

# Preferences, Personality Psychology, and Economics: Some New Results

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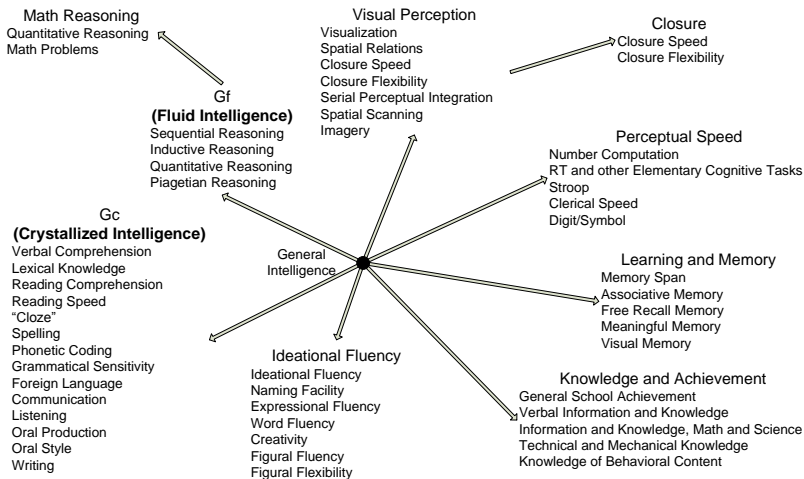
## What Are The Market (Life) Relevant Skills?

- a Traits versus skills
- b Traits as strategies
- c Relating psychological “traits” to “economic preferences”

## Cognition: “g”

- “g”: a product of early Twentieth Century psychology.
- Concept of “g” has been broadened even beyond subcomponents of “fluid” and “crystallized” intelligence.
- But still is at the center of a hierarchy of correlated traits.
- **Circularity: Validation in psychology is often done using grades and other test scores.**
- Rarely look at workplace or real behavioral productivity of these traits.
- Exceptions
  - a. Personnel psychology
  - b. AFQT and studies of achievement tests in economics

**Figure 1:** An Hierarchical Scheme of General Intelligence and Its Components



Source: Recreated from Ackerman and Heggestad [1997], based on Carroll [1993].

**Table 1:** The Big Five Domains and Their Facets

<b>Big Five Personality Factor</b>	<b>American Psychology Association Dictionary description</b>	<b>Facets (and correlated trait adjective)</b>	<b>Related Traits</b>	<b>Childhood Temperament Traits</b>
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
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*

**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
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

**Table 1:** The Big Five Domains and Their Facets

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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)	<b>Internal vs. External Locus of control</b> <b>Core self-evaluation</b> 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 [1992b]). 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 Person-Situation Debate

- Is variation across people in behavior a consequence of personal traits or of situations?

Mischel [*Personality and Assessment*, 1968, p. 146]

*“... 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.”*



## Evidence on The Predictive Power of Personality Traits

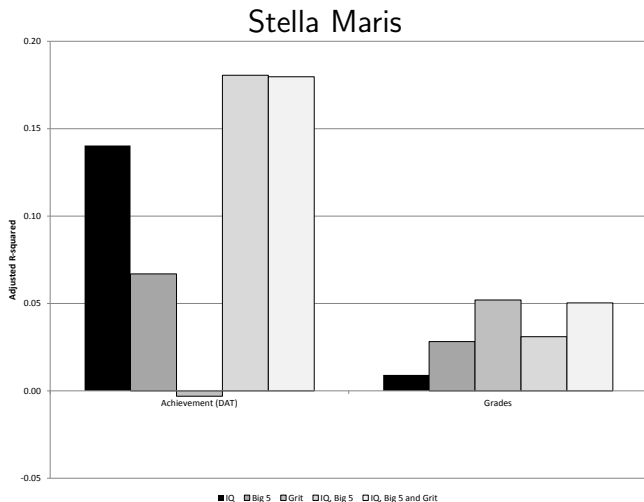
## Main Findings from Predictive Analyses

- **Conscientiousness is the most predictive Big Five trait across many outcomes.**
  - a. Educational attainment, grades
  - b. Job performance across a range of occupational categories (predictive power of “g” decreases with job complexity)
  - c. Longevity
  - d. Criminality
- Neuroticism (and related *locus of control*)
  - a. Predicts schooling outcomes
  - b. Labor market search
- Other traits play roles at finer levels.
- The GED is an informative “natural experiment”

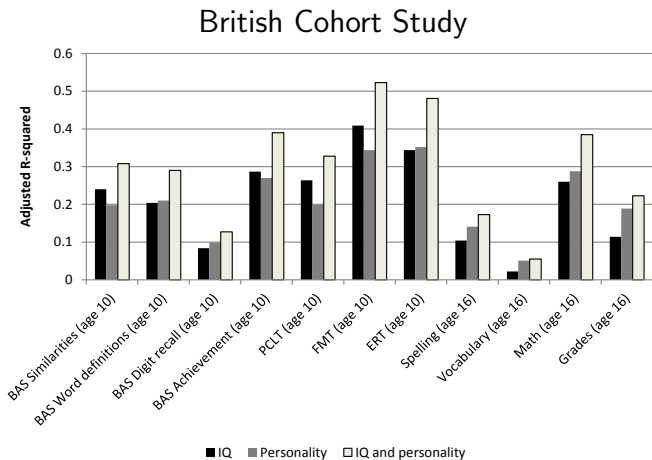
## **What Do Grades and Achievement Tests Measure?**

Lex Borghans, Bart H. H. Golsteyn, James J. Heckman and John Eric Humphries, *PNAS* (2016)

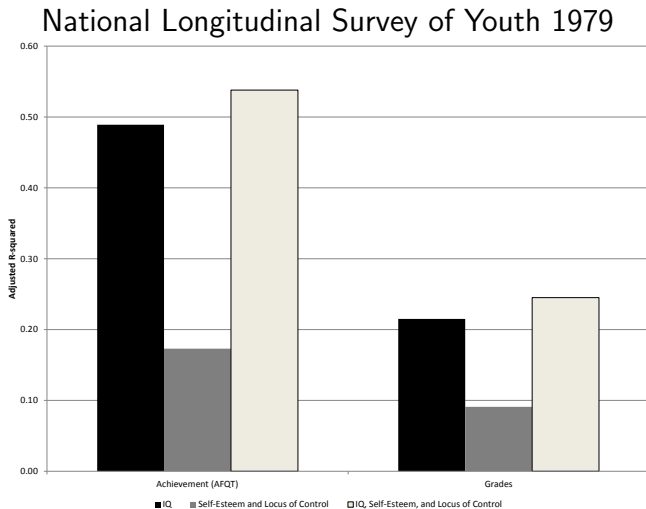
**Figure 2:** Decomposing Achievement Tests and Grades into IQ and Personality



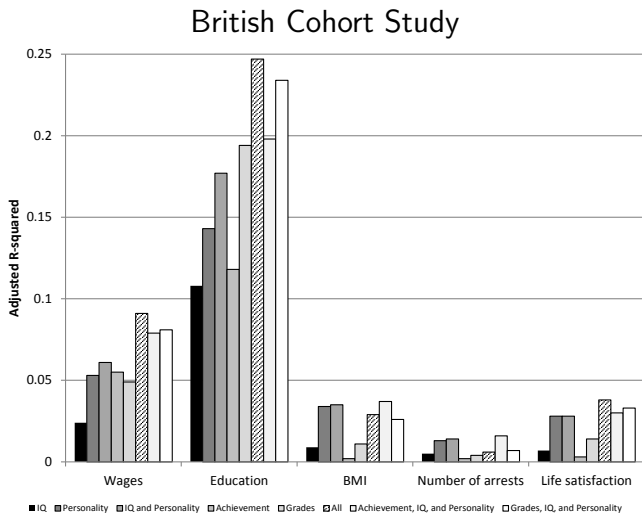
**Figure 3:** Decomposing Achievement Tests and Grades into IQ and Personality



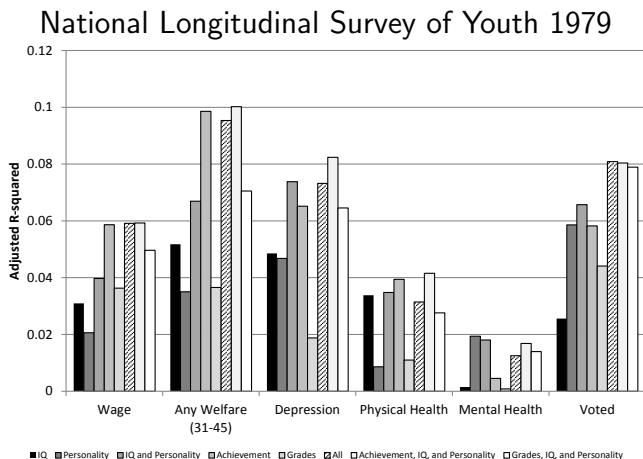
**Figure 4:** Decomposing Achievement Tests and Grades into IQ and Personality



**Figure 5: Decomposing Life Outcomes into IQ and Personality**



**Figure 6:** Decomposing Life Outcomes into IQ and Personality





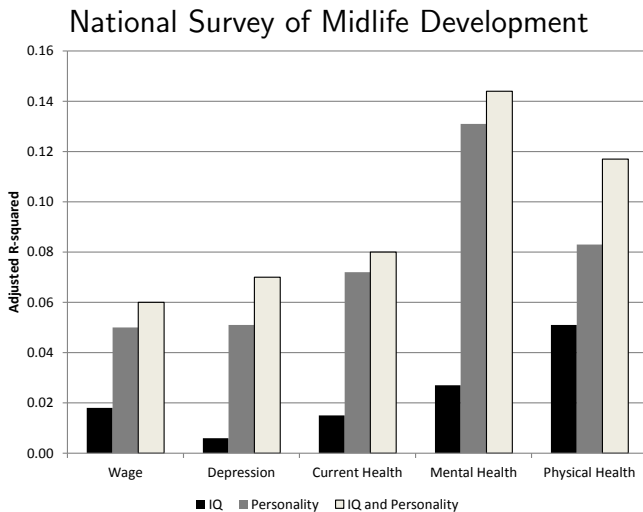
**Figure 7:** Decomposing Life Outcomes into Cognition and Personality

Table 2: Data Analyzed

Datasets	IQ	Achievement Tests	Grades	Personality Measures	Adult Outcomes
Stella Maris (Dutch H.S. students)	✓	✓	✓	✓ (Big Five; Grit)	NA
BCS (Children born in one week in 1970 followed until 38)	✓	✓	✓	✓ <sup>(1)</sup>	✓
NLSY79 (Prospective survey youth 14–21 in 1979, currently followed)	✓	✓	✓	✓ (Self Esteem; Locus of Control)	✓
MIDUS (Survey in adult life, baseline 24–34 in 1995; follow-up 2004–2006)	✓	NA	NA	✓ (Big Five)	✓

Note: “NA” denotes “not available.” Details on each data set and their measures are provided in Web Appendices 2–5. <sup>(1)</sup> Self esteem, locus of control, disorderly activity, antisocial behavior, introversion, and neuroticism.

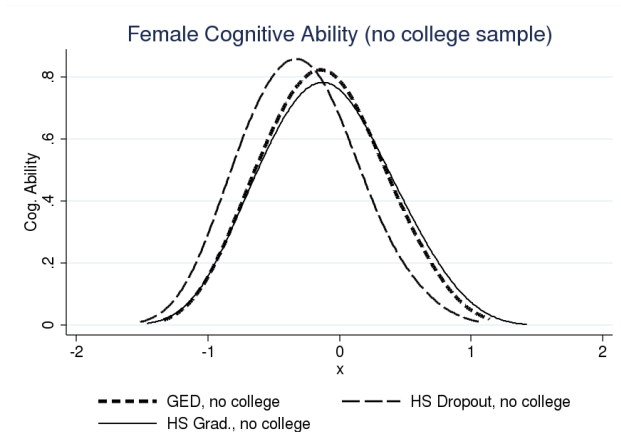
**Table 3:** Correlations (Pearson Correlations)

Correlations	Stella Maris	BCS	NLSY	MIDUS
$\rho$ (IQ, Achievement)	0.378	0.509	0.698	-
$\rho$ (IQ, Grades)	0.112	0.338	0.464	-
$\rho$ (Achievement, Grades)	0.316	0.379	0.610	-
$\rho$ (IQ, Personality)	0.195	0.451	0.291	0.189
$\rho$ (Achievement, Personality)	0.294	0.446	0.410	-
$\rho$ (Grades, Personality)	0.257	0.433	0.305	-

$p$ -values are presented in Web Appendix 6.

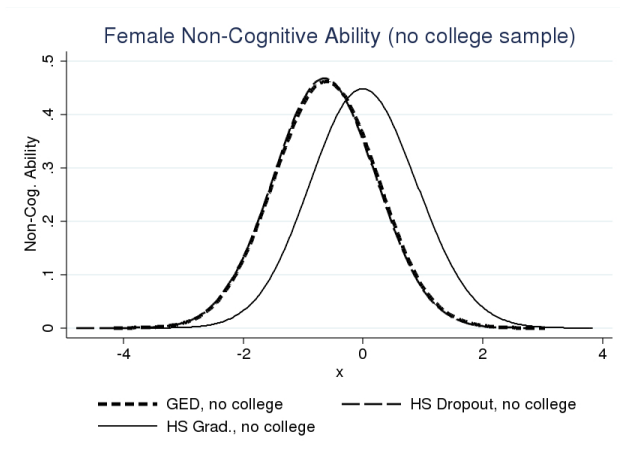
## GEDs

**Figure 8:** Distribution of Cognitive and Non-Cognitive Skills by Education Group



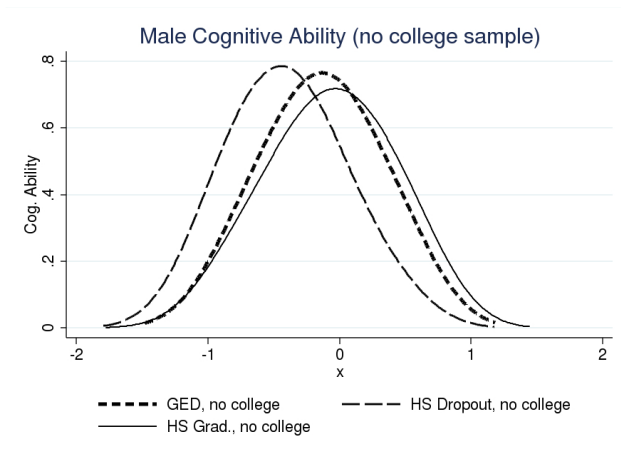
Source: Heckman, Humphries, and Veramendi (2010).

**Figure 8:** Distribution of Cognitive and Non-Cognitive Skills by Education Group, cont'd



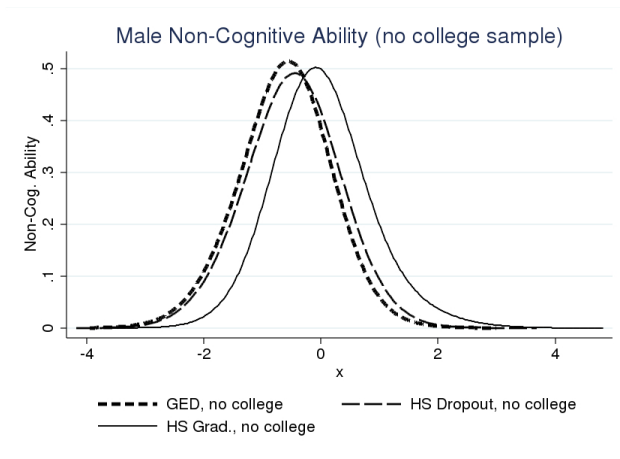
Source: Heckman, Humphries, and Veramendi (2010).

**Figure 8:** Distribution of Cognitive and Non-Cognitive Skills by Education Group, cont'd



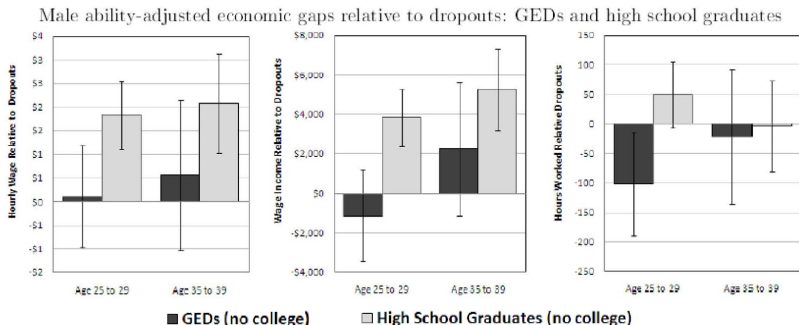
Source: Heckman, Humphries, and Veramendi (2010).

**Figure 8:** Distribution of Cognitive and Non-Cognitive Skills by Education Group, cont'd



Source: Heckman, Humphries, and Veramendi (2010).

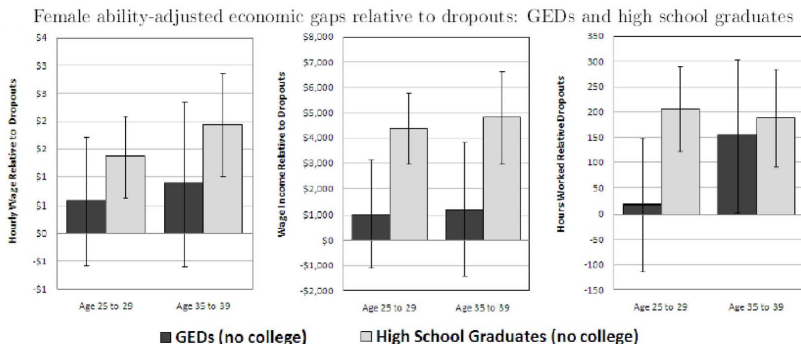
## Figure 9: Ability-Adjusted Economic Gaps Relative to Dropouts: GEDs and High School Graduates for Males



Source: Heckman, Humphries, and Mader (2010).



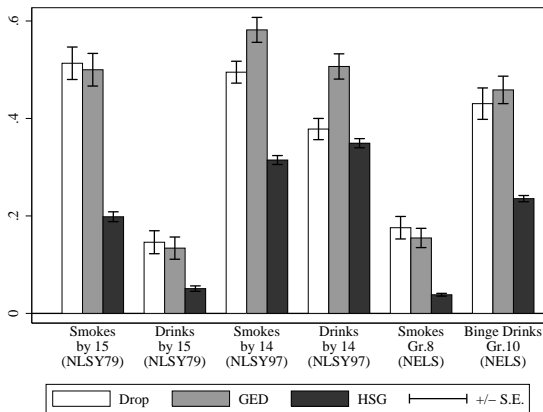
## Figure 9: Ability-Adjusted Economic Gaps Relative to Dropouts: GEDs and High School Graduates for Females



Source: Heckman, Humphries, and Mader (2010).

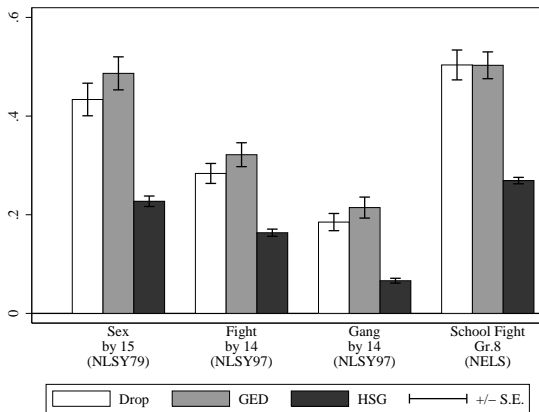
[Link to Appendix](#)

**Figure 10:** Measures of Adolescent Behaviors for Male Dropouts, GED Recipients, and High School Graduates: Smoking and Drinking



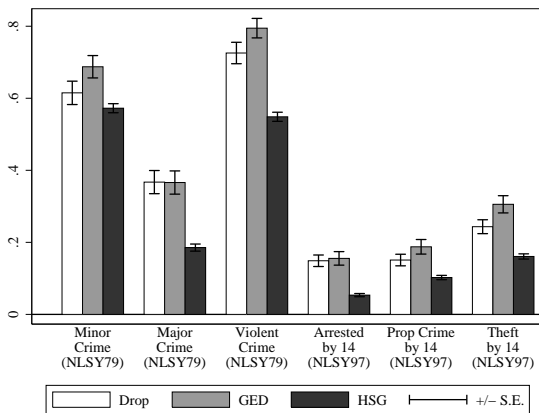
Sources: Heckman et al. (2012, Chapter 3). National Longitudinal Survey of Youth 1979, National Longitudinal Survey of Youth 1997, National Educational Longitudinal Survey. school. Notes: Minor crime includes vandalism, shoplifting, petty theft, fraud, holding or selling stolen goods. Major crime includes auto theft, breaking/entering private property, grand theft. Violent crime includes fighting, assault, aggravated assault.

**Figure 10:** Measures of Adolescent Behaviors for Male Dropouts, GED Recipients, and High School Graduates: Sex and Violent Behavior



*Sources:* Heckman et al. (2012, Chapter 3). National Longitudinal Survey of Youth 1979, National Longitudinal Survey of Youth 1997, National Educational Longitudinal Survey. *Notes:* Minor crime includes vandalism, shoplifting, petty theft, fraud, holding or selling stolen goods. Major crime includes auto theft, breaking/entering private property, grand theft. Violent crime includes fighting, assault, aggravated assault.

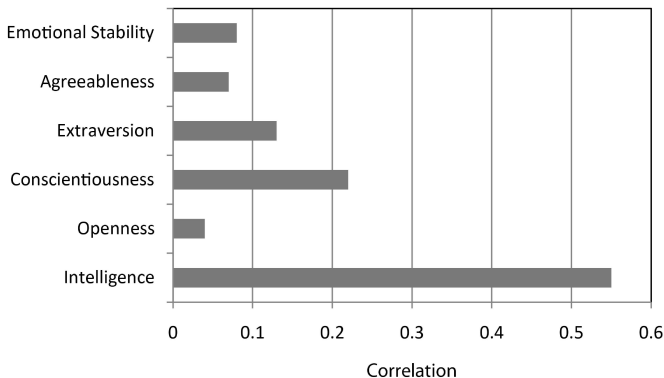
**Figure 10:** Measures of Adolescent Behaviors for Male Dropouts, GED Recipients, and High School Graduates: Criminal Behavior



Sources: Heckman et al. (2012, Chapter 3). National Longitudinal Survey of Youth 1979, National Longitudinal Survey of Youth 1997, National Educational Longitudinal Survey. school. Notes: Minor crime includes vandalism, shoplifting, petty theft, fraud, holding or selling stolen goods. Major crime includes auto theft, breaking/entering private property, grand theft. Violent crime includes fighting, assault, aggravated assault.

## Labor Market Outcomes

## Figure 11: Associations with Job Performance



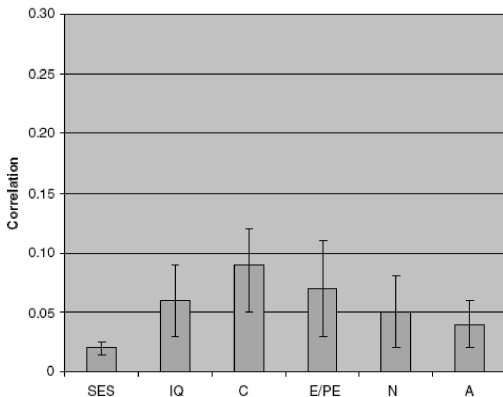
*Notes:* The values for personality are correlations that were corrected for sampling error, censoring, and measurement error. Job performance was based on performance ratings, productivity data and training proficiency. The authors do report the timing of the measurements of personality relative to 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].

## Personality and Health



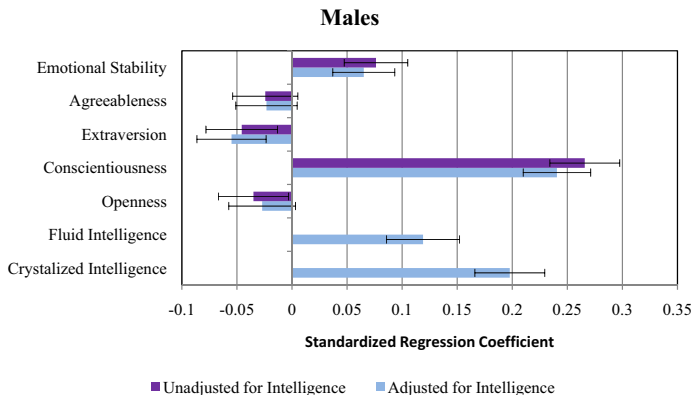
**Figure 12:** Correlations of Mortality with Personality, IQ, and Socioeconomic Status (SES)



*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, Kuncel, Shiner et al. [2007].

**Figure 13:** Association of the Big Five and intelligence with years of completed schooling



*Notes:* The figure displays standardized regression coefficients from a multivariate regression 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 21 and 94.

*Source:* Almlund et al. (2011) German Socio-Economic Panel (GSOEP), waves 2004–2008.

## **Economic Models of Personality and Their Implications for Measurement of Personality and Preference**

## How to Conceptualize These Correlations and Establish a Causal Basis for Them? Place the concept of personality within economic model(s).

- a *Personality as a strategy*: Define personality as an *emergent property* of a system.
- b Use the economic model(s) to frame and solve a central identification problem in empirical psychology (cognitive and noncognitive).
- c How to go from measurements of personality to personality traits.

## **Economic Frameworks for Conceptualizing and Measuring Personality and Personality Traits**

## How to interpret personality measurements within economic models?

Through

- Preferences? (standard approach) – but which preferences?
- Constraints? (Borghans, Duckworth, Heckman and ter Weel) or
- Expectations? (recent papers) or
- Strategies? (social interaction and situation)
- All four

## All measures are captured by performance on tasks

- All measurement systems in psychology are based on performance on these tasks gauged in various ways.
- Taking an IQ test is a task.
- Reporting a personality trait is a task.
- Distinction between traits and tasks is flimsy.

- All measurements of ability, personality, and motivation involve assessing performance on tasks.
- $a$  = actions taken.
  - **a** Produced by effort, goods, and personality traits.
- $a = f(\underbrace{e}_{\text{effort}}, \underbrace{X}_{\text{goods}}, \underbrace{\theta}_{\text{personality "traits"}})$
- $V(a, e, \psi)$ : expected valuation function of actions.
- $\psi$ : preference parameters.



- Suppose agents max  $V$  subject to

a

$$\underbrace{\bar{e}}_{\text{endowment of effort}} = \sum_i^I \underbrace{e_i}_{\text{effort allocated to action } i}$$

b

$$Y + w_j \underbrace{e_j}_{\text{effort on job}} = \underbrace{P'X}_{\text{price goods}}$$

**Question: What is the distinction between  $\psi$  and  $\theta$ ?**

- How can an economist define personality?

**Question:**

- How to identify “traits” for vectors of observed actions  $a \in \mathcal{A}$ ?

## Personality and Preference Parameters

**Table 4:** Overview of Empirical Studies of the Links Between Preferences and Traits

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

See ADHK for more complete discussion.

## **Investigating the Link: The Relationship Between Economic Preferences and Psychological Personality Measures**

Anke Becker, Thomas Deckers, Thomas Dohmen, Armin Falk, and Fabian Koss (2012, *Annual Review of Economics*)

[Link to Tomas Jagelka's 2018 Paper](#)

**Table 5:** Overview of the experimental measures in data set from laboratory experiments among university students

Preference	Experiment	Measure
Time	Two lists of choices between an amount of money “today” and an amount of money “in 12 months”.	Average switching point over both lists of choices from the early to the delayed amount.
Risk	Two lists of choices between a lottery and varying safe options.	Average switching point over both lists of choices from the lottery to the safe option.
Positive Reciprocity	Second-mover behavior in two versions of the trust game (strategy method).	Average amount sent back in both trust games.
Negative Reciprocity	Investment into punishment after unilateral defection of the opponent in a prisoner’s dilemma (strategy method).	Amount invested into punishment.
Trust	First mover behavior in two versions of the trust game.	Average amount sent as a first mover in both trust games.
Altruism	First mover behavior in a dictator game with a charitable organization as recipient.	Size of donation.





## Correlation Structure

## Experimental Data

Table 6: Spearman correlation structure experimental data set

	Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism	LoC
Time	0.0370	0.0057	-0.0084	0.1026**	-0.0518	0.0847
Risk	-0.0379	-0.0611	0.0762*	0.0202	-0.1201***	0.0434
Pos. Reciprocity	0.1724***	0.0140	0.0211	0.2042***	0.0361	0.0152
Neg. Reciprocity	-0.0885*	-0.0393	0.0943*	-0.1451***	-0.0136	-0.1418**
Trust	0.1232***	-0.1300***	0.0004	0.1665***	-0.0134	-0.0140
Altruism	0.1242**	-0.0979*	0.0249	0.1911***	0.0847*	0.0480

\*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% level, respectively. Correlations between economic preferences and the Big Five were calculated using 394–477 observations. Correlations between economic preferences and locus of control were calculated using between 254–315 observations. All measures are standardized.

## Representative Experimental Data

Table 7: Pearson correlation structure representative experimental data

	Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism
Time	-0.0080	-0.0682	-0.0655	-0.0830*	-0.0602
Risk	0.1356***	-0.0720	0.0757	-0.0941**	-0.0290

\*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% level, respectively. All measures are standardized.

## Representative Panel Data

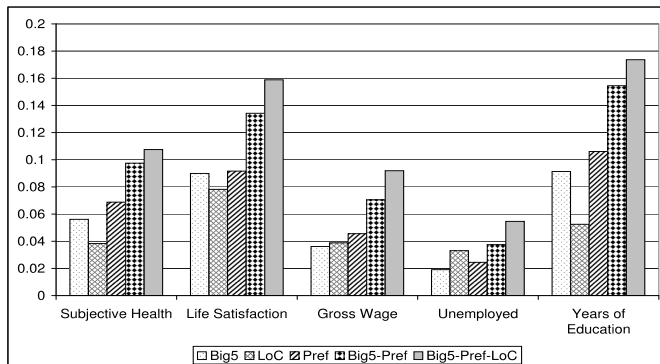
**Table 8:** Pearson correlation structure between personality measures and economic preferences from SOEP observations

	Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism	LoC
Time	0.0183**	0.1122***	-0.0415***	0.3122***	-0.0584***	0.0681***
Risk	0.2793***	-0.0400***	0.2601***	-0.1454***	-0.0996***	0.1521***
Pos. Reciprocity	0.1814***	0.2520***	0.1473***	0.1842***	0.0872***	0.0954***
Neg. Reciprocity	-0.0522***	-0.1558***	-0.0264***	-0.3756***	0.0612***	-0.2154***
Trust	0.1272***	-0.0680***	0.0575***	0.0945***	-0.1919***	0.2094***
Altruism	0.1756***	0.1495***	0.1670***	0.2557***	0.0908***	0.0874***

\*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% level, respectively. Correlations are calculated using 14,243 observations. All measures are standardized.

# Explanatory Power for Life Outcomes

Figure 14: Adjusted  $R^2$  for Life Outcomes



Adjusted  $R^2$ 's for linear regressions for life outcomes. The number of observations available varies for the different life outcomes: subjective health (14,218), life satisfaction (14,214), gross wage (7,199), unemployed (9,095), and years of education (13,768). Gross wage measures the gross hourly wage.

## Personality As A Strategy

- Effort across tasks: vector  $e = (e_1, \dots, e_J)$ .
- Affect productivity in tasks  $i$   $P = (P_1, \dots, P_J)$ ; Reward  $R_j$ .
- Output:

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

- $X$  goods,  $W$  price

- A utility function over  $X$ ,  $P$ , and  $e$ : preference parameter vector  $\psi \in \Psi$ .
- Preferences capture the psychologists' "goals."
- $\psi$  associated with choices and choice behavior.
- $\theta = (\theta_1, \dots, \theta_J)$ : vector of "skill endowments"
- $P = G_p(e_p, X_p, \theta)$ : one possible definition of productivity.
- Dig deeper.



- Preferences:

$$U(X, P, e \mid \psi), \quad (1)$$

- Agent maximizes (1) with respect

$$Y + R'P = W'X, \quad (2)$$

- $Y$  is a flow of unearned income available

$$\sum_{j=1}^J e_j = \bar{e}. \quad (3)$$

- (1) captures notion that
  - 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.

- $\mathcal{I}$  is information possessed by the agent.
- Agent can be interpreted as making decisions based on

$$E[U(X, P, e | \psi) | \mathcal{I}]. \quad (4)$$

- General specification: agents can also be uncertain about their preferences ( $\psi$ ),
- “Traits” ( $\theta$ ),
- The prices they face for goods ( $W$ ),
- The rewards to productivity ( $R$ ),
- The outcomes of purchase decisions ( $X$ ),
- And their endowments of effort ( $\bar{e}$ ).
- Freudian version: Agents may not act on what they know but rather on what subconscious motives drive them.

## An Economic Definition of Personality

- **Personality traits:** components of  $e$ ,  $\theta$  and  $\psi$  that affect behavior.
- We observe **measured personality—behaviors** generated by incentives, goals, and traits.

## How to Characterize Personality?

- Personality as the performance (the  $P_j$ ) and effort (the  $e_j$ ) that arise from solutions to the optimization problems just stated.
- Does not capture the full range of behaviors considered by personality psychologists that constitute aspects of personality.
- Actions considered by psychologists include a variety of activities that economists normally do not study, e.g., cajoling, beguiling, bewitching, charming, etc.
- To capture these more general notions: Introduce a set of “actions” broader than what is captured by  $e$ .

## Personality as Actions

- Actions: behaviors that affect how tasks are accomplished.
- Include aspects of behavior that go beyond effort  $e$ .
- Tasks: accomplished by actions.
- The  $i^{\text{th}}$  possible action to perform task  $j$ :  $a_{i,j}$ ,  $i \in \{1, \dots, K_j\}$ .
- Array actions in a vector  $a_j = (a_{1,j}, \dots, a_{K_j,j}) \in \mathcal{A}$ .
- The actions may be the same or different across the tasks.
- The actions are strategies agents use in response to situations.

- The productivity of the agent in task  $j$  depends on the actions taken in that task:

$$P_j = \tau_j (a_{1,j}, a_{2,j}, \dots, a_{K_j,j}). \quad (5)$$

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

$$a_{i,j} = \nu_{i,j} \left( \theta, e_{i,j}, \underbrace{X_j}_{\text{goods used}} \right) \quad (6)$$

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 behavior.

- Agents may have utility over actions beyond the utility they get from consuming the outputs of tasks.
- $a$ : choice of actions applied to all tasks:  
( $a = (a_1, \dots, a_J)$ ).
- $\mathcal{M}$ : the set of actions, including actions that do not directly contribute to productivity.

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

- Keep  $X_{i,m}$  implicit as a good.

- The agent solves

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

with respect to  $X$  and  $e$  given the stated constraints.



## Introducing Situations: Person vs Situation Debate

- Situations indexed by  $h \in \mathcal{H}$ .
- For a person with traits  $\theta$  and effort vector  $e_j$  with action  $a_{i,j}$ , using the specification (6)
- The action function can be expanded to be dependent on situation  $h$ :

$$a_{i,j,h} = \nu_{i,j}(\theta, e_{i,j,h}, X_{i,j}, h), \quad (7)$$

- Productivity on a task generalized to

$$P_{j,h} = \tau_j(\theta, a_{1,j,h}, \dots, a_{K_j,j,h}, X_{j,h}, h). \quad (8)$$

## Framing the Person vs Situation Debate

- Failure to control for situation  $h$ , like failure to control for effort, contaminates identification of traits using measures of actions or productivities.
- $T \in \mathcal{T}$ : vector of traits  $(\theta, \psi, \bar{e})$ .
- The solution to the general constrained maximization problem is to pick goods  $X$ , situation  $h$ , actions  $a_{i,j}$ , and effort  $e_j$ ,  $j \in \{1, \dots, J\}$  subject to the constraints.
- $h$  is fixed if the situation is forced on the agent.
- For simplicity, we analyze this case.
- More generally, situations chosen and self control strategies rely on this.
- The situations are (strategic) interactions among agents.
- Can model situations as games (see, e.g., Todd and Wolpin, *JPE*, for classroom games)

- Personalities differ depending on trait endowments, constraints, and situations.
- Actions: the data used to identify “traits.”
- Personality psychologists use actions (e.g., “dispositions”) to infer traits.

- Many personality psychologists define personality as

*“enduring patterns of thoughts, feelings  
and behaviors”*

- Tendencies of persons to respond in certain ways under certain circumstances.

## Enduring Patterns

- What are enduring patterns of actions?
- “**Enduring actions:**” average of  $a$  functions for a person with a given trait vector  $T = t$  over situations and efforts.
- History and context dependent concept.
- Endogenously chosen situations?

- Task  $j$  and trait vector  $t$
- Average action for information set  $\mathcal{I}$ :

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

- $\mathcal{S}_{T,\mathcal{I}}(h, e_{i,j}, X_{i,j})$ : support of  $(h, e_{i,j})$  given  $T$  and  $\mathcal{I}$ .

- $g(h, e_{i,j}, X_{i,j} \mid T = (\theta, \psi, \bar{e}), \mathcal{I})$ : density of  $(h, e_{i,j}, X_{i,j})$  given  $T = (\theta, \psi, \bar{e})$  and information set  $\mathcal{I}$ .
- $\bar{a}_{T,j,\mathcal{I}}$  is the “enduring action” of agents across situations in task  $j$  with information  $\mathcal{I}$ , i.e., the average personality.
- If  $\nu_{i,j}$  is separable in  $T$ , the marginal effect of personality trait vector  $\theta$  is the same in all situations.
- This is implicit assumption in personality psychology.

- “Enduring traits:” average over tasks,  $j$ ? Situations?  $h$ ? Both?
- Only under separability in  $T$  will one obtain the same marginal effect of  $\theta$ .
- Epstein (1979) and a subsequent literature present some evidence against nonseparability and in favor of an “enduring trait” that is common across situations.
- An open research topic.



## **Psychological Variables as Constraints: Another Way to Conceptualize Personality**

- A constraint-driven model need not produce a unique choice outcome for all persons with the same constraints.

- Thurstone (1927), Block and Marschak (1960), Bock and Jones (1968), and McFadden (1974, 1981), write the utility of agent  $i$  for choice  $l$  as  $U_{i,l}$ .
- $U_{i,l}$  is the motivation for choice (goal)  $l$  by agent  $i$ .
- Choice sets,  $B_i$ , differ among persons depending on their capacities.
- Agent  $i$  chooses  $\hat{l}_i$  as the maximal element in the choice set  $B_i$ :

$$\hat{l}_i = \arg \max_{l \in B_i} \{U_{i,l}\}$$

- A familiar model writes  $U_{i,l} = V_{i,l} + \varepsilon_{i,l}$ , where  $V_{i,l}$  is agent  $i$  valuation for  $l$  and  $\varepsilon_{i,l}$  is a random “taste” shock.
- When  $V_{i,l} = V_l$ , and  $\varepsilon_{i,l}$  is iid extreme value type 1, the probability that  $l$  is selected from choice set  $B_i$  is

$$\begin{aligned} \Pr(l \mid B_i) &= \frac{\exp(V_l)}{\sum_{j \in B_i} \exp(V_j)} \text{ for } l \in B_i \\ &= 0, \text{ for } l \notin B_i. \end{aligned} \tag{9}$$

- If agents have zero mean scale preference among the choices ( $V_l = 0$ ) so that all choices (goals) have the same mean utility, we obtain a version of Becker’s (1962) model of irrational behavior.

Depending on how the constraints are determined, one can capture a variety of aspects of choice behaviour.

- A shy person may limit her options in a way an extrovert does not.
- An intelligent person may have a much richer choice set not only because of greater earnings capacity but also because of much greater imagination.
- Much like greater pixel resolution in imaging machines, those with higher IQ may resolve reality in a more fine-grained and less biased way.
- We capture the effect of these traits on the choice sets, which may also depend on material endowments.

## Another Model

### Incorporating Personality and Cognitive Ability into Conventional Economic Models: A Simple Framework for Organizing the Evidence

- How should one incorporate psychological traits into conventional economic models?
- One could think of them as public goods.
- This is the approach implicitly adopted by most personality psychologists.
- One could also think of psychological traits as excludable private goods.
- More of a trait used in one activity means less of the trait available for use in other activities.

## Digression on Becker's Household Production

[Link to Appendix](#)

## Traits Entering Household Production

[Link to Appendix](#)



[Link to Appendix for Becker et al.](#)

Further information on the relationship between economic preferences and conventional personality measures

## Other Research

### Altruism and Social Preferences

- There is a large literature in economics on altruism and an emerging literature in economics on social preferences.
- Bergstrom (1997) and Laitner (1997) discuss models of interdependent family preferences.
- Andreoni (1995) shows that pure models of altruism are inconsistent with the evidence (“warm glow”).
- Villanueva (2005) and Laferrère and Wolff (2006) summarize the mixed evidence on altruism in families.

- A recent literature explores social preferences which are distinct from altruism per se.
- Altruism is based on the assumption that the preferences of one agent depend on the consumption or utility of other agents.
- Social preferences are preferences that depend on agent's evaluations of a social condition (inequality, for example) or the intentions of other agents.
- Fehr and Schmidt (1999) analyze inequality aversion (in which people dislike inequality rather than valuing the consumption or utility of agents per se).
- Fehr and Gächter (2000), and Falk and Fischbacher (2006) present evidence on reciprocity and conditional cooperation, in which agents act in a pro-social or antisocial manner depending on the behavior of others with whom they interact.
- Fehr and Schmidt (2006) summarize the theory and empirical support for social preferences.

## Identifying Personality “Traits” from Measured Performance on Tasks

- Key assumption: Some tasks may require only a single trait or a subset of all of the traits.

- 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  $\theta$ , say  $\theta_{1,j}$ , and we standardize for incentives and effort.

- Assumes task  $j$  output is

$$P_j = \phi_j(\theta_{1,j}, e_j).$$

- One must standardize for the 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**.
- *Need to standardize for effort to measure the trait.*
- Otherwise produces variation in the measured trait across situations with different incentives.

## A Fundamental Identification Problem

- Operationalization and construct validation require heroic assumptions.
- Even if one adjusts for effort in a task, productivity in a task may depend on *multiple traits*.
- Thus two components of  $\theta$  (say  $\underbrace{\theta_{1,\mu}}_{\text{mental}}$ ,  $\underbrace{\theta_{1,\pi}}_{\text{personality}}$ ) 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.



- Ignore measurement error for now.
- 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 support of  $e_j$  and  $e_{j'}$  is disjoint, no  $(\theta_{1,\mu}, \theta_{1,\pi})$  uniquely defined.
- If the system of equations satisfies a local rank condition, then one can solve for the pair  $(\theta_{1,\mu}, \theta_{1,\pi})$  at  $e^*$ .

- Note, however, that **only the pair is identified**.
- One cannot (without further information) determine which component of the pair is  $\theta_{1,\mu}$  or  $\theta_{1,\pi}$ .
- In the absence of **dedicated constructs** (constructs that are generated by only one component of  $\theta$ ), 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.
- Need only one such construct joined with patterned structures on how  $\theta$  enters other task to identify the vector  $\theta$  (e.g., one example is a recursive, triangular structure).

## Examples of Nonidentification Problems

IQ and Achievement Test Scores Reflect Incentives and Efforts, and Capture Both Cognitive and Personality Traits

## Table 9: 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)

- Many other studies (see ADHK).

## Hard Evidence on Soft Skills

- How are validities determined?

Table 10: Validities of GED Test

Test	Correlation	Source(s)
Armed Forces Qualification Test (AFQT)	0.75 - 0.79 †	Means and Laurence (1984)
Iowa Test of Educational Development	0.88 †	Means and Laurence (1984)
American College Test (ACT)	0.80 †	Means and Laurence (1984)
Adult Performance Level (APL) Survey	0.81 †	Means and Laurence (1984)
New York's Degrees of Reading Power (DRP) Test	0.77 †	Means and Laurence (1984)
Test of Adult Basic Education (TABE)	0.66-0.68 †	Means and Laurence (1984)
General Aptitude Test Battery (GATB)	0.61-0.67 †	Means and Laurence (1984)
National Adult Literacy Survey (NALS) factor	0.78 ‡	Baldwin (1995)

† Uses mean GED subtest scores

‡ Uses a general GED factor

Table 11: Cognitive Ability Validities

Test	Validation Domain	Estimate(s)	Source(s)
SAT (Achievement)	1st Year College GPA	0.35 - 0.53	Kobrin et al. (2008)
ACT (Achievement)	Early College GPA	0.42	ACT, Inc. (2007)
GED (Achievement)	HS Senior GPA	0.33 - 0.49	GED Testing Service (2009)
DAT (Achievement)	College GPA	0.13 - 0.62 <sup>†</sup>	Omizo (1980)
AFQT (Achievement)	9th Grade GPA	0.54	Borghans et al. (2011)
WAIS (IQ)	College GPA	0.38 - 0.43	Feingold (1982)
WAIS (IQ)	HS GPA	0.62	Feingold (1982)
Various IQ**	9th Grade GPA	0.42	Borghans et al. (2011)
WISC (IQ)	WRAT (Achievement)	0.44 - 0.75 <sup>‡</sup>	Hartlage and Steele (1977)

Table 11: Cognitive Ability Validities

Test	Validation Domain	Estimate(s)	Source(s)
WISC-R (IQ)	WRAT (Achievement)	0.35 - 0.76 <sup>†</sup>	Hartlage and Steele (1977)
Various IQ**	AFQT (Achievement)	0.65	Borghans et al. (2011)
Stanford Binet (IQ)	WISC-R (IQ)	0.77 - 0.87	Rothlisberg (1987), Greene et al. (1990)
Raven's (IQ)	WAIS-R (IQ)	0.74 - 0.84	O'Leary et al. (1991)
WIAT (Achievement)	CAT/2 (Achievement)	0.69 - 0.83*	Michalko and Saklofske (1996)

<sup>†</sup> Large range is due to varying validity of eight subtests of DAT

<sup>‡</sup> Ranges are given because correlations vary by academic subject

\* Ranges are given because correlations vary by grade level

\*\* IQ is pooled across several IQ tests using IQ percentiles

**Notes:** WISC – Wechsler Intelligence Scale for Children, WISC-R – Wechsler Intelligence Scale for Children - Revised, WAIS - Wechsler Adult Intelligence Scale, Raven's IQ – Raven's Standard Progressive Matrices, GED – General Educational Development, DAT – Differential Aptitude Test, WIAT – Wechsler Individual Achievement Test, CAT – California Achievement Test, WRAT – Wide Range Achievement Test



**Table 12:** Correlations Among NLSY79 Measures of Cognition

	Correlation between IQ, AFQT, and GPA		
	IQ	Achievement (AFQT)	Grade Point Average (GPA)
IQ	1		
AFQT	0.65	1	
GPA(9th)	0.42	0.54	1

*Source:* National Longitudinal Survey of Youth (NLSY79). Pooled male and female random sample. *Notes:* The Armed Forces Qualifying Test (AFQT) was administered in 1980 when subjects were 15-22. AFQT is adjusted for schooling at the time of the test conditional on final schooling, following the procedure in Hansen et al. (2004). AFQT is constructed from Arithmetic Reasoning, Word Knowledge, Math Knowledge, and Paragraph Comprehension tests. IQ and GPA are from high school transcripts. IQ is pooled across several IQ tests using IQ percentiles. GPA is the individual's core-subject GPA measured in 9th grade when virtually all sample participants are enrolled. Differences between males and females are slight. For the sake of brevity we report pooled results.

**Table 13:** Validities in Labor Market Outcomes from the National Longitudinal Survey of Youth, 1979

NLSY79 R <sup>2</sup> (tests and school performance)						
Outcomes	Males			Females		
	<u>IQ</u>	<u>GPA (10<sup>th</sup> grade)</u>	<u>AFQT</u>	<u>IQ</u>	<u>GPA (10<sup>th</sup> grade)</u>	<u>AFQT</u>
Hourly Wage Age 35	0.03	0.05***	0.05***	0.11***	0.10***	0.13***
Hours Worked Age 35	0.10***	0.12***	0.21***	0.02	0.10***	0.17***
Any Welfare Age 35	-0.09***	-0.11***	-0.23***	-0.20***	-0.23***	-0.36***

Source: Borghans et al. (2011).

## Stability of Traits Changing Preference Parameters and Psychological Traits?

- If they change, to what extent do environments and investments influence the developmental trajectories of personality traits?

**Figure 15:** Mean Executive Function (MEF) App Mean Total Score by Age in Months in Typically Developing Children from 2-17.9 Years

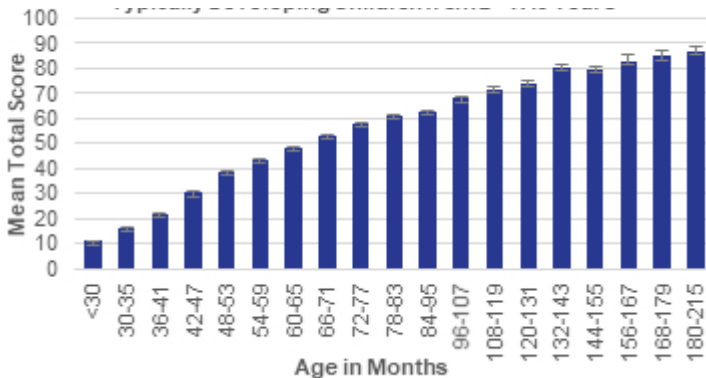


Fig 1. Note:  $N = 32.795$ ;  $p < .0001$ . Bars show standard error.

## Results from the Psychological Literature Based on Cross Sections

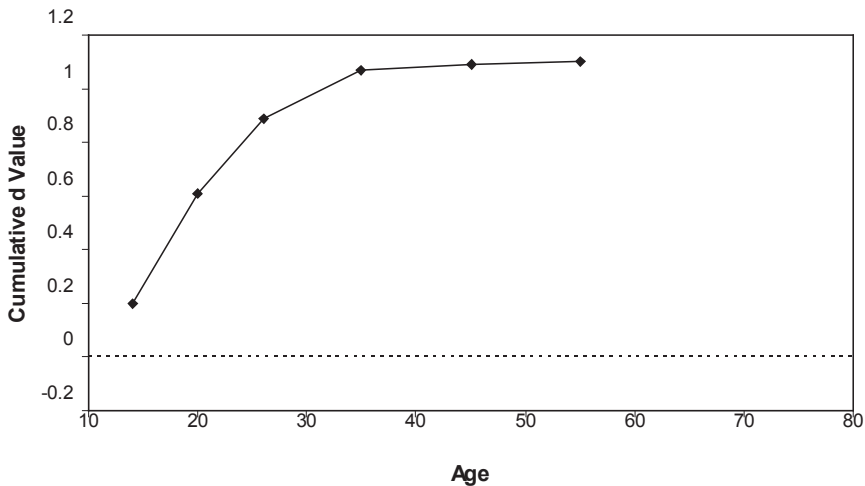
- The malleability of personality can be defined and measured in several ways: Mean-level change refers to change over time in absolute levels of a trait and is measured by changes in scores over time.
- Rank-order change, in contrast, refers to changes in the ordinal ranking of a trait in a population and is measured by test-retest rank correlations.
- Cognitive abilities exhibit dramatic mean-level change from early childhood through adolescence, but, over the same period, strong rank-order stability.

- A second useful dichotomy contrasts normative change, defined as changes that are typical of the average individual in a given population, and caused either by biological programming (ontogenic) or by predictable changes in social roles (sociogenic), and non-normative change, encompassing both intentional change, caused by deliberate, self-directed efforts, deliberately chosen changes in social roles and atypical life events (trauma, for example).

## Mean Level Changes

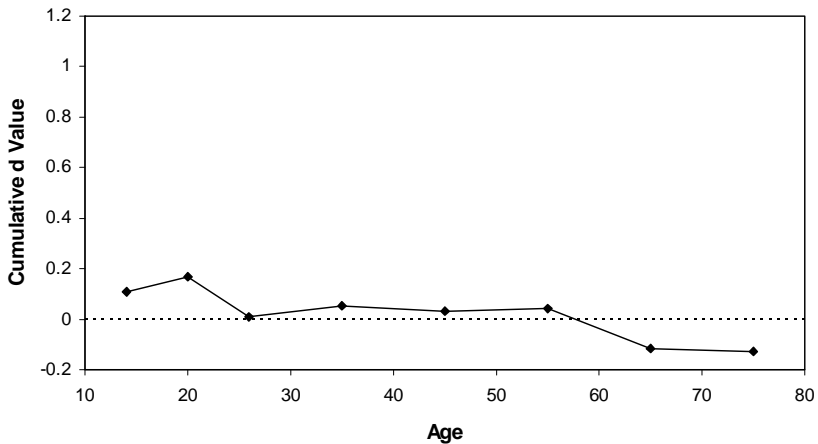
- People typically become more socially dominant

## Social Dominance

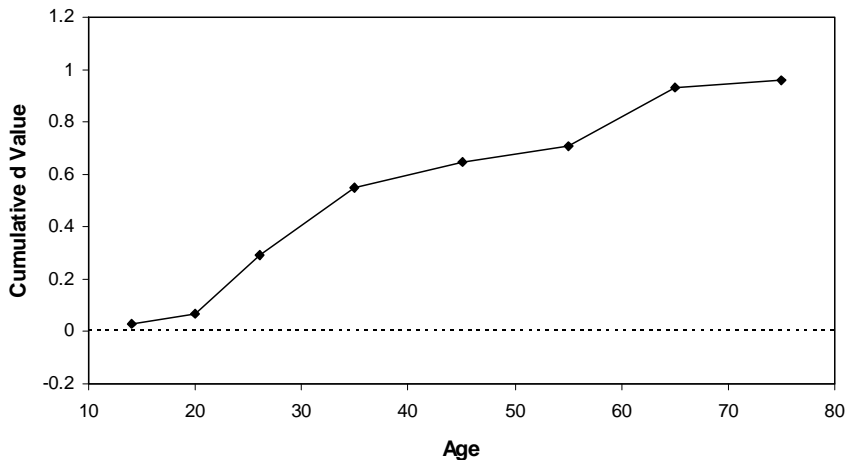




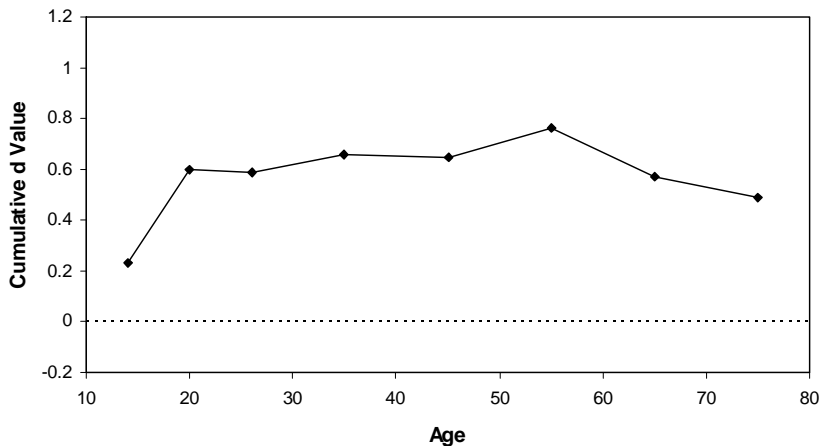
## Social Vitality



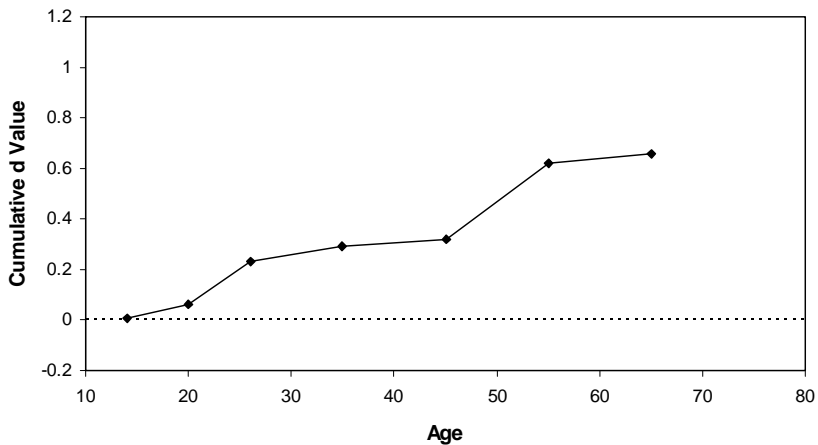
# Conscientiousness



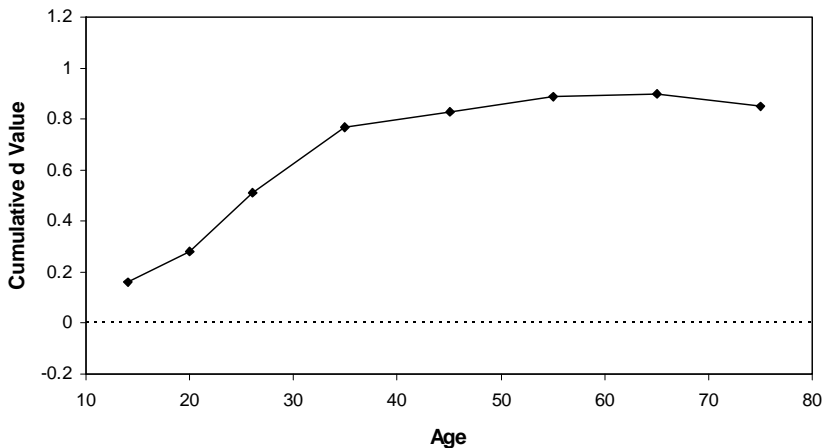
## Openness to Experience



## Agreeableness

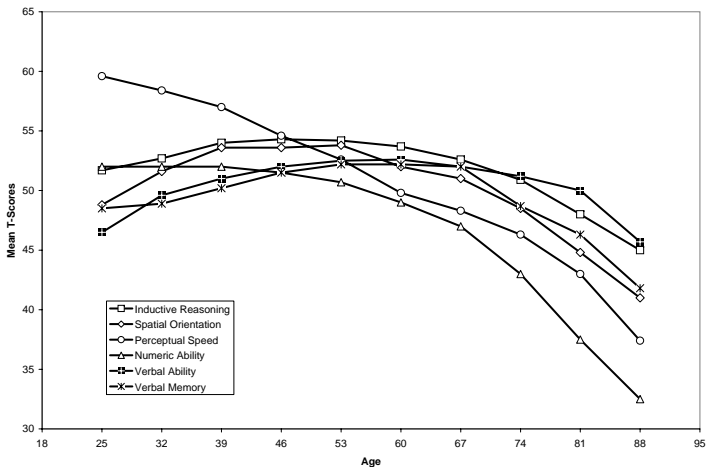


## Emotional Stability

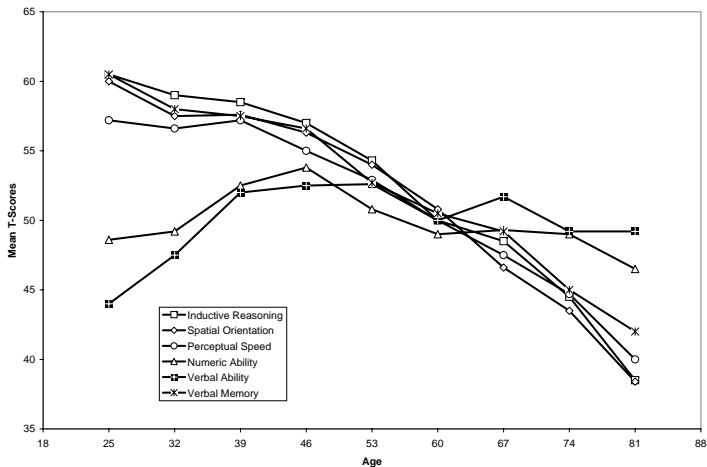


- Figure 16a shows mean-level changes in cognitive skills using a longitudinal analysis, and the bottom panel of Figure 16b shows mean-level changes using a cross-sectional analysis.

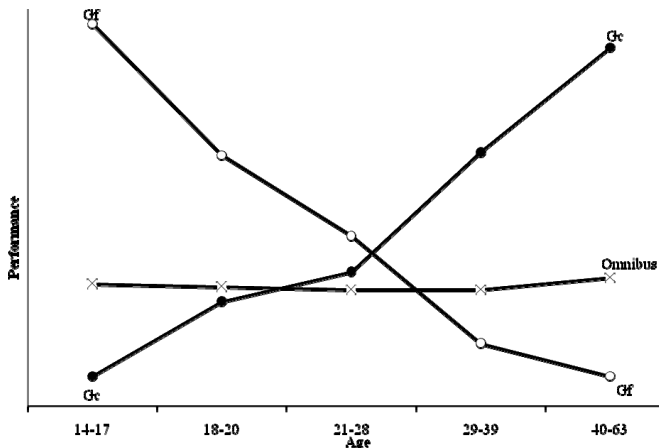
**Figure 16:** Mean-Level Changes in Cognitive Skills Using a Longitudinal Analysis



**Figure 16:** Mean-Level Changes in Cognitive Skills Using a Cross-Sectional Analysis







**Figure 4c**

*Fluid intelligence decreases and crystallized intelligence increases across the lifespan*

Note: Figure from Horn (1970). Used with permission of Elsevier.

## Rank-Order Change in Cognitive and Personality Skills

- Figure 17a shows graphs of rank order stability of personality by age.
- Figure 17b shows rank order stability of IQ over broad age ranges.

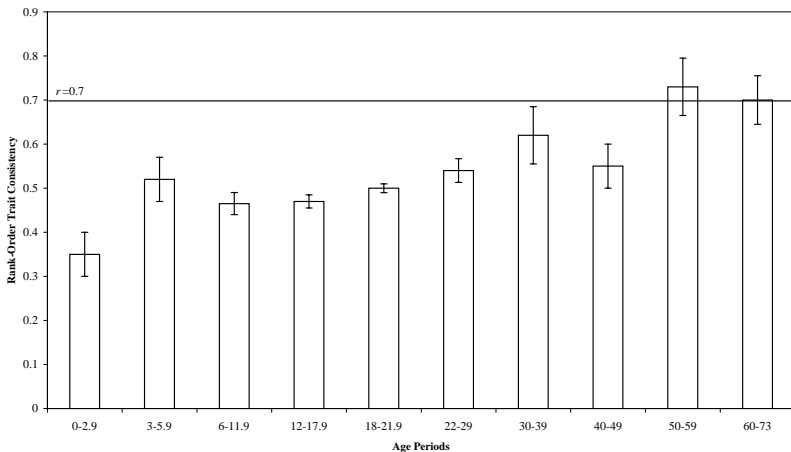
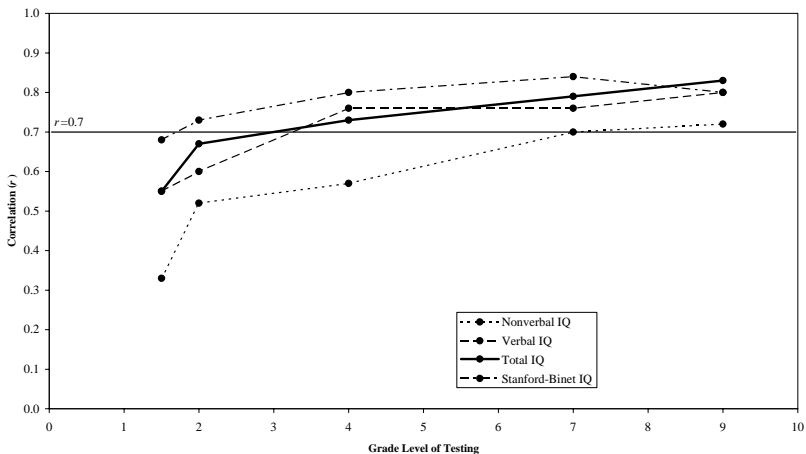
**Figure 17: Rank Order Stability: Personality by Age**

Figure 17: Rank Order Stability: IQ over Broad Age Ranges

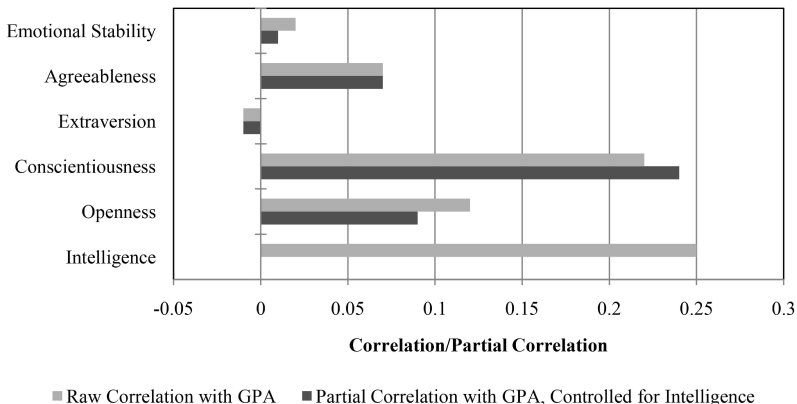


# Factor Analysis: A Key Tool in Defining and Measuring Personality

[Link to Appendix](#)

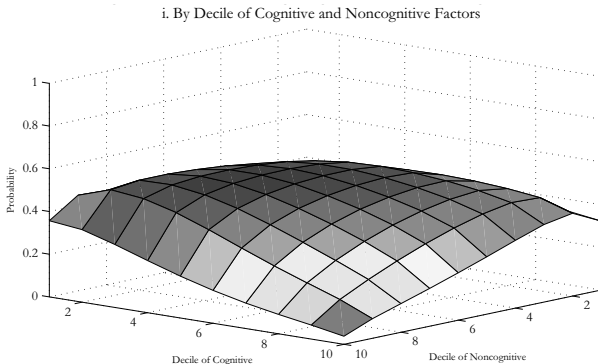
## Appendix

**Figure 18:** 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].

## Figure 19: Probability of Being a High School Graduate at Age 30 and Not Going on to Further Education, Males

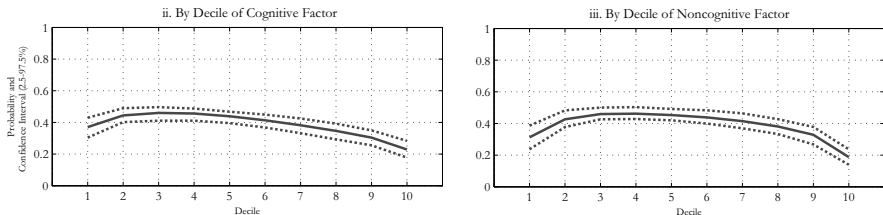


*Notes:* The data are simulated from the estimates of the model and the NLSY79 sample. Higher deciles are associated with higher values of the variable. The confidence intervals are computed using bootstrapping (200 draws). Solid lines depict probability, and dashed lines, 2.5%-97.5% confidence intervals. 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, Stixrud and Urzua [2006, Figure 19].



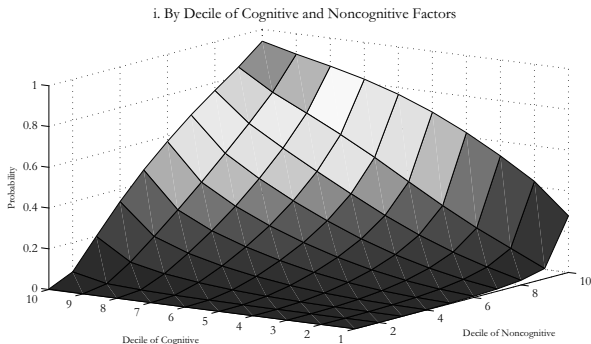
## Figure 19: Probability of Being a High School Graduate at Age 30 and Not Going on to Further Education, Males



*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, Stixrud and Urzua [2006, Figure 19].

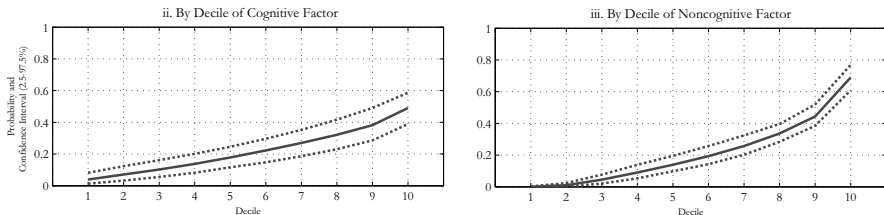
## Figure 20: Probability of Being a 4-year-college Graduate or Higher at Age 30, Males



*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, Stixrud and Urzua [2006, Figure 21].

## Figure 20: 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, Stixrud and Urzua [2006, Figure 21].

[Return to main text](#)

**Appendix for Becker et al.  
The Relationship Between Economic Preferences and  
Psychological Personality Measures Paper**

**Table 14:** Spearman correlation structure experimental data set

	Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism	LoC
Time	0.0388	0.0162	-0.0114	0.1077**	-0.0684	0.1063*
Risk	0.0027	-0.0486	0.0786*	0.0206	-0.0995**	0.0485
Pos. Reciprocity	0.1606***	0.0078	0.0177	0.2029***	0.0152	0.0441
Neg. Reciprocity	-0.0967*	-0.0221	0.0462	-0.083*	-0.0165	-0.1376**
Trust	0.1354***	-0.1198***	0.002	0.1696***	-0.002	-0.0648
Altruism	0.0969*	-0.0804	0.0034	0.2000***	0.0879*	0.0418

\*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% level, respectively. Correlations between economic preferences and the Big Five were calculated using 394–477 observations. Correlations between economic preferences and Locus of Control were calculated using 254–315 observations. All measures are standardized.

**Table 15:** Spearman correlation structure representative experimental data

	Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism
Time	-0.0199	-0.0737	-0.0764*	-0.0829*	-0.0598
Risk	0.1315*	-0.0744	0.0661	-0.0854*	-0.0261

\*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% level, respectively. All measures are standardized.

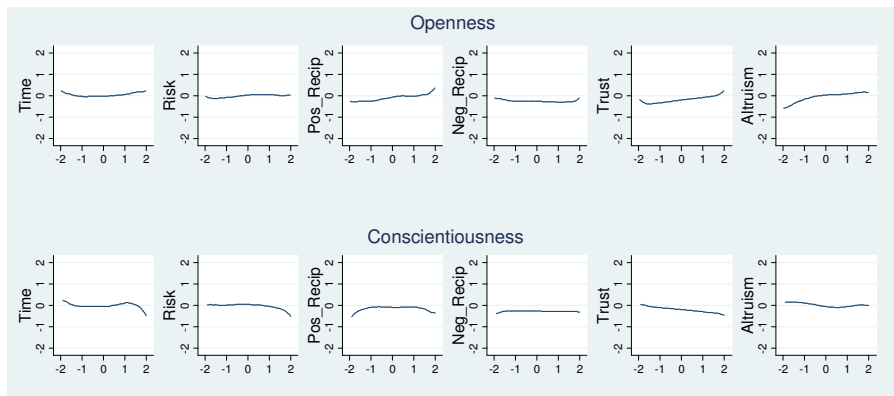
**Table 16:** Spearman Correlation Structure SOEP

	Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism	LoC
Time	0.0233	0.1192	-0.0342	0.3099	-0.0643	0.0709
Risk	0.2632	-0.0500	0.2452	-0.1496	-0.1049	0.1426
Pos. Reciprocity	0.1835	0.2622	0.1547	0.1947	0.0808	0.1041
Neg. Reciprocity	-0.0616	-0.1767	-0.0426	-0.3853	0.0572	-0.2257
Trust	0.1224	-0.0693	0.0523	0.0788	-0.1889	0.2012
Altruism	0.1693	0.1501	0.1602	0.2416	0.0860	0.0843

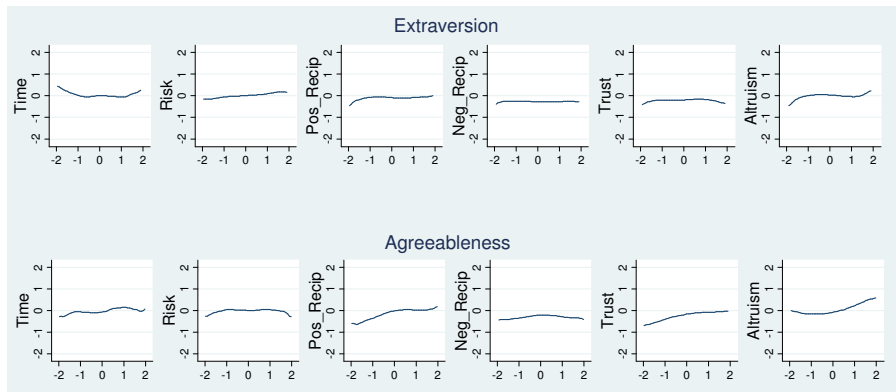
All correlations are significant at the 1% level and are calculated using 14,243 observations. All measures are standardized.



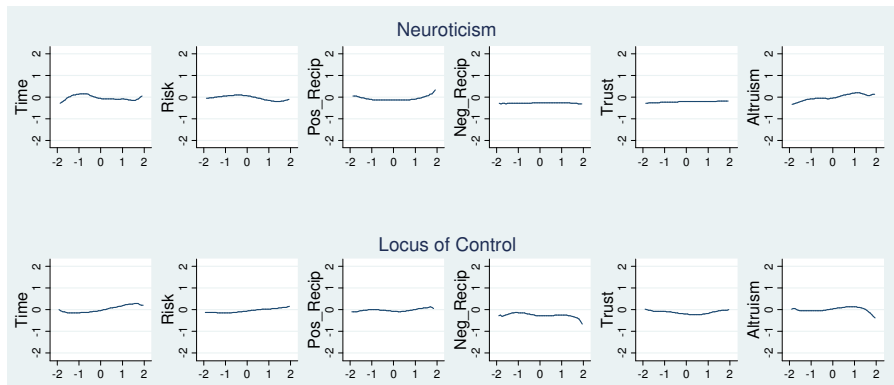
**Figure 21:** Kernel-weighted local linear polynomial regressions using experimental data



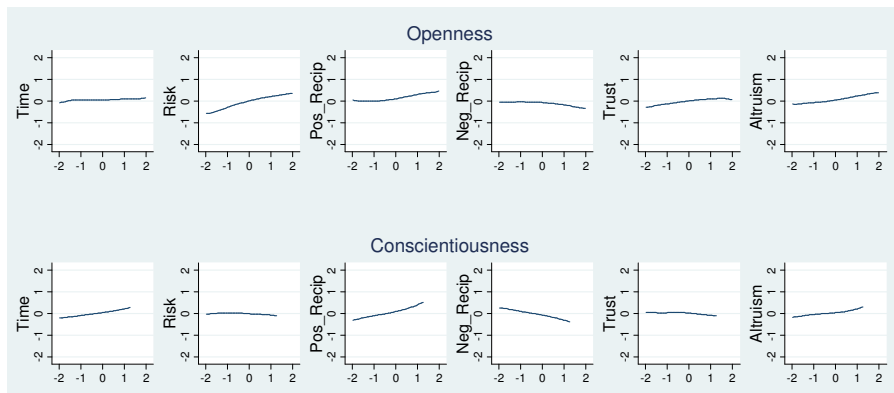
**Figure 21:** Kernel-weighted local linear polynomial regressions using experimental data Cont'd



**Figure 21:** Kernel-weighted local linear polynomial regressions using experimental data Cont'd



**Figure 22:** Kernel-weighted local linear polynomial regressions using SOEP data



**Figure 22:** Kernel-weighted local linear polynomial regressions using SOEP data Cont'd

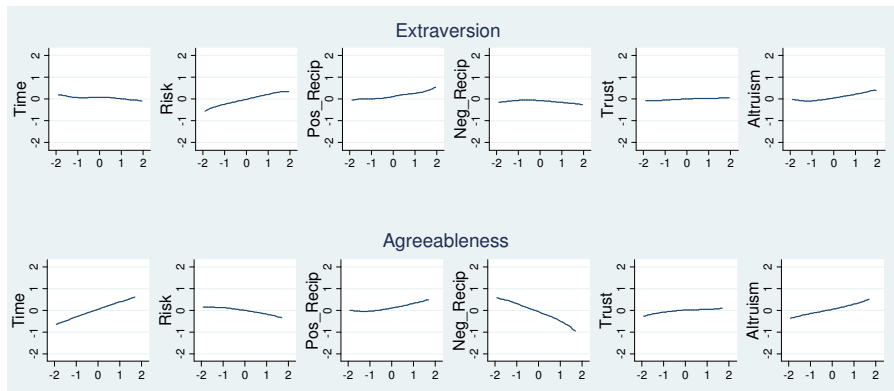
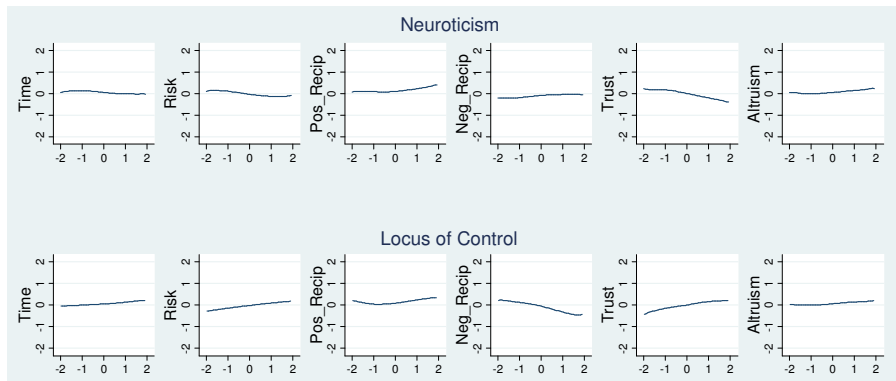


Figure 22: Kernel-weighted local linear polynomial regressions using SOEP data Cont'd



**Table 17: Outcome Regressions: Representative Experimental Data**

	(1)	(2)	(3)	(4)	(5)
Life Outcomes	Subj. Health	Life Satisf.	Gross Wage	Unemployed	Years of Educ.
Openness	0.043*** (0.009)	0.123*** (0.017)	0.989*** (0.162)	-0.018*** (0.004)	0.667*** (0.027)
Conscientiousn.	0.038*** (0.009)	0.106*** (0.017)	0.565*** (0.161)	-0.014*** (0.004)	-0.182*** (0.026)
Extraversion	0.026*** (0.009)	0.134*** (0.017)	-1.201*** (0.154)	0.006* (0.004)	-0.309*** (0.026)
Agreeableness	0.033*** (0.010)	0.139*** (0.018)	-1.288*** (0.165)	0.023*** (0.004)	-0.146*** (0.028)
Neuroticism	-0.140*** (0.009)	-0.186*** (0.016)	-1.009*** (0.158)	0.018*** (0.004)	-0.272*** (0.026)

\*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% level, respectively. All measures are standardized.

**Table 17: Outcome Regressions: Representative Experimental Data**  
Cont'd

	(1)	(2)	(3)	(4)	(5)
Life Outcomes	Subj. Health	Life Satisf.	Gross Wage	Unemployed	Years of Educ.
LoC	0.105*** (0.008)	0.307*** (0.015)	1.899*** (0.145)	-0.043*** (0.003)	0.421*** (0.024)
Patience	0.024*** (0.008)	0.129*** (0.015)	-0.343** (0.136)	0.001 (0.003)	-0.151*** (0.023)
Risk	0.131*** (0.009)	0.076*** (0.017)	0.415** (0.166)	0.003 (0.004)	0.210*** (0.027)
Pos. Recip.	-0.035*** (0.008)	0.006 (0.015)	0.388*** (0.140)	-0.002 (0.003)	0.005 (0.023)
Neg. Recip.	0.064*** (0.008)	0.039** (0.015)	-0.329** (0.147)	0.006* (0.003)	-0.137*** (0.024)

\*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% level, respectively. All measures are standardized.

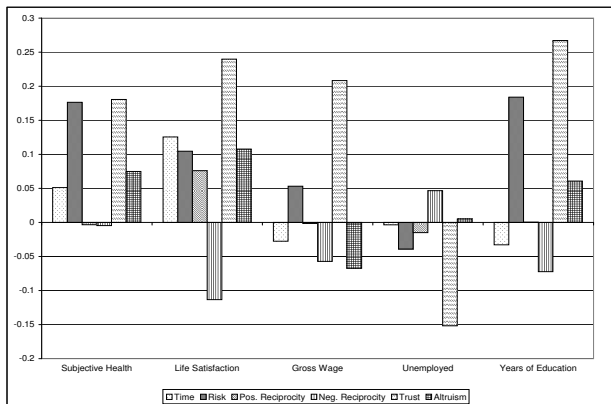


**Table 17:** Outcome Regressions: Representative Experimental Data  
Cont'd

	(1)	(2)	(3)	(4)	(5)
Life Outcomes	Subj. Health	Life Satisf.	Gross Wage	Unemployed	Years of Educ.
Trust	0.122*** (0.009)	0.308*** (0.015)	1.763*** (0.145)	-0.035*** (0.003)	0.587*** (0.024)
Altruism	0.070*** (0.009)	0.072*** (0.016)	-0.780*** (0.152)	0.005 (0.003)	0.084*** (0.025)
Constant	3.300*** (0.007)	6.852*** (0.014)	16.100*** (0.131)	0.099*** (0.003)	12.346*** (0.021)
Observations	14,218	14,214	7,199	9,095	13,768
Adj. R-squared	0.108	0.159	0.0919	0.0547	0.174

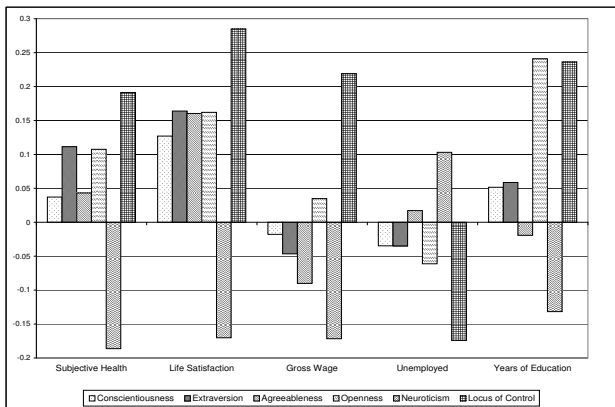
\*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% level, respectively. All measures are standardized.

**Figure 23:** Correlation Coefficients Between Preference Measures and Life Outcomes Using SOEP Data



Pearson correlation coefficients between preference measures and life outcomes using SOEP data. Trust always shows the strongest association with life outcomes. More trust and a higher willingness to take risk are always related to better life outcomes, e.g. better health and greater life satisfaction, whereas negative reciprocity is associated with less life satisfaction and lower wages. The number of observations available varies for the different life outcomes: subjective health (14,218), life satisfaction (14,214), gross wage (7,199), unemployed (9,095), years of education (13,768). Gross wage measures the gross hourly wage.

**Figure 24:** Correlation Coefficients Between Personality Measures and Life Outcomes Using SOEP Data



Pearson correlation coefficients between personality measures and life outcomes using SOEP data. The locus of control and neuroticism show the strongest associations with life outcomes. A more internal locus of control is always related to better outcomes (e.g. better health or more life satisfaction), whereas a higher degree of neuroticism is associated with lower wages or a higher probability of being unemployed. The number of observations available varies for the different life outcomes: subjective health (14,218), life satisfaction (14,214), gross wage (7,199), unemployed (9,095), years of education (13,768). Gross wage measures the gross hourly wage.

Table 18: Linear representation of outcome regressions

	Subjective Health (OLS)					Subjective Health (o. probit)				
	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC
adj. $R^2$ /pseudo $R^2$	0.0561	0.0383	0.0688	0.0975	0.1075	0.0220	0.0145	0.0268	0.0388	0.0429
F-Test/LR-Test	170.04	567.35	176.01	140.59	143.72	834.99	550.62	1016.47	1471.22	1627.11
AIC	37833	38094	37641	37201	<u>37043</u>	37139	37415	36960	36515	<u>36361</u>
BIC	37878	38109	37694	37292	<u>37142</u>	37207	37453	37035	36628	<u>36482</u>
	Life Satisfaction (OLS)					Life Satisfaction (o. probit)				
	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC
adj. $R^2$ /pseudo $R^2$	0.0899	0.0782	0.0917	0.1342	0.1588	0.0261	0.0219	0.0256	0.0390	0.0467
F-Test/LR-Test	281.88	1206.91	240.08	201.27	224.67	1406.38	1178.16	1376.73	2098.73	2513.61
AIC	55038	55216	55012	54335	<u>53926</u>	52448	52668	52480	51768	<u>51355</u>
BIC	55083	55231	55065	54426	<u>54024</u>	52561	52751	52601	51926	<u>51521</u>
	Gross Wage(OLS)									
	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC	-	-	-	-	-
adj. $R^2$ /pseudo $R^2$	0.0361	0.0388	0.0456	0.0704	0.0919	-	-	-	-	-
F-Test/LR-Test	54.97	291.20	58.31	50.57	61.71	-	-	-	-	-
AIC	55088	55088	55042	54857	<u>54690</u>	-	-	-	-	-
BIC	55102	55102	55090	54940	<u>54779</u>	-	-	-	-	-

Table 18: Linear representation of outcome regressions Cont'd

	Unemployed (OLS)					Unemployed (probit)				
	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC
adj. $R^2$ /pseudo $R^2$	0.0191	0.0331	0.0245	0.0375	0.0547	0.0322	0.0527	0.0412	0.0648	0.0926
F-Test/LR-Test	36.34	312.13	39.05	33.22	44.82	180.12	294.52	230.37	361.89	517.42
AIC	3067	2932	3017	2900	<u>2738</u>	5420	5298	5372	5250	<u>5097</u>
BIC	3110	2946	3067	2986	<u>2830</u>	5463	5312	5422	5336	<u>5189</u>
	Years of Education (OLS)					Years of Education (o. probit)				
	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC
adj. $R^2$ /pseudo $R^2$	0.0914	0.0525	0.1061	0.1545	0.1736	0.0209	0.0126	0.0241	0.0359	0.0415
F-Test/LR-Test	277.93	763.89	273.29	229.74	242.03	1355.80	817.10	1563.14	2329.14	2688.38
AIC	65506	66078	65282	64520	<u>64206</u>	63490	64021	63285	62529	<u>62171</u>
BIC	65551	66093	65335	64610	<u>64304</u>	63641	64141	63443	62724	<u>62375</u>

Table 19: Outcome Regressions: Flexible Specification

	Subjective Health (OLS)					Subjective Health (o. probit)				
	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC
adj. $R^2$ /pseudo $R^2$	.0632	.0388	.0714	.1054	.1165	.0251	.0146	.0282	.0435	.0483
F-Test/LR-Test	48.99	288.17	41.48	22.75	21.83	952.98	555.19	1068.56	1651.38	1834.03
AIC	37740	38088	37623	37142	<u>36977</u>	37051	37413	36949	36467	<u>36310</u>
BIC	37899	38110	37834	37732	<u>37665</u>	37232	37458	37184	37079	<u>37021</u>
	Life Satisfaction (OLS)					Life Satisfaction (o. probit)				
	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC
adj. $R^2$ /pseudo $R^2$	.0948	.0783	.0948	.1397	.1659	.0278	.0219	.0273	.0422	.0505
F-Test/LR-Test	75.47	605.45	56.12	30.967	32.41	1493.78	1178.45	1470.26	2273.51	2715.76
AIC	54976	55214	54984	54311	<u>53884</u>	52391	52670	52428	51725	<u>51309</u>
BIC	55135	55237	55196	54901	<u>54572</u>	52617	52761	52708	52383	<u>52065</u>
	Gross Wage(OLS)									
	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC	-	-	-	-	-
adj. $R^2$ /pseudo $R^2$	.0382	.0387	.0527	.0797	.1039	-	-	-	-	-
F-Test/LR-Test	15.30	145.74	15.84	9.092	10.27	-	-	-	-	-
AIC	55111	55090	55009	54851	<u>54672</u>	-	-	-	-	-
BIC	55256	<u>55111</u>	55202	55388	55298	-	-	-	-	-

Table 19: Outcome Regressions: Flexible Specification Cont'd

	Unemployed (OLS)					Unemployed (probit)				
	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC
adj. $R^2$ /pseudo $R^2$	.0212	.0385	.0291	.0463	.0705	.0357	.0539	.0498	.0852	.1166
F-Test/LR-Test	10.87	183.13	11.11	6.73	8.66	199.54	301.02	278.38	475.96	651.83
AIC	3062	2882	2995	2882	<u>2662</u>	5431	5294	5366	5268	<u>5118</u>
BIC	3211	<u>2903</u>	3194	3437	3309	5580	<u>5314</u>	5565	5823	5766
	Years of Education (OLS)					Years of Education (o. probit)				
	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC	Big5	LoC	Pref	Big5-Pref	Big5-Pref-LoC
adj. $R^2$ /pseudo $R^2$	.1043	.0525	.1200	.1771	.1982	.0243	.0126	.0281	.0433	.0497
F-Test/LR-Test	81.13	382.50	70.55	39.48	38.81	1575.60	817.25	1819.82	2808.59	3223.85
AIC	65324	66079	65087	64213	<u>63869</u>	63300	64023	63070	62181	<u>61792</u>
BIC	65482	66102	65297	64800	<u>64554</u>	63564	64151	63386	62874	<u>62583</u>



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## Appendix for Digression on Becker's Household Production

- We now formally introduce a revised theory of choice in which purchased goods are one of the inputs into the production of “commodities” that directly enter preferences.
- This approach reduces the need to rely on differences in tastes and increases the importance of differences in prices and incomes, the two parameters that can be treated by our framework.
- In addition, it incorporates the value of time systematically into the price structure and “full” income into the budget constraint.
- Preferences are assumed to be an ordered function of a set of commodities  $Z_1, \dots, Z_m$ , and for the reasons discussed earlier, the indifference curves between different  $Z_i$  can be considered strictly convex.

Households themselves “produce” these commodities by combining different market goods, own time, and other inputs in the production functions:

$$Z_i = f_i(X_1, X_2, \dots, X_i, t_1, t_2, \dots, t_p; R) \quad (10)$$

- $f_i$  = production function for  $Z_i$
- $X_1, \dots, X_i$  = inputs of different goods purchased into  $Z_i$
- $t_1, \dots, t_p$  = inputs of different kinds of time
- $R$  = other variables

The production of a meal, for example, may require the input of bread, wine, steak, shopping time, preparation time, chairs, cookbooks, and so forth. This approach abandons the traditional separation between production and consumption and makes households producers as well as consumers.

Choices are restricted to the opportunity space determined by various constraints, one being the set of production functions. The total expenditure on market goods is limited by the money income available, as in

$$\sum_{i=1}^m p_i X_i = I \quad (11)$$

- $X_i$  represents all the goods used to produce  $Z_i$

During any period, the sum of the time used to produce different commodities plus the time spent at work must equal the total time available:

$$\sum_{i=1}^m t_i + t_w = t \quad (12)$$

- $t$  is 168 hours per week, 720 hours per month, and so forth.
- An implication is that any time not spent at work, including time spent sleeping, would be an input into the production of some commodity.
- In rich countries especially, the time “budget” constraint is important as time is probably the major limitational factor.

Income not only equals the total expenditure on goods but also the sum of all factor payments, and can be written as:

$$wt_w + V = I = \sum p_i X_i \quad (13)$$

- $w$  = average wage rate
- $V$  = other income
- Hence, the separate goods and time constraints can be converted into a single total resource constraint by substituting for  $t_w$  from Equation 3:

$$\sum_{i=1}^m p_i X_i + \sum_{i=1}^m wt_i = wt + V = S \quad (14)$$

- If  $w$  were constant, the term  $S$  on the right would be a measure of income, not the actual income  $I$ , but the “full” income that would be realized if all time were devoted to market work.
- Unlike  $I$ ,  $S$  is not affected by variations in time worked caused by unemployment, overtime, illness, or retirement.
- Thus, by using  $S$  to measure the constraint on resources, the major causes of the difference between actual and “permanent” earnings are automatically eliminated.
- The terms on the left show that full income is “spent” partly on goods and partly by foregoing earnings to use time in household production.
- The first term gives the goods component of the price of commodities and the second the time component.

- This interpretation becomes more transparent if a fixed amount of  $X_i$  and a fixed amount of  $t_i$  are always required to produce a unit of  $Z_i$ .
- Then the general production functions  $f_i$  could be written in the simple form

$$X_i = a_i Z_i; t_i = b_i Z_i \quad (15)$$



- $a_i$  and  $b_i$  are fixed input-output coefficients

$$\sum_{i=1}^m a_i p_i Z_i + \sum_{i=1}^m b_i w Z_i = \sum_{i=1}^m \pi_i Z_i = S \quad (16)$$

The term

$$\pi_i = a_i p_i + b_i w \quad (17)$$

is the sum of the cost of goods per unit of  $Z_i$ , given by  $a_i p_i$ , and the “shadow” or opportunity cost of time, given by  $b_i w$ , and is, therefore, the “shadow” price of a unit of  $Z_i$ .

- The cost of time is full integrated into the analysis and treated symmetrically to the cost of goods; indeed, in the United States, the opportunity cost of time may be more important than the direct costs of goods.
- Each household can be said to choose the  $Z_i$  subject to the single resource constraint.
- Put in this form, the analysis is formally the same as in the conventional approach, and the theorems derived earlier still hold.

- A weighted average of the full-income elasticities of the  $Z_i$  would add up to unity, and a “pure” decline in the relative price of  $Z_i$  would increase its quantity consumed.
- A major novelty of the new approach is in the effect of wage rates on consumption.
- An increase in the wage rate would increase the cost of all the  $Z_i$ , but especially of those  $Z_i$  with a relatively important time component. (Why?)
- The *relative* prices of these commodities would increase, and their consumption would be discouraged.

## Environmental Variables

- In the new approach, the effects of age, education, climate, ability, and other “environmental” variables on behavior can be introduced through the household production functions instead of through tastes.
- These variables would be represented by  $R$ .
- For example, households in warm climates could produce a “comfortable indoor temperature” with smaller inputs of heating fuel, insulation, and clothing than could those in cold climates.
- Similarly, educated persons may be able to produce a given level of “health” with relatively small inputs of food and medical care because of greater awareness of the vitamin content of different foods, the deleterious effects of cigarette smoking, or the benefits of exercise.

- Again, “abler” housewives could produce better “meals” from a given expenditure on food and time.
- If an increase in one environmental variable, say, education, improved efficiency by reducing the  $a_i$  and  $b_i$  input coefficients, it would reduce the cost of producing commodities, and thus would expand opportunities, *even if full income were not affected*.
- If all input coefficients fell by the same percentage, all commodity prices would also fall by the same percentage (Why?), and no substitution effects would result.
- An income effect would result from the expansion in opportunities, and the  $Z_i$  would be increased in proportion to their income elasticities.

- What would be the effect on demand for different goods and time, which are more directly observable than the  $Z_i$ ?
- If an increase in education reduced all input coefficients by the same percentage, the percentage increase in output from given inputs would be the same for all commodities.
- This would, however, be too small an increase for commodities with income elasticities greater than unity, too large for those with elasticities less than unity, and just right for those with elasticities equal to unity.
- Consequently, more of the goods and time entering the first set of commodities (the “luxuries”) would be used, less of those entering the second set (the “necessities”), and the same amount of those entering the third.



- In this model, education and other environmental variables enter the demand functions for goods not because they change tastes, as in the traditional approach, but because they change the efficiency of household production.
- Moreover, their effects on demand can not only be *described* statistically, but can also be *predicted*.
- For example, even if (full) money income were held constant, an increase in education would tend to increase the demand for goods (and time) with high income elasticities and reduce the demand for those with low elasticities.
- By reducing the reliance on ad hoc shifts in tastes, this method of handling environmental variables is a powerful tool for greatly expanding the predictive content of economic theory.

## Appendix of Chapter

1. Since the price of  $Z_i$  is  $\pi_i = a_i p_i + b_i w$ , the effect on  $\pi_i$  of a change in, say, education that did not change wage rates or market prices would be

$$\frac{d\pi_i}{dE} = p_i \frac{da_t}{dE} + w \frac{db_i}{dE} \quad (18)$$

or

$$\tilde{\pi}_i \equiv \frac{d\pi_i}{dE} \frac{1}{\pi_i} = s_i \tilde{a}_i + (1 - s_i) \tilde{b}_i \quad (19)$$

where

$$s_i = \frac{a_i p_i}{\pi_i}, \quad \tilde{a}_i = \frac{da_i}{dE} \frac{1}{a_i}, \quad \text{etc.} \quad (20)$$

If  $\tilde{a}_i = \tilde{b}_i$ , clearly

$$\tilde{\pi}_i = \tilde{a}_i = \tilde{b}_i \quad (21)$$

and if  $\tilde{a}_i = \tilde{b}_i = \tilde{a}_j$ , all  $i$  and  $j$ , then

$$\tilde{\pi}_i = \tilde{\pi}_j \quad (22)$$

If real full income is defined as

$$S^* = \frac{S}{\pi} = \frac{S}{\sum \nu_i \pi_i} \quad (23)$$

where the  $\nu_i$  are fixed weights, then abstracting from the effect of  $E$  on  $S$ ,

$$\tilde{S}^* = -\pi = -\sum \left( \frac{\nu_i \pi_i}{\pi} \right) \tilde{\pi}_i \quad (24)$$

The above equation reduces to

$$\tilde{S}^* = -\tilde{\pi}_i \quad (25)$$

2. If the income elasticity of demand for  $Z_i$  were  $\eta_i$ , the increased demand for  $Z_i$  would be

$$\tilde{Z}_i^D = \tilde{S}^* \eta_i = -\tilde{\pi}_i \eta_i = -\tilde{\pi}_i \eta_i \quad (26)$$

The increased supply of  $Z_i$  from given inputs of  $X_i$  and  $t_i$  would be

$$\tilde{Z}_i^S = -\tilde{\pi}_i \quad (27)$$

and, therefore, the induced change in demand for  $X_i$  (or  $t_i$ ) would be

$$\tilde{X}_i^D = \tilde{Z}_i^D - \tilde{Z}_i^S \quad (28)$$

$$= -\tilde{\pi}_i(\eta_i - 1) \quad (29)$$

$$= -\tilde{\pi}(\eta_i - 1)$$

3. The demand for  $Z_i$  would also be affected by a substitution effect; the total change would be

$$\tilde{Z}_i^D = -\tilde{\pi}\eta_i - \epsilon_i(\tilde{\pi}_i - \tilde{\pi}) \quad (30)$$

where

$$\epsilon_i = -\frac{\partial Z_i}{\partial(\pi_i/\pi)} \cdot \frac{\pi_i/\pi}{Z_i} \quad (31)$$

is the “pure” elasticity of demand.



Since  $\tilde{Z}_i^S$  is still given above,

$$\tilde{X}_i^D = -\tilde{\pi}\eta_i - \epsilon_i(\tilde{\pi}_i - \tilde{\pi}) + \tilde{\pi}_i \quad (32)$$

or, by adding and subtracting  $\tilde{\pi}$ ,

$$\tilde{X}_i^D = -\tilde{\pi}(\eta_i - 1) - (\tilde{\pi}_i - \tilde{\pi})(\epsilon_i - 1) \quad (33)$$

The derived demand for  $X_i$  and  $t_i$  would move in the same direction as the relative price of  $Z_i$  if the price and income elasticities of demand for  $Z_i$  both exceeded unity, and in the opposite direction if they both were less than unity.

# Problems

1. When income, age, and a few other variables are held constant, more educated persons are healthier than less educated ones; yet probably the former spend less on medical care than do the latter. Can you explain this?
2. When permanent income is held constant, an increase in education appears to reduce the number of children and television sets a family has, and the pounds of food it consumes, at the same time that the amount spent per child, per television set, and per pound of food increases. Can you explain these effects by using the model of household production of commodities?

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## **Factor Analysis: A Key Tool in Defining and Measuring Personality**

- $T_{n,l}$ : trait  $l$  for person  $n$ .
- Use multiple measures on the same traits to control for measurement error.

### Dedicated Factor Case

- $P_{n,l}^q$ :  $q$ th measurement on trait  $l$  for person  $n$ .
- The  $q$ th measurement of factor  $l$  for person  $n$  is

$$P_{n,l}^q = \mu_l^q + \lambda_l^q T_{n,l} + \epsilon_{n,l}^q, \quad (34)$$
$$q = 1, \dots, Q_l, n = 1, \dots, N, l = 1, \dots, L$$

- More general case:

$$P_{n,l}^q = \mu_l^q + (\boldsymbol{\lambda}^q)' \mathbf{T}_n + \epsilon_{n,l}^q, \quad q = 1, \dots, Q_l. \quad (35)$$

- $\boldsymbol{\lambda}^q$  is a vector with possibly as many as L nonzero components.
- The  $\epsilon_{n,l}^q$  are assumed to be independent of  $T_n$  and mutually independent within and across constructs ( $l$  and  $l'$  are two constructs).
- Cunha, Heckman and Schennach [2010] develop nonlinear factor models (nonlinear and nonparametric).

- Conventional psychometric validity of a collection of items or test scores for different constructs has three aspects.

### **Discriminant Validity**

- a Factor  $T_l$  for construct  $l$  is statistically independent of factor  $T_{l'}$  for construct  $l' \neq l$ .

### **Convergent Validity**

- b A factor  $T_l$  is assumed to account for the intercorrelations among the items or tests within a construct  $l$ .
- c Item-specific and random error variance are low (intercorrelations among items are high within a cluster).



## Predictive Validity

- An alternative criterion for validating measurement systems is based on the predictive power of the tests for real world outcomes, that is, on behaviors measured outside of the exam room or observer system.

## Problems with Predictive Validity

- 1 All measurements of factor  $T_{n,l}$  can claim incremental predictive validity as long as each measurement is subject to error ( $\epsilon_{n,l}^q \neq 0$ ).
- 2 *Reverse causality*.
- 3 Especially problematic when interpreting contemporary correlations between personality measurements and outcomes.

- The problem of reverse causality is sometimes addressed by using early measures of traits determined well before the outcomes are measured to predict later outcomes.
- This approach is problematic if the traits the analyst seeks to identify evolve over time and the contemporary values of traits drive behavior.
- Trades a reverse causality problem with a version of an errors in variables problem.
- Early measures of the traits may be poor proxies for the traits that drive current measured behavior.

## Factor Models: A Brief Digression

Suppose we have five measurements on  $R_i$

- $i = 1, \dots, 5$
- $\tilde{R}_i = \mu_i + R_i$
- $E(R_i) = 0$
- Then  $E(\tilde{R}_i) = \mu_i$  and we identify means of measurements

## Identifying Variances and Factor Loadings

$$R_1 = \alpha_1\theta + \varepsilon_1, \quad R_2 = \alpha_2\theta + \varepsilon_2, \quad R_3 = \alpha_3\theta + \varepsilon_3,$$

$$R_4 = \alpha_4\theta + \varepsilon_4, \quad R_5 = \alpha_5\theta + \varepsilon_5,$$

$$\varepsilon_i \perp\!\!\!\perp \varepsilon_j, \quad i \neq j, \quad \theta \perp\!\!\!\perp \varepsilon_i, \quad i = 1, \dots, 5$$

$$E(\theta) = 0; \quad E(\varepsilon_i) = 0; \quad i = 1, \dots, 5$$

$$\text{Cov}(R_1, R_2) = \alpha_1\alpha_2\sigma_\theta^2$$

$$\text{Cov}(R_1, R_3) = \alpha_1\alpha_3\sigma_\theta^2$$

$$\text{Cov}(R_2, R_3) = \alpha_2\alpha_3\sigma_\theta^2$$

- Normalize  $\alpha_1 = 1$

$$\frac{\text{Cov}(R_2, R_3)}{\text{Cov}(R_1, R_2)} = \alpha_3$$

- $\therefore$  We know  $\sigma_\theta^2$  from  $\text{Cov}(R_1, R_2)$ .
- From  $\text{Cov}(R_1, R_3)$  we know

$$\alpha_3, \alpha_4, \alpha_5.$$

- Can get the variances of the  $\varepsilon_i$  from variances of the  $R_i$

$$\text{Var}(R_i) = \alpha_i^2 \sigma_\theta^2 + \sigma_{\varepsilon_i}^2.$$

- If  $T = 2$ , all we can identify is  $\alpha_1 \alpha_2 \sigma_\theta^2$ .
- If  $\alpha_1 = 1$ , and  $\sigma_\theta^2 = 1$ , we identify  $\alpha_2$ .
- Otherwise model is fundamentally underidentified.
- One factor model requires three (or more) measurements, plus a normalization (to set scale)

## 2 Factors: (some examples)

$$\theta_1 \perp\!\!\!\perp \theta_2$$

(For example.) This is not required in general (but it is for this example).

$$\varepsilon_i \perp\!\!\!\perp \varepsilon_j \quad \forall i \neq j$$

$$R_1 = \alpha_{11}\theta_1 + (0)\theta_2 + \varepsilon_1$$

$$R_2 = \alpha_{21}\theta_1 + (0)\theta_2 + \varepsilon_2$$

$$R_3 = \alpha_{31}\theta_1 + \alpha_{32}\theta_2 + \varepsilon_3$$

$$R_4 = \alpha_{41}\theta_1 + \alpha_{42}\theta_2 + \varepsilon_4$$

$$R_5 = \alpha_{51}\theta_1 + \alpha_{52}\theta_2 + \varepsilon_5$$

Let  $\alpha_{11} = 1$ ,  $\alpha_{32} = 1$ . (Set scale)



$$\text{Cov}(R_1, R_2) = \alpha_{21}\sigma_{\theta_1}^2$$

$$\text{Cov}(R_1, R_3) = \alpha_{31}\sigma_{\theta_1}^2$$

$$\text{Cov}(R_2, R_3) = \alpha_{21}\alpha_{31}\sigma_{\theta_1}^2$$

- Form ratio of  $\frac{\text{Cov}(R_2, R_3)}{\text{Cov}(R_1, R_2)} = \alpha_{31}$ ,
- $\therefore$  we identify  $\alpha_{31}, \alpha_{21}, \sigma_{\theta_1}^2$

$$\text{Cov}(R_1, R_4) = \alpha_{41}\sigma_{\theta_1}^2, \quad \therefore \text{since we know } \sigma_{\theta_1}^2 \therefore \text{we get } \alpha_{41}.$$

$$\vdots$$

$$\text{Cov}(R_1, R_k) = \alpha_{k1}\sigma_{\theta_1}^2$$

- $\therefore$  we identify  $\alpha_{k1}$  for all  $k$  and identify  $\sigma_{\theta_1}^2$ .

## Can Identify Other Parameters

$$\text{Cov}(R_3, R_4) - \alpha_{31}\alpha_{41}\sigma_{\theta_1}^2 = \alpha_{42}\sigma_{\theta_2}^2$$

$$\text{Cov}(R_3, R_5) - \alpha_{31}\alpha_{51}\sigma_{\theta_1}^2 = \alpha_{52}\sigma_{\theta_2}^2$$

$$\text{Cov}(R_4, R_5) - \alpha_{41}\alpha_{51}\sigma_{\theta_1}^2 = \alpha_{52}\alpha_{42}\sigma_{\theta_2}^2,$$

- By similar logic,

$$\frac{\text{Cov}(R_4, R_5) - \alpha_{41}\alpha_{51}\sigma_{\theta_1}^2}{\text{Cov}(R_3, R_4) - \alpha_{31}\alpha_{41}\sigma_{\theta_1}^2} = \alpha_{52}$$

- $\therefore$  we also identify  $\sigma_{\theta_2}^2$  for “2” loadings.

- If we have dedicated measurements on each factor do not need normalizations on the factors of  $R$ .
- Dedicated measurements set the scales and make factor models interpretable:

$$M_1 = \theta_1 + \varepsilon_{1M}$$

$$M_2 = \theta_2 + \varepsilon_{2M}$$

$$\text{Cov}(R_1, M) = \alpha_{11}\sigma_{\theta_1}^2$$

$$\text{Cov}(R_2, M) = \alpha_{21}\sigma_{\theta_1}^2$$

$$\text{Cov}(R_3, M) = \alpha_{31}\sigma_{\theta_1}^2$$

$$\text{Cov}(R_1, R_2) = \alpha_{11}\alpha_{21}\sigma_{\theta_1}^2$$

$$\text{Cov}(R_1, R_3) = \alpha_{11}\alpha_{31}\sigma_{\theta_1}^2$$

- Form the ratio

$$\frac{\text{Cov}(R_1, R_2)}{\text{Cov}(R_1, M)} = \alpha_{12} \quad \therefore \text{We identify } \sigma_{\theta_1}^2, \text{ etc.}$$

- $\therefore$  We can identify  $\alpha_{12}, \sigma_{\theta_1}^2$  and the other factors.

## General Case

$$\underset{T \times 1}{\mathbf{R}} = \underset{T \times 1}{\boldsymbol{\mu}} + \underset{T \times K}{\boldsymbol{\Lambda}} \underset{K \times 1}{\boldsymbol{\theta}} + \underset{T \times 1}{\boldsymbol{\varepsilon}}$$

- $\boldsymbol{\theta}$  are factors,  $\boldsymbol{\varepsilon}$  uniquenesses

$$E(\boldsymbol{\varepsilon}) = \mathbf{0}$$

$$Var(\boldsymbol{\varepsilon}\boldsymbol{\varepsilon}') = D = \begin{pmatrix} \sigma_{\varepsilon_1}^2 & 0 & \cdots & 0 \\ 0 & \sigma_{\varepsilon_2}^2 & 0 & \vdots \\ \vdots & 0 & \ddots & \vdots \\ 0 & \cdots & 0 & \sigma_{\varepsilon_T}^2 \end{pmatrix}$$

$$E(\boldsymbol{\theta}) = \mathbf{0}$$

$$Var(\mathbf{R}) = \boldsymbol{\Lambda}\boldsymbol{\Sigma}_{\boldsymbol{\theta}}\boldsymbol{\Lambda}' + D \quad \boldsymbol{\Sigma}_{\boldsymbol{\theta}} = E(\boldsymbol{\theta}\boldsymbol{\theta}')$$

- **The only source of information on  $\Lambda$  and  $\Sigma_\theta$  is from the covariances.**
- Each variance is “contaminated” by a *uniqueness*.
- Associated with each variance of  $R_i$  is a  $\sigma_{\varepsilon_i}^2$ .
- Each uniqueness variance contributes one new parameter.
- How many unique covariance terms do we have?  
•  $\frac{T(T-1)}{2}$ .

- We have  $T$  uniquenesses;  $TK$  elements of  $\Lambda$ .
- $\frac{K(K-1)}{2}$  elements of  $\Sigma_{\theta}$ .
- $\frac{K(K-1)}{2} + TK$  parameters  $(\Sigma_{\theta}, \Lambda)$ .
- Need this many covariances to identify model  
“Ledermann Bound”:

$$\frac{T(T-1)}{2} \geq TK + \frac{K(K-1)}{2}$$

- (# of equations  $\geq$  # of unknowns.)

## Lack of Identification Up to Rotation

- Observe that if we multiply  $\Lambda$  by an orthogonal matrix  $C$ , ( $CC' = I$ ), we obtain

$$\text{Var}(R) = \Lambda C [C' \Sigma_{\theta} C] C' \Lambda' + D$$

- $C$  is a “rotation.”
- Cannot separate  $\Lambda C$  from  $\Lambda$ .
- Model not identified against orthogonal transformations in the general case.



Some common assumptions:

①  $\theta_i \perp\!\!\!\perp \theta_j, \forall i \neq j$

$$\Sigma_{\theta} = \begin{pmatrix} \sigma_{\theta_1}^2 & 0 & \cdots & 0 \\ 0 & \sigma_{\theta_2}^2 & 0 & \vdots \\ \vdots & 0 & \ddots & \vdots \\ 0 & \cdots & 0 & \sigma_{\theta_K}^2 \end{pmatrix}$$

joined with

ii

$$\Lambda = \begin{pmatrix} 1 & 0 & 0 & 0 & \dots & 0 \\ \alpha_{21} & 0 & 0 & 0 & \dots & 0 \\ \alpha_{31} & 1 & 0 & 0 & \dots & 0 \\ \alpha_{41} & \alpha_{42} & 0 & 0 & \dots & 0 \\ \alpha_{51} & \alpha_{52} & 1 & 0 & \dots & 0 \\ \alpha_{61} & \alpha_{62} & \alpha_{63} & 0 & \dots & 0 \\ \vdots & \vdots & \vdots & 1 & & \vdots \end{pmatrix}$$

## Other Possible Assumptions

Example.

$$R_1 = \alpha_{11}\theta_1 + (0)\theta_2 + \varepsilon_1 \quad (\text{only one dedicated measurement on } \theta_1)$$

$$R_2 = \alpha_{21}\theta_1 + \alpha_{22}\theta_2 + \varepsilon_2$$

$\vdots$

$$R_T = \alpha_{T1}\theta_1 + \alpha_{T2}\theta_2 + \varepsilon_T$$

- The  $\theta$  are freely correlated

## Theorem 1

(Williams, 2011)

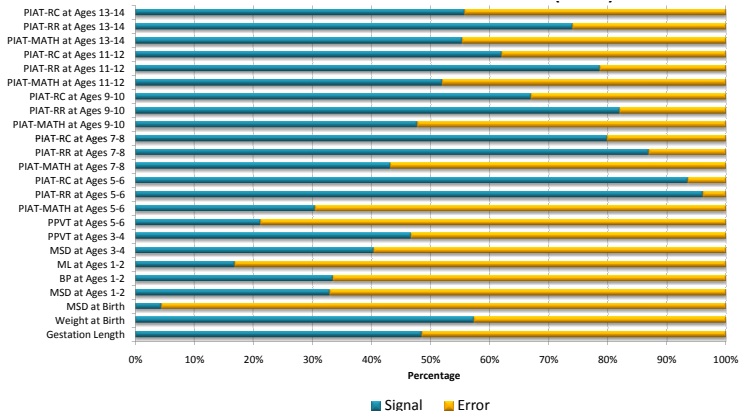
$$\begin{aligned} \text{If } (\theta_1, \theta_2) &\perp\!\!\!\perp (\varepsilon_1, \dots, \varepsilon_T) \\ \varepsilon_i &\perp\!\!\!\perp \varepsilon_j, \forall i \neq j \\ \theta_1 &\not\perp\!\!\!\perp \theta_2 \end{aligned}$$

Model identified if we normalize (e.g.)  $\alpha_{11} = 1$ ;  $\alpha_{22} = 1$  and set  $\alpha_{12} = 0$ .

## The Quantitative Importance of Measurement Error

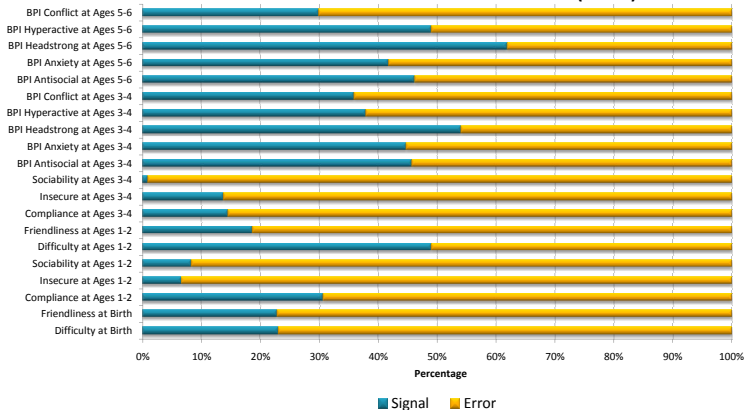
- The share of error variance for proxies of cognition, personality and investment ranges from 1%–90%.
- Not accounting for measurement error produces downward-biased estimates of self-productivity effects and perverse estimates of investment effects.

**Table 20:** Share of Residual Variance in Measurements of Cognitive Skills Due to the Variance of Cognitive Factor (Signal) and Due to the Variance of Measurement Error (Noise)



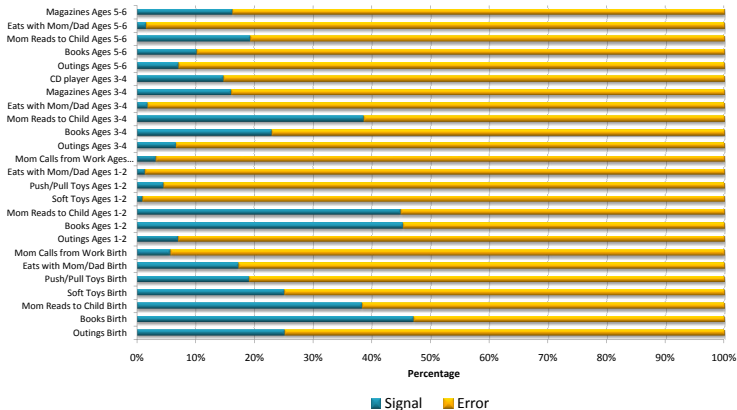
Source: Cunha, Heckman and Schennach [2010].

**Table 21:** Share of Residual Variance in Measurements of Socioemotional Skills Due to the Variance of Socioemotional Factor (Signal) and Due to the Variance of Measurement Error (Noise)



Source: Cunha, Heckman and Schennach [2010].

**Table 22:** Share of Residual Variance in Measurements of Investments Due to the Variance of Investment Factor (Signal) and Due to the Variance of Measurement Error (Noise)



Source: Cunha, Heckman and Schennach [2010].



## Faking

- “Faking” may corrupt measurements designed to proxy latent factors.
- There are at least two types of false responses:
  - a those arising from impression management and
  - b those arising from self-deception (Paulhus [1984]).

- Reference bias

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## Household Production

- Augment the task functions defined by Equation (9) to include levels of energy, and time, in vector  $e^j$

$$T_j = h_j(\theta^j, e^j) \text{ for } j = 1, \dots, J + 1 \quad (36)$$

$\theta^j$  is to be distinguished from  $\theta_j$ , the  $j^{\text{th}}$  component of vector  $\theta$ .

- Parallel notation for  $e^j$ .
- For a fixed input of psychological traits, higher levels of  $e^j$  may raise the output of the task.
- Thus if  $e^j = 0$ , the trait  $\theta^j$  may be switched off. However, if some traits have negative productivity in some tasks more energy may be allocated to those tasks to offset the negative trait.

- Output in activity  $Z_j$  is

$$Z_j = \varphi_j(T_j, X_j) \text{ for } j = 1, \dots, J + 1 \quad (37)$$

- The outputs in activity  $j$  depend on the task output  $T_j$  and the goods input  $X_j$ .
- Agents have preferences over  $Z_j$  and  $e_j$ .
- The effort expended in an activity may have psychic costs or benefits.
- There may be psychic costs in using  $e_j$  to suppress the expression of a trait.

- Preferences may also depend on  $\theta$  as well as other variables which we keep implicit.
- The utility function is

$$U = U(Z_1, \dots, Z_j, e^1, \dots, e^{J+1}, \theta) \quad (38)$$

- Income is return on asset flow  $Y$  plus labor earnings which we denote  $Z_{J+1} = \varphi_{J+1}(T_{J+1}, X_{J+1})$ .

$$\sum_{j=1}^{J+1} P_j X_j = Y + Z_{J+1} \quad (39)$$

- $Z_{J+1}$  is a hedonic earnings function which prices out traits and energy in the market.

## Two Ways to Introduce $\theta$

- It is possible to distinguish two different cases for  $\theta$ .
- For psychological traits, we can distinguish the case where  $\theta$  is a public good,  $\theta^j = \bar{\theta}$  for all  $j = 1, \dots, J + 1$ .
- When it is a private good,  $\sum_{j=1}^{J+1} \theta^j = \bar{\theta}$
- People are not stuck with their personality in all activities.



- For simplicity, we consider the pure private goods case and the pure public goods case. Assume that  $e$  is private.

$$e \quad \theta \begin{array}{c} \text{Public} \quad \text{Private} \\ \hline \text{case I} \quad \text{case II} \end{array}$$

- In case I, the additional constraint operating on the consumer beyond the budget constraint (39) is

$$\theta^j = \bar{\theta}, \quad \sum_{j=1}^{J+1} e^j = \bar{e}, \quad \text{for all } j = 1, \dots, J + 1. \quad (40)$$

- In case II, the operative constraints are

$$\sum_{j=1}^{J+1} \theta^j = \bar{\theta}, \quad \sum_{j=1}^{J+1} e^j = \bar{e} \quad (41)$$

## Case I: Traits as Public Goods

- In case I, different bundles of  $\bar{\theta}$  across persons create comparative advantages for agents in different tasks and thus produce comparative advantages in different activities.
- Case I is a version of Michael's (1973) model of environmental variables in a household production framework.

- For analytical simplicity, suppose that  $Z_j$  and  $T_j$ ,  $j = 1, \dots, J + 1$ , display constant returns to scale in non-public inputs.

- In terms of the technologies (9), when  $\theta$  is a public good, we assume constant returns to scale in  $e^j$  but that  $\theta^j = \bar{\theta}$  is a fixed, environmental variable.
- Different levels of  $\bar{\theta}$  produce different productivities in different tasks.
- Feeding  $\bar{\theta}$  into the activity functions (37), which are also assumed to be constant returns to scale, we can analyze the agent's problem of allocating effort among tasks and goods among activities using the analysis of Michael (1973).
- Financial and energy resources are not changed by  $\bar{\theta}$  except for its effect on  $Z_{J+1}$ .
- Holding energy and money resources fixed, changes in  $\bar{\theta}$  produce reallocations across budget categories.

## Several Cases

- Consider an increase in conscientiousness.
- This will likely increase earnings (via  $Z_{J+1}$ ), and will enhance productivity in some tasks intensive in conscientiousness and activities based on those tasks more than other tasks and activities.
- The increased income will support more of all activities.
- The differential shift in productivity across tasks and activities will reduce the prices of activities that are more intensive in the use of conscientiousness.
- If the demands for those activities are price elastic compared to the demands for the less conscientiousness-intensive activities, the demand for the inputs used in those activities will increase.
- If the demands are relatively inelastic, the demands will decrease because of the greater productivity for the inputs.
- Standard Marshall's 4 rules analysis.

- If a trait reduces productivity, the chain of logic just presented runs in reverse.
- With increases in (for example) neuroticism, shadow prices of activities intensive in that trait will increase.
- Labor earnings will tend to decrease.
- In the price-elastic case, consumers will tend to substitute away from activities intensive in the trait and the demand for inputs will decrease.
- In the inelastic case, input demands will increase as agents substitute goods and energy inputs into the activities that are inelastically demanded.

- The same level of the traits is found in all activities, but in general, energy or time will be allocated differentially among activities.
- A person who allocates more energy or time to a task will manifest more of the trait.
- If inputs are complementary, at the same scale of output more of the task will be demanded.
- Unless one controls for these inputs, one may fail to capture the uniformity of traits across tasks and activities.
- In all of these cases, purchase patterns of market goods will provide information on endowments and allocation of energy and traits.



## Case II: Traits as Private Goods

- The case when traits are private goods produces the possibility of different levels of traits being used in different tasks and activities.
- Responses of activity levels to changes in rewards across activities will be more price-elastic when traits can be allocated across activities than when traits are fixed.
- Equiproportionate expansions in  $(\bar{\theta}, \bar{e})$  differentially expand the consumption possibility set for activities intensive in  $(\theta, e)$  and reduce their shadow prices, producing substitution effects in task production and activity consumption that promote consumption in activities intensive in the traits.

- The public goods case imposes more constraints on the system than the private goods case.
- Compared to the case of public goods for traits, agents will reduce their allocation of the trait from activities where their productivity is negative and will spend less effort ( $e$ ) in overriding the effects of negative traits in productivity.
- The trait will be shifted into less costly activities and less energy will be spent controlling it.

## The Evidence

- The evidence would seem to favor case II, since different levels of traits are often found in different activities.
- However, since most of the estimates reviewed do not adjust for the inputs that affect the manifestation of the traits, one must be cautious in reaching this conclusion.
- Such adjustments are indicated by the theory but are not yet standard in economics or psychology.

- The roles of time and energy in amplifying or reducing the effects of the traits in activities needs to be systematically explored to make the theory empirically operational as are the effects of traits on the purchase of related goods (for example, shy people may seek to live in secluded areas, houses with high walls and seek jobs with little human contact).
- In the private goods specification of the model (case II), the motivation for the supply of traits to different activities depends on preferences (utility rewards  $U$ ), on productivity in  $Z_j$ , and in productivity in the tasks  $T_j$ . In this framework, it is possible to formalize many of the currently disparate concepts of personality psychology.
- It would be very informative to estimate both versions of the model and to test between them.

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**“Are Economists’ Preferences Psychologists’ Personality Traits?”**  
by Tomas Jagelka (2018)

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