

Integrating Personality Psychology into Economics

James Heckman

(University of Chicago, American Bar Foundation,
University College Dublin)

성격심리학과 경제학의 통합

제임스 헤크만

(시카고 대학교 교수, 미국변호사협회 회원, 더블린 대학교 교수)

* This research was supported by grants from NIH R01-HD054702, R01-HD065072, and K01-AG033182; the University of Chicago; The Institute for New Economic Thinking (INET); A New Science of Virtues: A Project of the University of Chicago; the American Bar Foundation; a conference series from the Spencer Foundation; the JB & MK Pritzker Family Foundation; the Buffett Early Childhood Fund; the Geary Institute, University College Dublin, Ireland; and an anonymous funder. This paper draws on Almlund *et al.* (2011). I thank Angela Duckworth and Tim Kautz for helpful comments.

** 본 논문은 2011년 8월 9일 KDI에서 개최된 2011 KDI Journal of Economic Policy Conference에서 발표된 것임.

*** 제임스 헤크만: (e-mail) jjh@uchicago.edu, (address) 1126 E 59th St. Chicago, IL 60637, USA

• Key Word: Personality Psychology(성격심리학), Behavioral Economics(행태경제학), Identification(식별), Causality(인과관계)

• JEL Code: I2, J24

• Received: 2011. 8. 22

• Referee Process Started: 2011. 8. 24

• Referee Reports Completed: 2011. 9. 9

ABSTRACT

This paper reviews the problems and potential benefits of integrating personality psychology into economics. Economists have much to learn from and contribute to personality psychology.

경제학자는 성격심리학으로부터 얻을 것이 영역으로 통합함으로써 얻을 수 있는 장점
많으며, 동시에 성격심리학에 기여할 수 과, 이 과정에서 발생하는 문제점을 검토하
있다. 본 논문에서는 성격심리학을 경제학의 고 있다.

What can economists learn from and contribute to personality psychology? What do we learn from personality psychology? Personality traits predict many behaviors—sometimes with the same or greater strength as conventional cognitive traits. Personality psychology considers a wider array of actions than are usually considered by economists and enlarges the economist's way to describe and model the world. Personality traits are not set in stone. They change over the life cycle. They are a possible avenue for policy intervention.

Personality psychologists lack precise models. Economics provides a clear framework for recasting the field. Economics now plays an important role in clarifying the concepts and empirical content of psychology. More precise models reveal basic identification problems that plague measurement in psychology. At an empirical level, "cognitive" and "noncognitive" traits are not easily separated.

Moreover, personality psychologists typically present correlations and not causal relationships. Many contemporaneously measured relationships suffer from the problem of reverse causality. Economists can apply their tools to define and estimate causal mechanisms. In addition, psychological measures have substantial measurement error. Econometric tools account for measurement error, and doing so makes a difference. Economists formulate and estimate mechanisms of investment—how traits can be changed for the better.

There are major challenges in integrating personality psychology and economics. Economists need to link the traits of psychology with the preferences, constraints and expectation mechanisms of economics. We need to develop rigorous methods for analyzing causal relationships in both fields. We also need to develop a common language and a common framework to promote interdisciplinary exchange.

There is a danger in assuming that basic questions of content and identification have been answered by psychologists at the level required for rigorous economic analysis. In explaining outcomes, how important is the person? How important is the situation? How important is their interaction? I address these issues in this paper.

1. A Brief History of Personality Psychology

Alfred Binet, architect of the first modern intelligence test that became the Stanford-Binet IQ test, noted that performance in school

"...admits of other things than intelligence; to succeed in his studies, one must have qualities which depend on attention, will, and character; for example a certain docility, a regularity of habits, and especially continuity of effort. A child, even if intelligent, will learn little in class if he never listens, if he spends his time in playing tricks, in giggling, is playing truant."

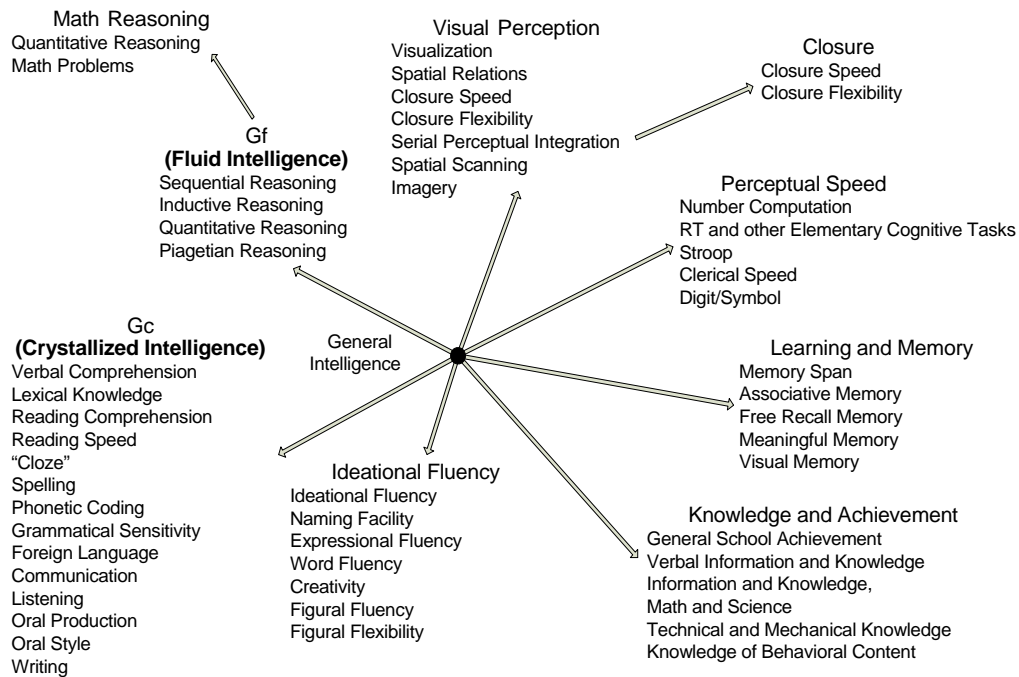
-Binet (1916, p.254)

All later pioneers have made similar statements. Many feature the Big Five trait “Conscientiousness” as a main determinant of success.¹ Before considering the Big Five traits, it is useful to briefly examine the modern concept of cognition by way of contrast.

2. Cognition: “g” – a single factor that is claimed to represent intelligence

Traditional “g” is a product of early Twentieth Century psychology. The concept of “g” has been broadened even beyond the traditional subcomponents of “fluid” and “crystallized” intelligence. Figure 1 summarizes current thinking where “g” or general intelligence is at the top of a large pyramid of cognitive traits.

[Figure 1] An Hierarchical Scheme of General Intelligence and Its Components



Source: Recreated from Ackerman and Heggestad (1997), based on Carroll (1993).

¹ See Almlund *et al.* (2011).

3. Personality Traits

Early pioneers used a lexical approach to define personality. They classified words that are used to describe people. This practice culminated in the “Big Five” derived from factor analysis of measurements of personality extracted from a variety of measures—observer reports, tests and measured productivity on the job (Costa and McCrae, 1992; Goldberg, 1993). No single “ g_p ” explains all traits. There are strong correlations within clusters but weak correlations across clusters.

<Table 1> The Big Five Domains and Their Facets

Big Five Personality Factor	American Psychology Association Dictionary description	Facets (and correlated trait adjective)	Related Traits	Childhood Temperament Traits
Conscientiousness	“the tendency to be organized, responsible, and hardworking”	Competence (efficient) Order (organized) Dutifulness (not careless) Achievement striving (ambitious) Self-discipline (not lazy) Deliberation (not impulsive)	Grit Perseverance Delay of gratification Impulse control Achievement striving Ambition Work ethic	Attention/ (lack of) distractibility Effortful control Impulse control/ delay of gratification Persistence Activity*
Openness to Experience	“the tendency to be open to new aesthetic, cultural, or intellectual experiences”	Fantasy (imaginative) Aesthetic (artistic) Feelings (excitable) Actions (wide interests) Ideas (curious) Values (unconventional)	—	Sensory sensitivity Pleasure in low- intensity activities Curiosity
Extraversion	“an orientation of one’s interests and energies toward the outer world of people and things rather than the inner world of subjective experience; characterized by positive affect and sociability”	Warmth (friendly) Gregariousness (sociable) Assertiveness (self-confident) Activity (energetic) Excitement seeking (adventurous) Positive emotions (enthusiastic)	—	Surgency Social dominance Social vitality Sensation seeking Shyness* Activity* Positive emotionality Sociability/affiliation
Agreeableness	“the tendency to act in a cooperative, unselfish manner”	Trust (forgiving) Straight-forwardness (not demanding) Altruism (warm) Compliance (not stubborn) Modesty (not show-off) Tender-mindedness (sympathetic)	Empathy Perspective taking Cooperation Competitiveness	Irritability* Aggressiveness Willfulness
Neuroticism/ Emotional Stability	Emotional stability is “predictability and consistency in emotional reactions, with absence of rapid mood changes.” Neuroticism is “a chronic level of emotional instability and proneness to psychological distress.”	Anxiety (worrying) Hostility (irritable) Depression (not contented) Self-consciousness (shy) Impulsiveness (moody) Vulnerability to stress (not self-confident)	Internal vs. External Locus of control Core self-evaluation Self-esteem Self-efficacy Optimism Axis I psychopathologies (mental disorders) including depression and anxiety disorders	Fearfulness/behavioral inhibition Shyness* Irritability* Frustration (Lack of) soothability Sadness

Notes: Facets specified by the NEO-PI-R personality inventory (Costa and McCrae [1992]). Trait adjectives in parentheses from the Adjective Check List (Gough and Heilbrun [1983]). *These temperament traits may be related to two Big Five factors.

Source: Table adapted from John and Srivastava (1999).

The Big Five predict many outcomes. The Big Five are defined without reference to any context (i.e., situation). This practice gives rise to an identification problem that I discuss below.

4. The Person-Situation Debate: A Strong Influence on Behavioral Economics

Is variation across people in behavior a consequence of personal traits or of situations? Economists are still badly divided over this question. The modern origins of the debate start with the works of psychologist Walter Mischel:

"...with the possible exception of intelligence, highly generalized behavioral consistencies have not been demonstrated, and the concept of personality traits as broad dispositions is thus untenable "

-Mischel (1968, p.146)

Many behavioral economists hold a similar view and appeal to Mischel as a guiding influence.

"The great contribution to psychology by Walter Mischel [. . .] is to show that there is no such thing as a stable personality trait."

-Thaler (2008)

The accumulated evidence speaks strongly against the claims of Mischel and the behavioral economists.²

5. Personality Psychology After the Person-Situation Debate

Correlational evidence shows that for many outcomes, measured personality traits are as predictive, and are sometimes more predictive, than standard measures of cognition. Traits are stable across situations. Situations also matter. Behavioral genetics show that personality traits are as heritable as cognitive traits. Alterations in brain structure and function through accidents, disease and by experiments affect measured personality.³

6. The Predictive Power of Personality Traits

A growing body of evidence suggests that personality measures—especially those

² See Almlund *et al.* (2011).

³ See Almlund *et al.* (2011)

related to Conscientiousness, and, to a lesser extent, Neuroticism—predict a wide range of outcomes. The predictive power of any particular personality measure tends to be less than the predictive power of IQ but in some cases rivals or exceeds it.

7. Difficulties in Synthesizing Studies of the Effects of Personality

Measures of personality and cognition differ among studies. Different studies use different measures of predictive power. Many studies do not address the question of causality, i.e., does the measured trait cause (rather than just predict) the outcome?

Few economists or psychologists working on the relationship between personality and outcomes address the issue of causality, and when they do so, it is usually by employing early measures of cognition and personality to predict later outcomes. This practice trades an endogeneity problem with an errors in variables problem. Almlund *et al.* (2011) discuss alternative approaches to causality building on the analysis of Hansen *et al.* (2004).

8. Main Findings from Predictive Analyses

The predictive power of “g” decreases with the level of job complexity. Personality traits are predictive at all levels of job complexity. Conscientiousness is the most predictive Big Five trait across many outcomes such as educational attainment, grades, job performance across a range of occupational categories, longevity and criminality. Neuroticism (and related Locus of Control) predicts schooling outcomes and labor market search. Other traits play roles at finer levels. I now present examples of the power of personality traits.

8-1. Educational Attainment and Achievement

In explaining educational attainment, Conscientiousness plays a powerful role. See Figure 2.

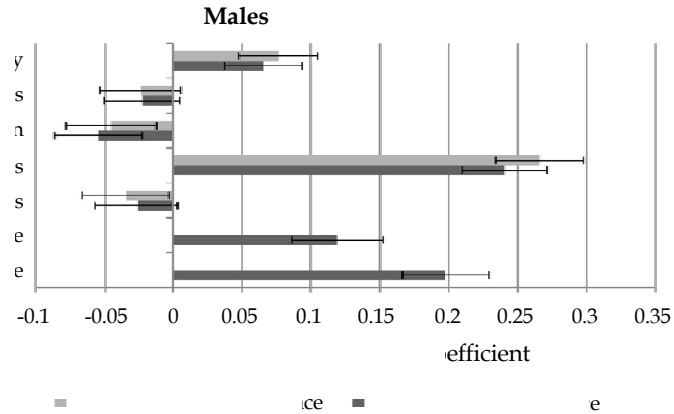
Another example is the GED in America. GEDs are high school dropouts who exam certify to be high school equivalents. They have the same cognitive skills as high school graduates but much lower noncognitive skills. See Figures 3 and 4.

GEDs earn at the rate of dropouts. Their lower levels of noncognitive skill leads to lower wages than ordinary high school graduates even though they have the same level of cognitive skills.

Cognitive and noncognitive skills are both important in explaining college graduation. See Figures 5 and 6. Persons with low levels of noncognitive skills are unlikely to graduate college, as are persons with low levels of cognitive skills.

Similar results hold for course grades. See Figure 7. Indeed, course grades are a good measure of conscientiousness (See Almlund *et al.*, 2011; Borghans *et al.*, 2011.).

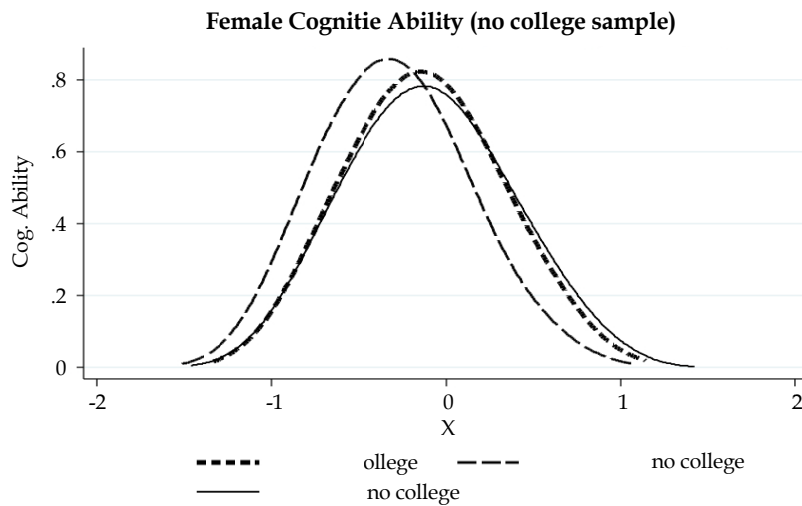
[Figure 2] Association of the Big Five and Intelligence with Years of Schooling in GSOEP



Note: The figure displays standardized regression coefficients from multivariate of years of school attended on the Big Five and intelligence, controlling for age and age-squared. The bars represent standard errors. The Big Five coefficients are corrected for attenuation bias. The Big Five were measured in 2005. Years of schooling were measured in 2008. Intelligence was measured in 2006. The measures of intelligence were based on components of the Wechsler Adult Intelligence Scale (WAIS). The data is a representative sample of German adults between the ages of 21 and 94.

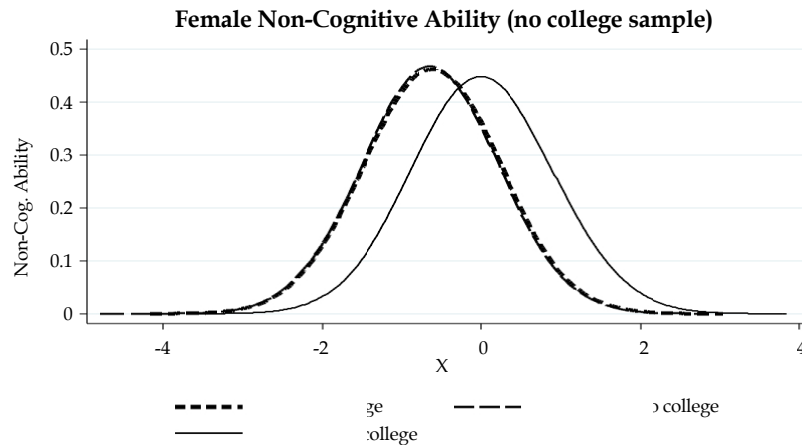
Source: German Socio-Economic Panel (GSOEP), waves 2004-2008, calculations performed by Pia Pinger (See Almlund *et al.*, 2011.).

[Figure 3] Distribution of Cognitive and Non-Cognitive Skills by Education Group



Source: Heckman *et al.* (2011).

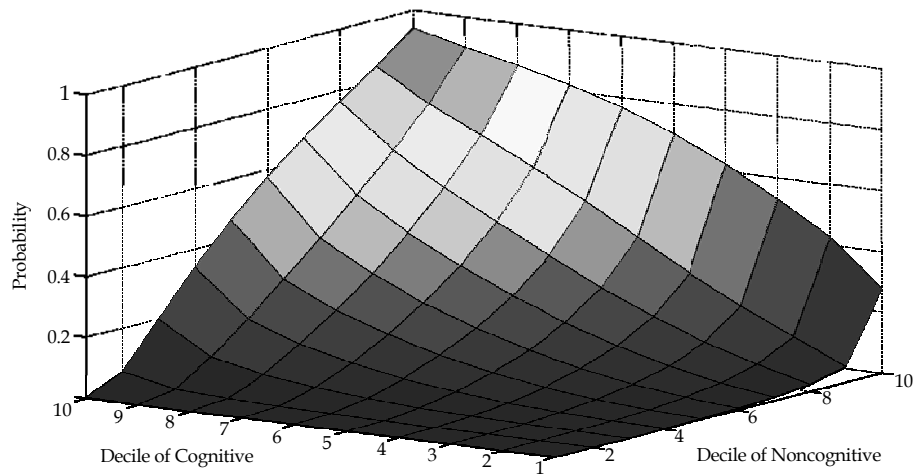
[Figure 4] Distribution of Cognitive and Non-Cognitive Skills by Education Group



Source: Heckman *et al.* (2011).

[Figure 5] Probability of Being a 4-year-college Graduate or Higher at Age 30, Males

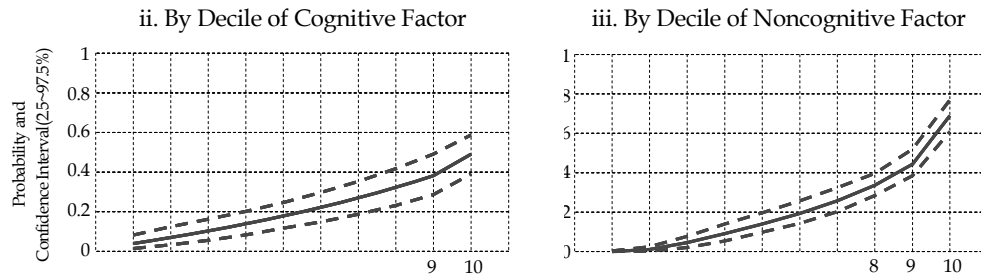
i. By Decile of Cognitive and Noncognitive Factors



Notes: The data are simulated from the estimates of the model and the NLSY79 sample. Higher deciles are associated with higher values of the variable. The confidence intervals are computed using bootstrapping (200 draws). Solid lines depict probability, and dashed lines, 2.5–97.5% confidence intervals. The upper curve is the joint density. The two marginal curves (ii) and (iii) are evaluated at the mean of the trait not being varied.

Source: Heckman *et al.* (2006, Figure 21).

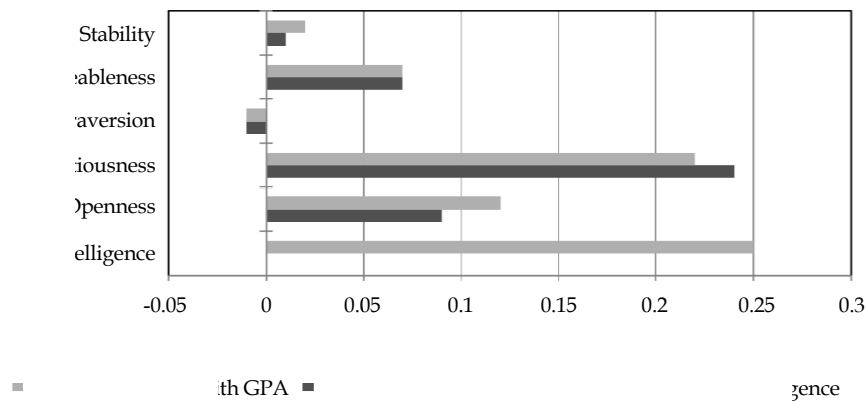
[Figure 6] Probability of Being a 4-year-college Graduate or Higher at Age 30, Males



Notes: The data are simulated from the estimates of the model and the NLSY79 sample. Higher deciles are associated with higher values of the variable. The confidence intervals are computed using bootstrapping (200 draws). Solid lines depict probability, and dashed lines, 2.5~97.5% confidence intervals. The upper curve is the joint density. The two marginal curves (ii) and (iii) are evaluated at the mean of the trait not being varied.

Source: Heckman *et al.* (2006, Figure 21).

[Figure 7] Correlations of the Big Five and Intelligence with Course Grades

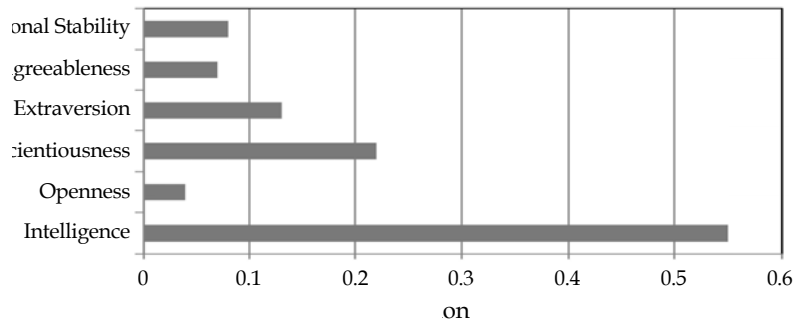


Notes: All correlations are significant at the 1% level. The correlations are corrected for scale reliability and come from a meta analysis representing a collection of studies representing samples of between N=31,955 to N=70,926, depending on the trait. The meta-analysis did not clearly specify when personality was measured relative to course grades.

Source: Poropat (2009).

8-2. Labor Market Outcomes

Intelligence is the greatest single predictor of job performance, especially in complex tasks, but noncognitive skills are also important predictors. See Figure 8.

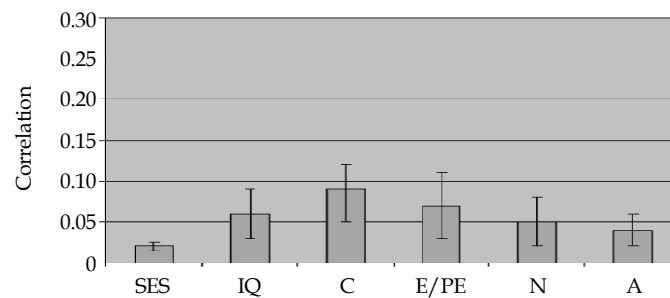
[Figure 8] Associations with Job Performance

Notes: The values for personality are correlations that were corrected for sampling error, censoring, and measurement error. Job performance was based on performance ratings, productivity data and training proficiency. The authors do report the timing of the measurements of personality relative to job performance. Of the Big Five, the coefficient on Conscientiousness is the only one that is statistically significant with a lower bound on the 90% credibility value of 0.10. The value for IQ is a raw correlation.

Sources: The correlations reported for personality traits come from a meta-analysis conducted by Barrick and Mount (1991). The correlation reported for IQ and job performance come from Schmidt and Hunter (2004).

8-3. Longevity

Personality traits also predict longevity. In particular, Conscientiousness is a better predictor than IQ. See Figure 9.

[Figure 9] Correlations of Mortality with Personality, IQ, and Socioeconomic Status (SES)

Notes: The figure represents results from a meta-analysis of 34 studies. Average effects (in the correlation metric) of low socioeconomic status (SES), low IQ, low Conscientiousness (C), low Extraversion/Positive Emotion (E/PE), Neuroticism (N), and low Agreeableness (A) on mortality. Error bars represent standard error. The lengths of the studies represented vary from 1 year to 71 years.

Source: Roberts *et al.* (2007).

9. Conceptualizing Personality Within an Economic Model

How should one conceptualize these correlations and establish a causal basis for them? Recent work (Almlund *et al.*, 2011) develops economic models of personality and their implications for measurement of personality and preference. They place the concept of personality within an economic framework. Personality is defined as an emergent property of a system. Economic models frame and solve a central identification problem in empirical psychology: How to go from measurements of personality to personality traits.

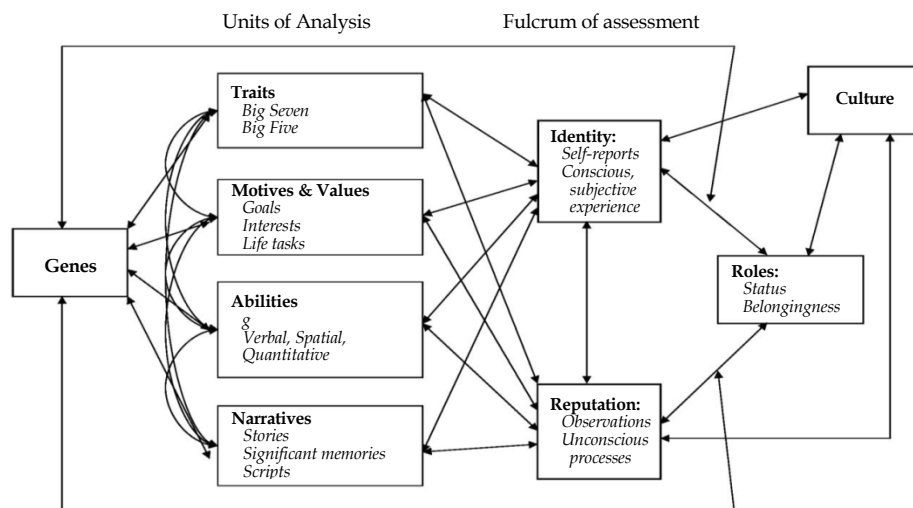
It is important to distinguish **personality traits** from **measured personality**. One definition of personality by a leading **psychologist** is:

“Personality traits are the relatively enduring patterns of thoughts, feelings, and behaviors that reflect the tendency to respond in certain ways under certain circumstances.”

-Roberts (2009, p.140)

His conceptual framework for personality is presented in Figure 10. Personality is a property of a system. This type of analysis is typical of the models used in personality psychology.

[Figure 10] Roberts’s Model of Personality



Source: Roberts (2006).

10. An Economic Framework for Conceptualizing and Measuring Personality and Personality Traits

How can we interpret personality within economic models? Through preferences (the standard approach), constraints (Borghans *et al.*, 2008) or through expectations? Or does it operate through all three?

10-1. Personality Affects Productivity

Almlund *et al.* (2011) develop models in which productivity in task j depends on the traits of agents represented by trait vector θ , and the “effort” they expend on the task, e_j :

$$P_j = \phi_j(\theta, e_j), \quad j \in \mathcal{J} = \{1, \dots, J\}, e_j \in \mathcal{E}, \theta \in \Theta \quad (1)$$

Traits θ are endowments, like a public good. $\sum_{j=1}^J e_j = \bar{e}$. \bar{e} is endowment.

$\phi_j(\theta, e_j)$ is concave and increasing in e_j ; $\frac{\partial^2 \phi_j}{\partial \theta \partial e_j} \geq 0, \forall j$. R_j is the reward per unit task output. The agent is assumed to maximize

$$\sum_{j=1}^J R_j \phi_j(\theta, e_j) \quad (2)$$

with respect to $\{e_j\}_{j=1}^J$ subject to the constraint $\sum_{j=1}^J e_j = \bar{e}$. In general as $R_j \uparrow e_j \uparrow$.

Effort in one task might diminish effort in another. If tasks are mutually exclusive, we obtain the Roy model (Heckman and Honoré, 1990; Heckman and Sedlacek, 1985).

10-2. Identifying Personality Traits From Measured Performance on Tasks

I next consider a basic identification problem. Some tasks may require only a single trait or only a subset of all of the traits. Divide θ into “mental” (μ) and “personality” (π) traits, θ_μ and θ_π . To use performance on a task (or on multiple measures of the task) to identify a trait requires that performance on certain tasks (performance on a test, performance in an interpersonal situation, etc.) depends exclusively on one component of θ , say $\theta_{1,j}$, as well as on the effort used in the task. Thus measurement assumes task j output is generated by the following relationship:

$$P_j = \phi_j(\underbrace{\theta_{1,j}}_{\substack{\text{single} \\ \text{trait} \\ \text{used in} \\ \text{trait } j}}, e_j)$$

We need to standardize for effort at a benchmark level, say e^* , to use P_j to identify a measure of the trait $\theta_{1,j}$.

The activity of picking a task (or a collection of tasks) that measure a particular trait ($\theta_{1,j}$ in our example) is called **operationalization** in psychology. Demonstrating that a measure successfully operationalizes a trait is called **construct validity**. Note, however, that we need to standardize for effort to measure the trait. Otherwise variation in effort produces variation in the measured trait across situations with different incentives.

10-3. A Fundamental Identification Problem

Operationalization and construct validation require heroic assumptions. Even if one adjusts for effort in a task, measured productivity may depend on multiple traits. Thus two components of θ (say $\theta_{1,\mu}, \theta_{1,\pi}$) may determine productivity in j . Without further information, one cannot infer which of the two traits produces the productivity in j . In general, even having two (or more) measures of productivity that depend on $(\theta_{1,\mu}, \theta_{1,\pi})$ is not enough to identify the separate components.

Consider the following case of two productivity measures for the two tasks j and j' :

$$P_j = \phi_j(\theta_{1,\mu}, \theta_{1,\pi}, e_j)$$

$$P_{j'} = \phi_{j'}(\theta_{1,\mu}, \theta_{1,\pi}, e_{j'}), \quad j \neq j'.$$

Standardize measurements at a common level of effort $e_j = e_{j'} = e^*$. Note that if the supports of e_j and $e_{j'}$ are disjoint, no $(\theta_{1,\mu}, \theta_{1,\pi})$ exists. Assume that the $\phi_k()$ are known. If the system of equations satisfies a local rank condition, then one can solve for the pair $(\theta_{1,\mu}, \theta_{1,\pi})$ at e^* . **Only the pair is identified**. One cannot (without further information) determine which component of the pair the $\theta_{1,\mu}$ or $\theta_{1,\pi}$.

In the absence of **dedicated constructs** (constructs that are generated by only one component of θ), there is an intrinsic identification problem that arises in using measures of productivity in tasks to infer traits. Analysts have to make one normalization in order to identify the traits. However, we need only one such construct joined with patterned structures on how θ enters other task to identify the vector θ (e.g. one example is a recursive, triangular structure). See the discussion in Almlund *et al.* (2011).

10-4. Examples of Nonidentification

IQ and achievement test scores reect incentives and efforts, and capture both cognitive and personality traits. Table 2 summarizes the evidence that paying

<Table 2> Incentives and Performance on Intelligence Tests

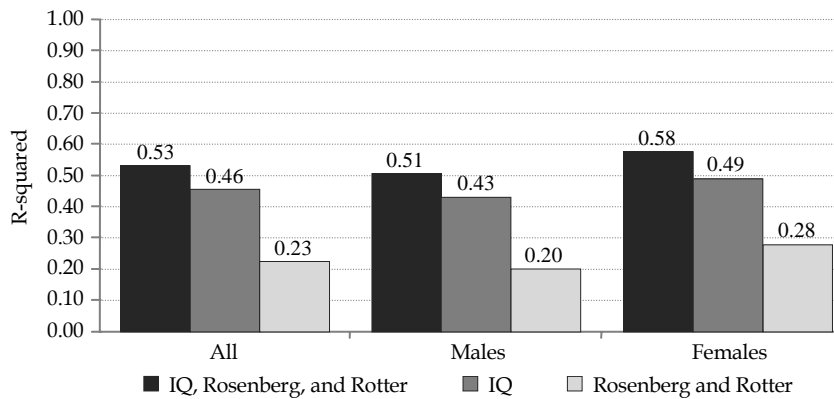
Study	Sample and Study Design	Experimental Group	Effect size of incentive (in standard deviations)	Summary
Edlund (1972)	Between subjects study. 11 matched pairs of low SES children; children were about one standard deviation below average in IQ at baseline	M&M candies given for each right answer	Experimental group scored <u>12 points</u> higher than control group during a second testing on an alternative form of the Stanford Binet (about 0.8 standard deviations)	"...a carefully chosen consequence, candy, given contingent on each occurrence of correct responses to an IQ test, can result in a significantly higher IQ score." (p.319)
Breuning and Zella (1978)	Within and between subjects study of 485 <i>special education</i> high school students all took IQ tests, then were randomly assigned to control or incentive groups to retake tests. Subjects were below-average in IQ.	Incentives such as record albums, radios (<\$25) given for improvement in test performance	Scores increased by about 17 points. Results were consistent across the Otis-Lennon, WISC-R, and Lorge-Thorndike tests.	"In summary, the promise of individualized incentives contingent on an increase in IQ test performance (as compared with pretest performance) resulted in an approximate 17-point increase in IQ test scores. These increases were equally spread across subtests... The incentive condition effects were much less pronounced for students having pretest IQs between 98 and 120 and did not occur for students having pretest IQs between 121 and 140." (p.225)

disadvantaged students for correct answers on IQ tests substantially raises measured IQ. Almlund *et al.* (2011) summarize many other studies

A considerable fraction of the variance in achievement tests is explained by personality traits. See Figure 11. Grades are explained more by the Big Five traits than by IQ. See Figure 12.

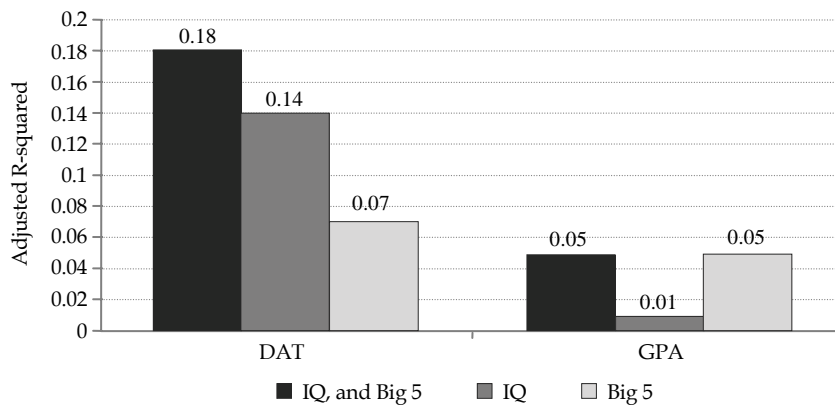
10-5. Measures of Personality in Psychology Based on Linear Factor Analysis

Such measures account for measurement error, and identify factors that can be interpreted as traits. Cunha *et al.* (2010) develop nonlinear factor models (nonlinear and nonparametric). Using these models they establish that measurement error is quantitatively important. The share of error variance for proxies of cognition, personality and investment ranges from 1~90%. Not accounting for measurement error produces downward-biased estimates of self-productivity effects and perverse estimates of investment effects.

[Figure 11] AFQT Score Decomposed by IQ, Rosenberg, and Rotter

Notes: The data come from the NLSY. Rosenberg, and Rotter were administered in 1979. The ASVAB was administered in 1980. To account for varying levels of schooling at the time of the test, scores have been adjusted for schooling at the time of the test conditional on final schooling using the method developed in Hansen *et al.* (2004). AFQT is constructed from the Arithmetic Reasoning, Word Knowledge, Numeric Operations, and Paragraph Comprehension ASVAB subtests. DAT and DAT percentile, IQ, and GPA are from high school transcript data. IQ is pooled across several IQ tests using IQ percentiles. GPA is the individual's core-subject GPA from each year of school. Sample excludes the military over-sample. Background variables include mother's highest grade completed, father's highest grade completed, southern residence at age 14, urban residence at age 14, living in a broken home at age 14, receiving newspapers in the household at age 14, receiving magazines in the household at age 14, and the household having a library card at age 14.

Source: Borghans *et al.* (2011).

[Figure 12] DAT scores and GPA decomposed by IQ and Personality

Notes: Data is from Stella Maris, a high school in the Netherlands. Students were administered part of a Raven's IQ test and personality questions based on the Big 5. DAT and GPA are from high school records.

Source: Borghans *et al.* (2011).

11. A Definition of Personality

I now add preferences and goals to the analysis. Preferences and goals also shape effort. They are personality traits broadly defined. Income is the return to productivity:

$$\text{Income} = \sum_{j=1}^J R_j P_j$$

Preferences are defined over final consumption goods X , productivity P and effort e :

$$U(X, P, e | \psi), \psi \in \Psi. \quad (3)$$

Agents have preferences over goods, agents may value the output of tasks in their own right and agents may value the effort devoted to tasks. The agents maximize (3) with respect

$$\underbrace{Y}_{\substack{\text{exogenous} \\ \text{flow of} \\ \text{income}}} + R'P = \underbrace{W'}_{\substack{\text{prices} \\ \text{of} \\ \text{goods}}} X \quad (4)$$

11-1. Adding Uncertainty

Let \mathcal{I} be the information possessed by an agent. “ E ” denotes the expectation operator. The agent can be interpreted as making decisions based on

$$E[U(X, P, e | \psi) | \mathcal{I}]. \quad (5)$$

11-2. Personality Traits

Personality traits are the components of e , θ and ψ that affect behavior. We observe **measured personality** – behaviors generated by incentives, goals, and traits.

11-3. Actions

Actions are styles of behavior that affect how tasks are accomplished. They are aspects of behavior that go beyond effort. Smiling, cajoling, etc. are examples. Tasks are accomplished by taking actions. The i^{th} possible action to perform task j is denoted $a_{i,j}, i \in \{1, \dots, K_j\}$. Array actions in a vector $a_j = (a_{1,j}, \dots, a_{K_j,j}) \in \mathcal{A}$.

Actions may be the same or different across the tasks. The productivity of the agent in task j depends on the actions taken in that task:

$$P_j = \tau_j (a_{1,j}, a_{2,j}, \dots, a_{k,j}). \quad (6)$$

The actions themselves depend on traits θ and “effort” $e_{i,j}$:

$$a_{i,j} = v_{i,j}(\theta, e_{i,j}) \quad (7)$$

where

$$\sum_{i=1}^{K_j} e_{i,j} = e_j \text{ and } \sum_{j=1}^J e_j = \bar{e}.$$

Actions generalize the notion of effort to a broader class of behaviors.

Let \mathcal{M} be the set of actions, including actions that do not directly contribute to productivity. Let M be the index set of items in \mathcal{M} .

$$a_{i,m} = v_{i,m}(\theta, e_{i,m}), m \in M, \mathcal{A} \subseteq \mathcal{M}.$$

The agent solves

$$\max E[U(a, X, P, e | \psi) | \mathcal{I}]$$

with respect to X and e given the stated constraints.

We can introduce situations indexed by $h \in \mathcal{H}$. For a person with traits θ and effort vector e_j with action $a_{i,j}$, using the specification (7), the action function can be expanded to be dependent on situation h :

$$a_{i,j,h} = v_{i,j}(\theta, e_{i,j,h}, h). \quad (8)$$

11-4. A Definition of Personality

Let $T \in \mathcal{T}$ be a vector of traits (θ, ψ, \bar{e}) . Personality is a response function.

$$\textbf{Personality: } a = a(R, W, T, h, Y, \mathcal{I}). \quad (9)$$

The behavior that constitutes personality is defined as a pattern of actions in response to the constraints, endowments, and incentives facing agents given their goals and preferences.

Actions—not traits—constitute the data used to identify the traits. Personality psychologists use actions (e.g., “dispositions”) to infer traits. Identification issues similar to those previously discussed apply to this broader set of measurements of behaviors.

11-5. Personality as Enduring Actions

Many personality psychologists define personality as “*enduring patterns of thoughts, feelings and behaviors*” that reflect tendencies of persons to respond in certain ways under certain circumstances (See Cervone and Pervin [2009]). What are enduring patterns of actions? “Enduring actions” are the average of the a functions for a person with a given trait vector $T = t$ over situations and efforts.

11-6. Average Actions

Consider task j and trait vector $T = (\theta, \psi, \bar{e})$. Define the average action for information set \mathcal{I} :

$$\bar{a}_{T,j,\mathcal{I}} = \int_{\mathcal{S}_{T,\mathcal{I}}(h,e_{i,j})} v_{i,j}(\theta, e_{i,j}, h) g(h, e_{i,j} | T = (\theta, \psi, \bar{e}), \mathcal{I}) dh de_{i,j}$$

where $\mathcal{S}_{T,\mathcal{I}}(h, e_{i,j})$ is the support $(h, e_{i,j})$ of given T and \mathcal{I} . $g(h, e_{i,j} | T = (\theta, \psi, \bar{e}), \mathcal{I})$ is the density of $(h, e_{i,j})$ given $T = (\theta, \psi, \bar{e})$ and information set \mathcal{I} . $\bar{a}_{T,i,\mathcal{I}}$ is the “enduring action” of agents across situations in task j with information \mathcal{I} , i.e., the **average personality**. Only if $v_{i,j}$ is separable in the T , the marginal effect of personality trait vector θ is the same in all situations.

One can define the “enduring traits” in a variety of ways, say by averaging over tasks, j , situations, h , or both. Only under separability in T will one obtain the same marginal effect of θ . Epstein (1979) and a subsequent literature present evidence against nonseparability but in favor of an “enduring trait” that is common across situations. He argues strongly against the extreme form of situational specificity assumed in modern behavioral economics.

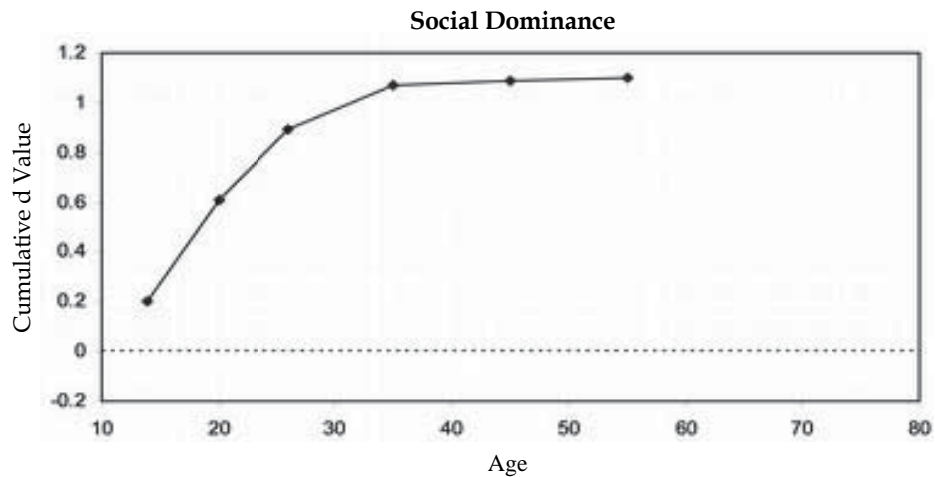
12. Stability and Change in Personality Traits and Preferences

While it is commonly thought that personality traits are stable, at least in adult life, in fact traits change over the life cycle. See Figures 13~16.

12-1. Processes of Development Discussed in the Literature

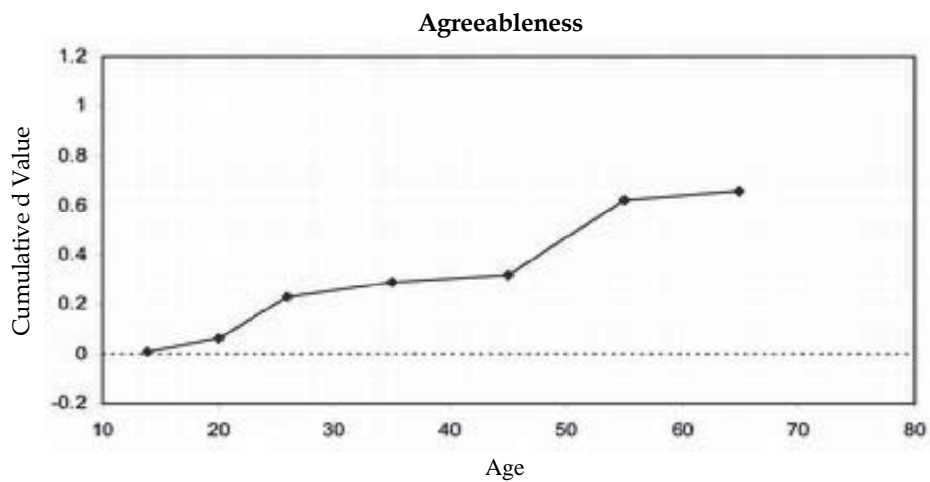
There are many hypothesized mechanisms of change. Two common processes discussed in the literature are ontogeny (programmed developmental processes common to all persons) and sociogeny (shared socialization processes). Personality also changes through external forces above and beyond common ontogenic and sociogenic processes. Such changes operate through alterations in normal biology, such as brain lesions and chemical interventions. A channel that receives a lot of attention in economics is investment: educational interventions and parental investment that affect personality throughout the life cycle.

[Figure 13] Cumulative Mean-Level Changes in Personality Across the Life Cycle



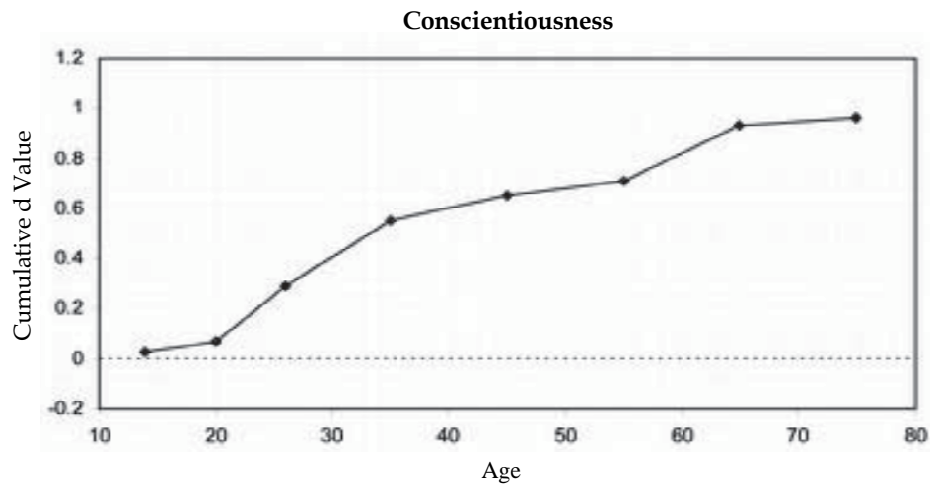
Note: Social vitality and social dominance are aspects of Big Five Extraversion. Cumulative values represent total lifetime change in units of standard deviations ("effect sizes").
 Source: Figure taken from Roberts *et al.* (2006) and Roberts and Mroczek (2008). Reprinted with permission of the authors.

[Figure 14] Cumulative Mean-Level Changes in Personality Across the Life Cycle



Note: Social vitality and social dominance are aspects of Big Five Extraversion. Cumulative d values represent total lifetime change in units of standard deviations ("effect sizes").
 Source: Figure taken from Roberts *et al.* (2006) and Roberts and Mroczek (2008). Reprinted with permission of the authors.

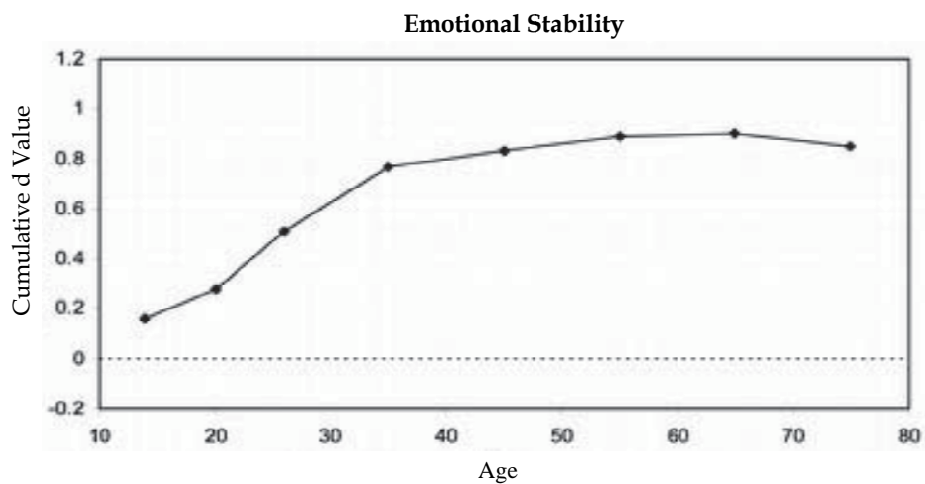
[Figure 15] Cumulative Mean-Level Changes in Personality Across the Life Cycle



Note: Social vitality and social dominance are aspects of Big Five Extraversion. Cumulative d values represent total lifetime change in units of standard deviations ("effect sizes").

Source: Figure taken from Roberts *et al.* (2006) and Roberts and Mroczek (2008). Reprinted with permission of the authors.

[Figure 16] Cumulative Mean-Level Changes in Personality Across the Life Cycle



Note: Social vitality and social dominance are aspects of Big Five Extraversion. Cumulative d values represent total lifetime change in units of standard deviations ("effect sizes").

Source: Figure taken from Roberts *et al.* (2006) and Roberts and Mroczek (2008). Reprinted with permission of the authors.

12-2. Life Cycle Dynamics

Let T^v be traits at age $v, v \in \{1, \dots, V\} \in \mathcal{V}$. Information \mathcal{I}^v may be updated through various channels of learning. The technology of skill formation (Cunha and Heckman, 2007, 2009) postulates the following equation of motion:

$$T^{v+1} = \eta^v \left(\underbrace{T^v}_{\text{self-productivity}}, \underbrace{IN^v}_{\text{investment}}, h^v \right), v = 0, \dots, V-1. \quad (10)$$

Functions can be nonautonomous (v -dependent). Situations may change over time as a function of past actions, past situations, investment, information, and the like:

$$h^{v+1} = \chi^v(h^v, IN^v, a^v). \quad (11)$$

Information \mathcal{I}^v may also change over the life cycle through experimentation and learning:

$$\mathcal{I}^{v+1} = \rho^v(\mathcal{I}^v, a^v, T^v, IN^v, h^v). \quad (12)$$

Figure 17 summarizes the dynamics of skill formation as formulated in Cunha and Heckman (2007, 2009).

Cunha *et al.* (2010) estimate technology (10) using longitudinal data on the development of children with rich measures of parental investment and of child traits. Self-productivity becomes stronger as children become older, for both cognitive and noncognitive capability formation. The elasticity of substitution for cognitive inputs is smaller in the adolescent years, so that it is more difficult to compensate for the effects of adverse environments on cognitive endowments at later ages than it is at earlier ages.

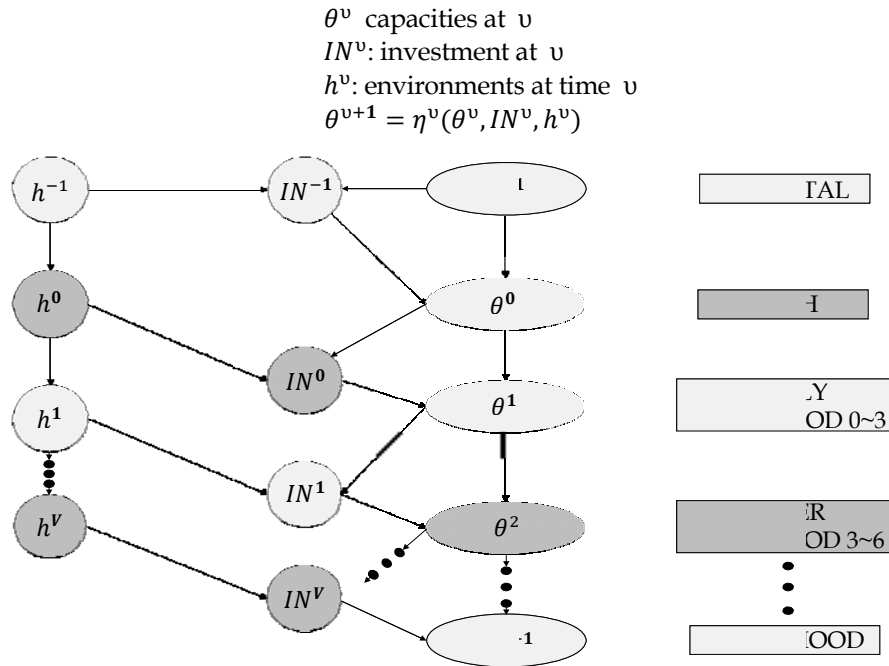
This finding explains the evidence on ineffective cognitive remediation strategies for disadvantaged adolescents. Personality traits foster the development of cognition but not vice versa. Cunha *et al.* (2010) show that it is equally easy to substitute for deficits in personality traits at both early and late stages for socioemotional skills over the life cycle.

Overall, 16% of the variation in educational attainment is explained by factors extracted from adolescent cognitive traits, 12% is due to factors extracted from adolescent personality (socioemotional traits), and 15% is due to factors extracted from measured parental investments.

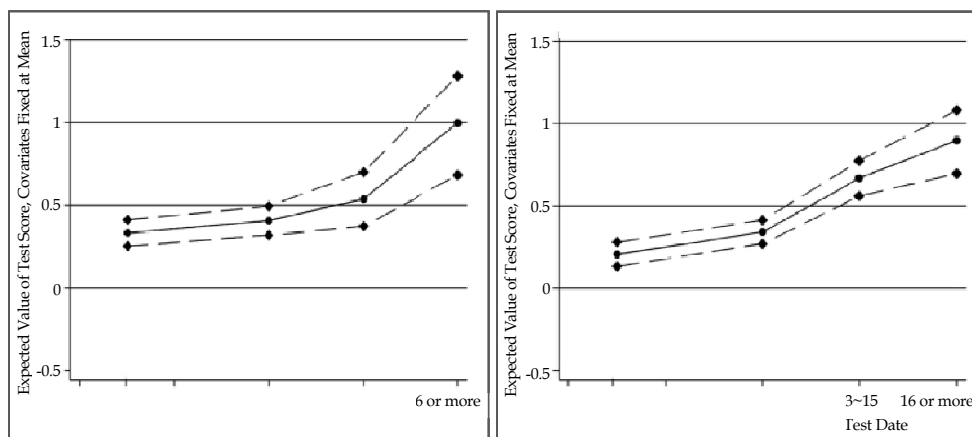
12-3. The Causal Effects of Schooling on Cognitive and Personality Traits

Using the methodology of Hansen *et al.* (2004), it is possible to estimate the causal effect of schooling on cognitive and noncognitive measurements. See Figures 18~21. Schooling has substantial effects on both types of traits.

[Figure 17] A Life Cycle Framework for Organizing Studies and Integrating Evidence: Period Life Cycle



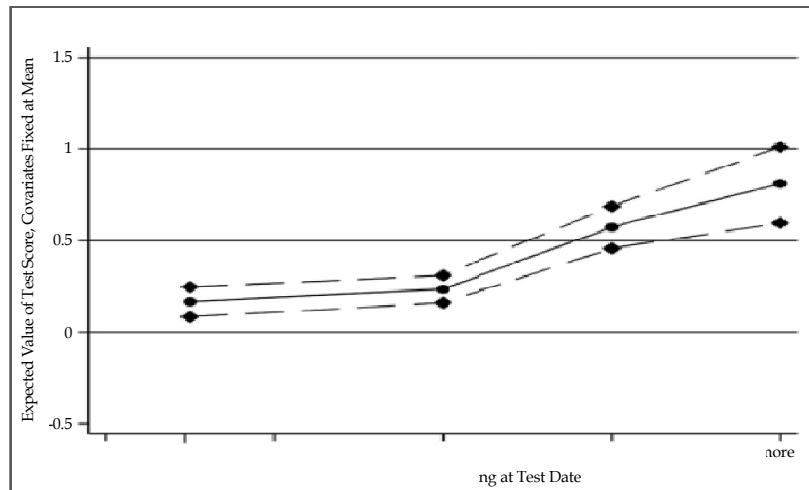
[Figure 18] Causal Effect of Schooling on ASVAB Measures of Cognition



Notes: Effect of schooling on components of the ASVAB. The first four components are averaged to create male's with average ability. We standardize the test scores to have within-sample mean zero, variance one. The model is estimated using the NLSY79 sample. Solid lines depict average test scores, and dashed lines, confidence intervals.

Source: Heckman *et al.* (2006, Figure 4).

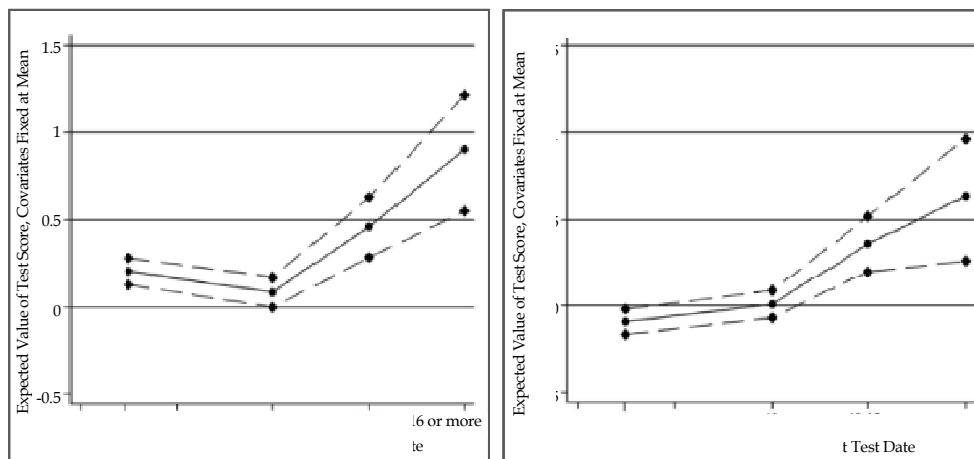
[Figure 19] Causal Effect of Schooling on ASVAB Measures of Cognition



Notes: Effect of schooling on components of the ASVAB. The first four components are averaged to create male's with average ability. We standardize the test scores to have within-sample mean zero, variance one. The model is estimated using the NLSY79 sample. Solid lines depict average test scores, and dashed lines, confidence intervals.

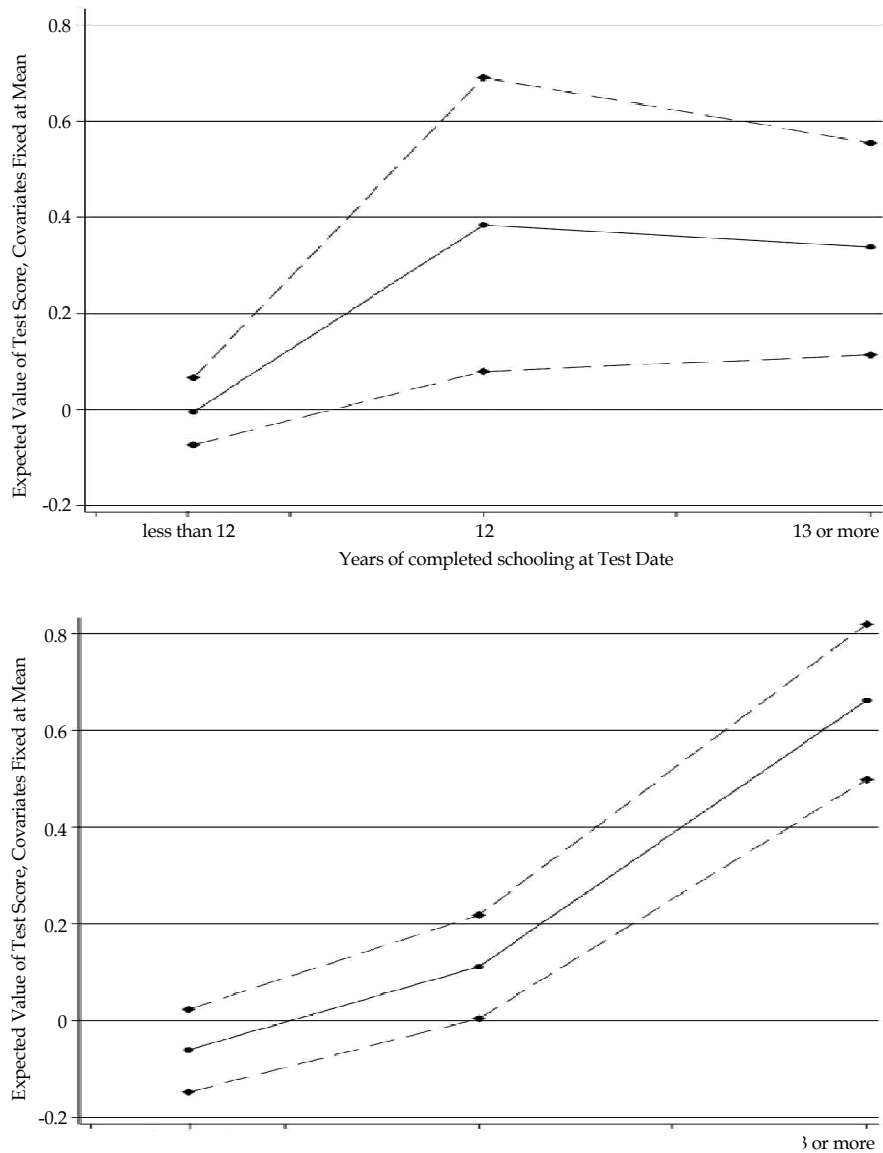
Source: Heckman *et al.* (2006, Figure 4).

[Figure 20] Causal Effect of Schooling on ASVAB Measures of Cognition



Notes: Effect of schooling on components of the ASVAB. The first four components are averaged to create male's with average ability. We standardize the test scores to have within-sample mean zero, variance one. The model is estimated using the NLSY79 sample. Solid lines depict average test scores, and dashed lines, confidence intervals.

Source: Heckman *et al.* (2006, Figure 4).

[Figure 21] Causal Effect of Schooling on Two Measures of Personality

Notes: The figures show the causal effect of schooling on two measures of personality traits. We standardize the test scores to have within-sample mean zero, variance one. The model is estimated using the NLSY79 sample. Solid lines depict average test scores, and dashed lines, confidence intervals.

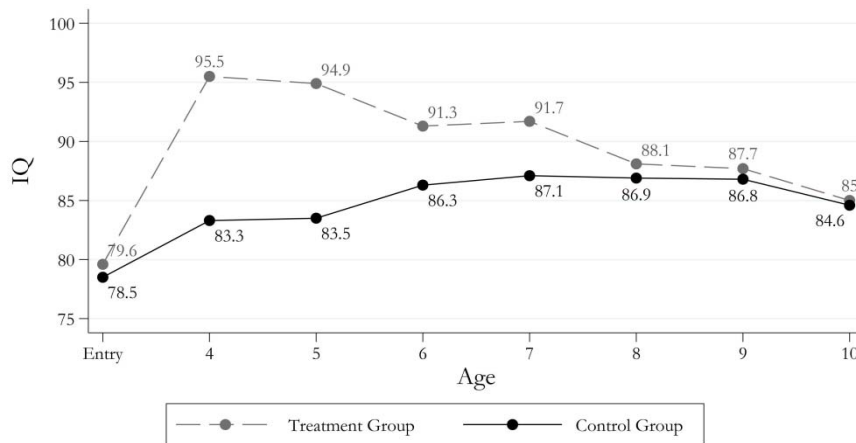
Source: Heckman *et al.* (2006, Figure 4).

12-4. The Evidence from Interventions

The Perry Preschool program intervened early in the lives of disadvantaged children. It has a 7~10% rate of return per annum (See Heckman *et al.*, 2010.). The Perry Preschool Program did not have a lasting improvement on cognitive ability, but it did improve important later-life outcomes through changes in personality (Heckman *et al.*, 2011).

The Perry Preschool Program worked primarily through socioemotional channels. It raised scores on achievement tests but not IQ tests. As previously noted, socioemotional factors and cognitive factors both explain performance on achievement tests (Duckworth, 2007; Borghans *et al.*, 2008; Borghans *et al.*, 2009).

[Figure 22] Perry Preschool Program: IQ, by Age and Treatment Group



Notes: IQ measured on the Stanford-Binet Intelligence Scale (Terman and Merrill, 1960). Test was administered at program entry and each of the ages indicated.

Source: Cunha *et al.* (2006) and Heckman and Masterov (2007) based on data provided by the High Scope Foundation.

13. Personality and Preference Parameters

Measures of personality predict a wide range of life outcomes that economists study. Personality psychologists define traits as relatively stable, person-specific determinants of behavior. Preferences are the natural counterpart of these traits in economics. However, the exact link between personality and preferences is unclear. Table 3 shows one possible correspondence between conventional economic preference parameters and personality measures.

An empirical Literature is emerging that attempts to make this correspondence. See Table 4.

<Table 3> Standard Preference Parameters and Conceptually Similar Measures in the Psychology Literature

Preference parameter	Personality measures
Time Preference	Conscientiousness Self-control Affective mindfulness Consideration of future consequences Elaboration of consequences Time preference
Risk Aversion	Impulsive sensation seeking Balloon Analogue Risk Task
Leisure Preference	Achievement Striving Endurance Industriousness
Social Preference	Warmth Gregariousness Trust Altruism Tender-mindedness Hostility

<Table 4> Empirical Studies of the Links Between Preferences and Traits

Preferences	Personality measures	Empirical study
Time Preference	Conscientiousness, Self-control, Affective mindfulness, Elaboration of consequences, Consideration of future consequences. Extraversion Time preference	Daly, Delaney and Harmen [2009] Dohmen, Falk, Huffman <i>et al.</i> [2009]
Risk Aversion	Sensation Seeking Openness Neuroticism, ambition, Agreeableness Balloon Analogue Risk Task	Zuckerman [1994], Eckel and Grossman [2002] Dohmen, Falk, Huffman <i>et al.</i> [2010] Borghans, Golsteyn, Heckman <i>et al.</i> [2009] Lejuez, Aklin, Zvolensky <i>et al.</i> [2003]
Social Preferences		
Altruism	Neuroticism, Agreeableness	Ashton, Paunonen, Helmes <i>et al.</i> [1998], Osiński [2009], Bekkers [2006]
Reciprocity	Neuroticism, Agreeableness, Conscientiousness	Dohmen, Falk, Huffman <i>et al.</i> [2008]
Trust	Neuroticism, Agreeableness, Openness, Conscientiousness	Dohmen, Falk, Huffman <i>et al.</i> [2008]

14. Summary and Conclusions

What can economists take from and contribute to personality psychology? What do we learn from personality psychology? Personality traits predict many behaviors sometimes with the same strength as conventional cognitive traits. Personality psychology considers a wider array of actions than are usually considered by economists. It enlarges the economist's way to describe and model the world. Cognition is one aspect of personality broadly defined.

Personality traits are not set in stone. They change over the life cycle. They are a possible avenue for intervention and policy.

Personality psychologists lack precise models. Economics provides a framework for recasting the field. More precise models reveal basic identification problems that plague measurement in psychology. Such analyses show that, at an empirical level, "cognitive" and "noncognitive" traits are not easily separated.

Personality psychologists typically present correlations—not causal relationships. Many contemporaneously measured relationships suffer from the problem of reverse causality. Econometric tools can be used to define and estimate causal mechanisms and to understand the causes of effects. Psychological measures have substantial measurement error. Econometric tools account for measurement error, and doing so makes a difference. Economists can formulate and estimate mechanisms of investment—how traits can be changed for the better.

There are major challenges in linking the traits of psychology with the preferences, constraints and expectation mechanisms of economics. Developing rigorous methods for analyzing causal relationships in both fields remains to be done. Developing a common language and framework to promote interdisciplinary exchange is required. There is a danger in assuming that basic questions of content and identification have been answered by psychologists at the level required for rigorous economic analysis.

References

- Ackerman, P. L. and E. D. Heggstad, "Intelligence, Personality, and Interests: Evidence for Overlapping Traits," *Psychological Bulletin* 121, 1997, pp.219~245.
- Almlund, M., A. Duckworth, J. J. Heckman, and T. Kautz, "Personality Psychology and Economics," In E. A. Hanushek, S. Machin, and L. Wößmann (eds.), *Handbook of the Economics of Education*, Volume 4. Amsterdam: Elsevier, Forthcoming, 2011.
- Ashton, M. C., S. V. Paunonen, E. Helmes, and D. N. Jackson, Kin Altruism, Reciprocal Altruism, and the Big Five Personality Factors, *Evolution and Human Behavior* 19 (1), 1998, pp.243~255.
- Barrick, M. R. and M. K. Mount, "The Big Five Personality Dimensions and Job Performance: A Meta-analysis," *Personnel Psychology* 44 (1), 1991, pp.1~26.
- Bekkers, R., "Traditional and Health-related Philanthropy: The Role of Resources and Personality," *Social Psychology Quarterly* 69 (4), 2006, pp.349~366.
- Binet, A. and T. Simon, *The Development of Intelligence in Children* (The Binet-Simon Scale), Psychological Science, Baltimore, MD: Williams & Wilkins Co, 1916.
- Borghans, L., A. L. Duckworth, J. J. Heckman, and B. ter Weel, "The Economics and Psychology of Personality Traits," *Journal of Human Resources* 43 (4), Fall 2008, pp.972~1059.
- Borghans, L., B. H. Golsteyn, J. J. Heckman, and H. Meijers, "Gender Differences in Risk Aversion and Ambiguity Aversion," *Journal of the European Economic Association* 7 (2-3), April 2009, pp.649~658.
- Borghans, L., B. H. H. Golsteyn, J. J. Heckman, and J. E. Humphries, "IQ, Achievement, and Personality," Unpublished Manuscript, University of Maastricht and University of Chicago (revised from the 2009 version), 2011.
- Borghans, L., H. Meijers, and B. ter Weel, "The role of Noncognitive Skills in Explaining Cognitive Test Scores," *Economic Inquiry* 46 (1), January 2008, pp.2~12.
- Carroll, J. B., *Human Cognitive Abilities: A Survey of Factor-Analytic Studies*. New York: Cambridge University Press, 1993.
- Cervone, D. and L. A. Pervin, *Personality: Theory and Research* (11th ed.), Hoboken: John Wiley and Sons, Inc, 2009.
- Costa, P. T. and R. R. McCrae, *Revised NEO Personality Inventory (NEO PI-R) and the NEO Five-Factor Inventory (NEO-FFI) Professional Manual*, Odessa, FL: Psychological Assessment Resources, 1992.
- Cunha, F. and J. J. Heckman, "The Technology of Skill Formation," *American Economic Review* 97 (2), May 2007, pp.31~47.
- Cunha, F. and J. J. Heckman, "The Economics and Psychology of Inequality and Human Development," *Journal of the European Economic Association* 7 (2-3), April 2009, pp.320~364. Presented as the Marshall Lecture, European Economics Association, Milan, Italy, August 29, 2008.
- Cunha, F., J. J. Heckman, L. J. Lochner, and D. V. Masterov, "Interpreting the Evidence on Life Cycle Skill Formation," In E. A. Hanushek and F. Welch (eds.), *Handbook of the Economics of Education*, Chapter 12, Amsterdam: North-Holland, 2006, pp.697~812.

- Cunha, F., J. J. Heckman, and S. M. Schennach, "Estimating the Technology of Cognitive and Noncognitive Skill Formation," *Econometrica* 78 (3), May 2010, pp.883~931.
- Daly, M., L. Delaney, and C. P. Harmon, "Psychological and Biological Foundations of Time Preferences," *Journal of the European Economic Association* 7 (2-3), 2009, pp.659~669.
- Dohmen, T., A. Falk, D. Huffman, and U. Sunde, "Representative Trust and Reciprocity: Prevalence and Determinants," *Economic Inquiry* 46 (1), 2008, pp.84~90.
- Dohmen, T., A. Falk, D. Huffman, and U. Sunde, "Are Risk Aversion and Impatience Related to Cognitive Ability?" *American Economic Review* 100 (3), 2010, pp.1238~1260.
- Duckworth, A. L., Unpublished Dataset, University of Pennsylvania, Department of Psychology, 2007.
- Eckel, C. C. and P. J. Grossman, "Sex Differences and Statistical Stereotyping in Attitudes Toward Financial Risk," *Evolution and Human Behavior* 23 (4), 2002, pp.281~295.
- Epstein, S., "The Stability of Behavior: I. On Predicting most of the People much of the Time," *Journal of Personality and Social Psychology* 37 (7), 1979, pp.1097~1126.
- Goldberg, L. R., "The Structure of Phenotypic Personality Traits," *American Psychologist* 48 (1), 1993, pp.26~34.
- Gough, H. G. and A. B. Heilbrun, "The Adjective Check List Manual," Palo Alto, CA: Consulting Psychologists Press, 1983.
- Hansen, K. T., J. J. Heckman, and K. J. Mullen, "The Effect of Schooling and Ability on Achievement Test Scores," *Journal of Econometrics* 121 (1-2), July-August 2004, pp.39~98.
- Heckman, J. J. and B. E. Honoré, "The Empirical Content of the Roy Model," *Econometrica* 58 (5), September 1990, pp.1121~1149.
- Heckman, J. J., J. E. Humphries, S. Urzúa, and G. Veramendi, "The Effects of Educational Choices on Labor Market, Health, and Social Outcomes," Unpublished Manuscript, University of Chicago, *Department of Economics*, 2011.
- Heckman, J. J., L. Malofeeva, R. Pinto, and P. A. Savelyev, "Understanding the Mechanisms Through which an Influential Early Childhood Program Boosted Adult Outcomes," Unpublished Manuscript, University of Chicago, Department of Economics (first draft, 2008). Under revision, *American Economic Review*, 2011.
- Heckman, J. J. and D. V. Masterov, "The Productivity Argument for Investing in Young Children," *Review of Agricultural Economics* 29 (3), 2007, pp. 446~493.
- Heckman, J. J., S. H. Moon, R. Pinto, P. A. Savelyev, and A. Q. Yavitz, "The Rate of Return to the HighScope Perry Preschool Program," *Journal of Public Economics* 94 (1-2), February 2010, pp.114~128.
- Heckman, J. J. and G. L. Sedlacek, "Heterogeneity, Aggregation, and Market Wage Functions: An Empirical Model of Self-selection in the Labor Market," *Journal of Political Economy* 93 (6), December 1985, pp.1077~1125.
- Heckman, J. J., J. Stixrud, and S. Urzúa, "The Effects of Cognitive and Noncognitive Abilities on Labor Market Outcomes and Social Behavior," *Journal of Labor Economics* 24 (3), July 2006, pp.411~482.
- John, O. P. and S. Srivastava, "The Big Five Trait Taxonomy: History, Measurement and Theoretical Perspectives," In L. A. Pervin and O. P. John (eds.), *Handbook of Personality: Theory and Research*, Chapter 4, New York: The Guilford Press, 1999, pp.102~138.
- Lejuez, C. W., W. M. Aklin, M. J. Zvolensky, and C. M. Pedulla, "Evaluation of the Balloon Analogue Risk Task (BART) as a Predictor of Adolescent Real-world Risk-taking Behaviours," *Journal of Adolescence* 26 (4), 2003, pp.475~479.

- Mischel, W., *Personality and Assessment*, New York: Wiley, 1968.
- Osinski, J., "Kin Altruism, Reciprocal Altruism and Social Discounting," *Personality and Individual Differences* 47 (4), 2009, pp.374~378.
- Poropat, A. E., "A Meta-analysis of the Five-factor Model of Personality and Academic Performance," *Psychological Bulletin* 135 (2), 2009, pp.322~338.
- Roberts, B. W., "Personality Development and Organizational Behavior," In B. Staw (ed.), *Research on Organizational Behavior*, Volume 27, Chapter 1, Oxford, UK: Elsevier Science/JAT Press, 2006, pp.1~41.
- Roberts, B. W., "Back to the Future: Personality and Assessment and Personality Development," *Journal of Research in Personality* 43 (2), 2009, pp.137~145.
- Roberts, B. W., N. R. Kuncel, R. L. Shiner, A. Caspi, and L. R. Goldberg, "The Power of Personality: The Comparative Validity of Personality Traits," Socioeconomic Status, and Cognitive Ability for Predicting Important Life Outcomes, *Perspectives in Psychological Science* 2 (4), December 2007, pp.313~345.
- Roberts, B. W. and D. Mroczek, "Personality Trait Change in Adulthood," *Current Directions in Psychological Science* 17 (1), 2008, pp.31~35.
- Roberts, B. W., K. E. Walton, and W. Viechtbauer, "Patterns of Mean-level Change in Personality Traits Across the Life Course: A Meta-analysis of Longitudinal Studies," *Psychological Bulletin* 132 (1), 2006, pp.1~25.
- Schmidt, F. L. and J. Hunter, "General Mental Ability in the World of Work: Occupational Attainment and Job Performance," *Journal of Personality and Social Psychology* 86 (1), 2004, pp.162~173.
- Terman, L. M. and M. A. Merrill, *Stanford-Binet Intelligence Scale: Manual for the Third Revision Form L-M*. Boston: Houghton Mifflin, 1960.
- Thaler, R. H., "A Short Course in Behavioral Economics," Edge Master Class, Sonoma, CA, July 25-27, July 2008.
- Zuckerman, M., *Behavioral Expressions and Biosocial Bases of Sensation Seeking*, New York: Cambridge University Press, 1994.