |

*$p < 0.1$ ** $p<0.05$ *** $p<0.01$

Note: Each model controls for Demographics & Big 5 personality traits.

The importance of showing results from both the "single predictor" models and the full model is to showcase the pattern. We see that individually Hit 15 and IQ both predict all forms of student success and trucking success; however, when entered into the same multivariate model the predictive power of Hit 15 outweighs IQ for graduation in 6 years. Also, the significance of Hit 15 in predicting trucker success is at the 1% level compared to IQ at the 10% level. Thus, Hit 15 does a better job in predicting student success in respect to six year graduation, as well as trucker success.

Not shown in the tables, but important to note, the Proactive aspect of Conscientiousness –one of the Big 5 personality traits—is positively related to each measurement of student success in all forms of the models (1-5). This differs from other studies which simply state Conscientiousness as a predictor of GPA. We have pinpointed the Proactive aspect, not the Inhibitive aspect, as the main contributor.

## Conclusions

This study was conducted to determine which factors predict collegiate success and if they are comparable to an industrial setting—trucking. The robustness of the Hit 15 findings for both 6 year graduation and trucking success suggests being able to reason backwards when planning ahead is important in both educational and industrial success. In the collegiate setting both short-term and long-term processes require thinking backward. For example, taking essential steps to complete an assignment on time or deciding the necessary classes to take to fulfill graduation requirements. Truckers are constantly planning short-term tasks—or "trips", thinking ahead about the amount of hours legally available to drive and the stops and routes which are required to successfully complete the trip under regulations. Thus, the need for backward induction ability is clearly present in both settings.

The results not only suggest backward reasoning ability to be a strong predictor of success in both collegiate and industrial settings, but it appears Hit 15 is capturing some aspect of cognitive skills not measured by existing instruments. The importance of the backward planning ability discovered here shows institutions that focusing on this skill could potentially improve graduation rates.