Noncognitive Skills: Acquisition and Economic Consequences

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Leibniz Network Conference
Mannheim

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Outline of Lecture

1. The definition of non-cognitive skills
2. Their measurement– alternative approaches and problems with the approaches
3. The importance of non-cognitive skills in predicting a variety of behaviors (absolutely and compared to that of cognitive skills)
4. The relationship of constructs in personality psychology with those in economics

5. How does personality psychology enhance economics? Economics personality psychology? Integration of the two fields.
6. Stability of personality and preference parameters
   a. Situational specificity
   b. Stability over the life-cycle given the situation
7. How investment affects the evolution of traits
8. Relationship between cognitive skills/non-cognitive skills in producing skills
9. **Technology of Skill Formation**

This presentation draws on results reported in the following papers, all posted on the conference website:

- Borghans, Duckworth, Heckman, and ter Weel (2008). "The Economics and Psychology of Personality Traits." Unpublished Manuscript, University of Chicago, Department of Economics. Forthcoming, *Journal of Human Resources*.
- Cunha and Heckman (2008). "Formulating, Identifying and Estimating the Technology of Cognitive and Noncognitive Skill Formation," Forthcoming, *Journal of Human Resources*.
- Cunha and Heckman (2007, May). "The Technology of Skill Formation," *American Economic Review*, 97(2), 31-47.

- Cunha, Heckman, and Schennach (2007). "Estimating the Technology of Cognitive and Noncognitive Skill Formation." Unpublished Manuscript, University of Chicago, Department of Economics. Presented at the Yale Conference on Macro and Labor Economics, May 5-7, 2006. Under revision, *Econometrica*.
- Heckman, Stixrud, and Urzua (2006, July). "The Effects of Cognitive and Noncognitive Abilities on Labor Market Outcomes and Social Behavior." *Journal of Labor Economics*, 24(3), 411-482.

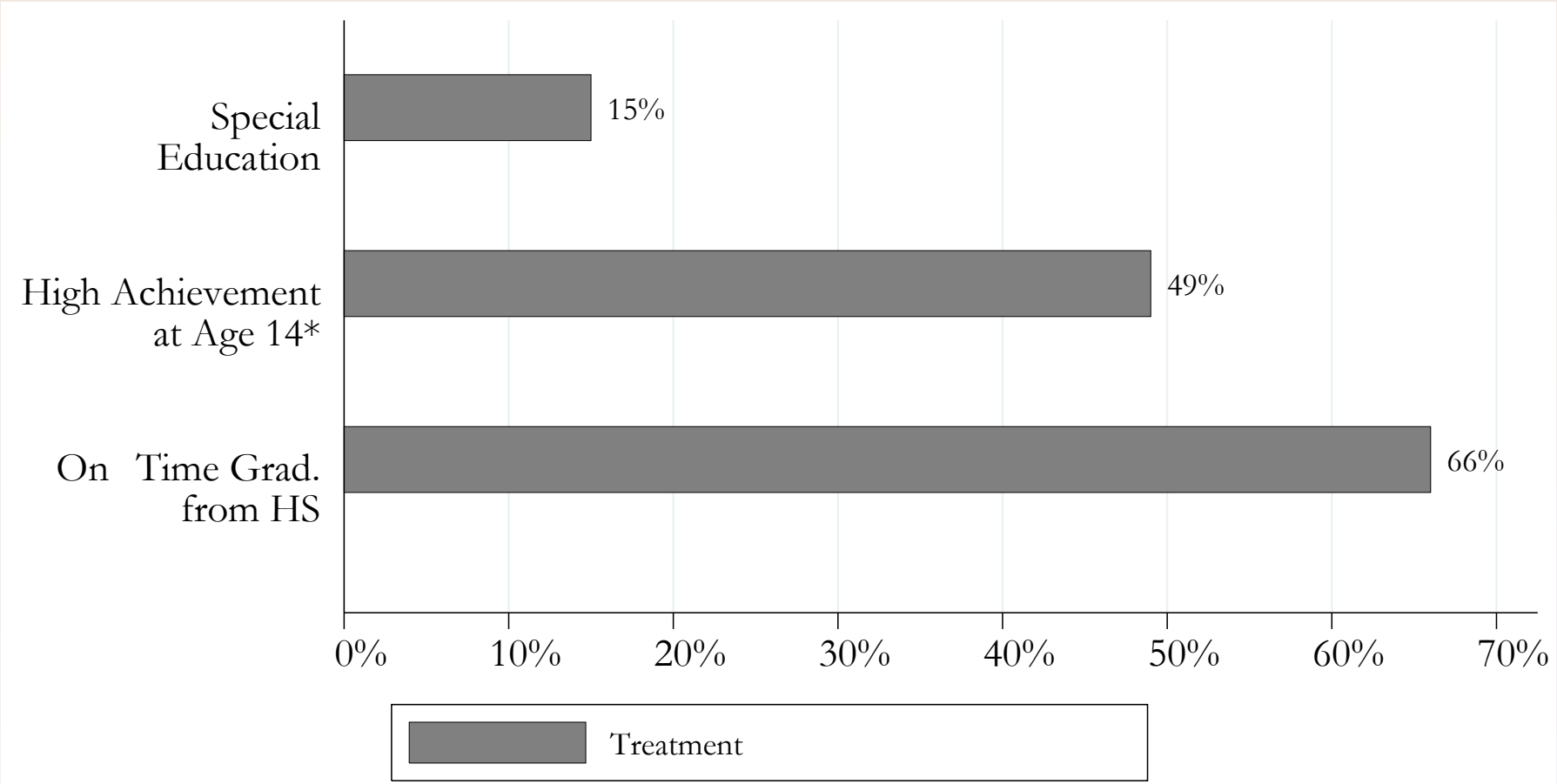
- Cunha, Heckman, Lochner, and Masterov (2006). "Interpreting the Evidence on Life Cycle Skill Formation." In Eric A. Hanushek and Finis Welch (Eds.), *Handbook of the Economics of Education*, Chapter 12, pp. 697-812, Amsterdam: North-Holland.
- Heckman (2007, August). "The Economics, Technology and Neuroscience of Human Capability Formation." *Proceedings of the National Academy of Sciences*, 104(3), 13250-13255.

Introduction

- Ample evidence from economics and psychology that cognitive ability is a powerful predictor of economic and social outcomes. (Herrnstein and Murray, 1994)
- The power of traits other than cognitive ability for success in life is vividly demonstrated by the Perry Preschool study.

- Perry did not raise IQ.
- It mainly raised noncognitive skills.
- Presentation by S. Moon and R. Pinto establishes this Friday.
- Estimated rate of return is 10% for both males and females.

Perry preschool program: educational effects, by treatment group



Source: Barnett (2004).
Notes: *High achievement defined as performance at or above the lowest 10th percentile on the California Achievement Test (1970).

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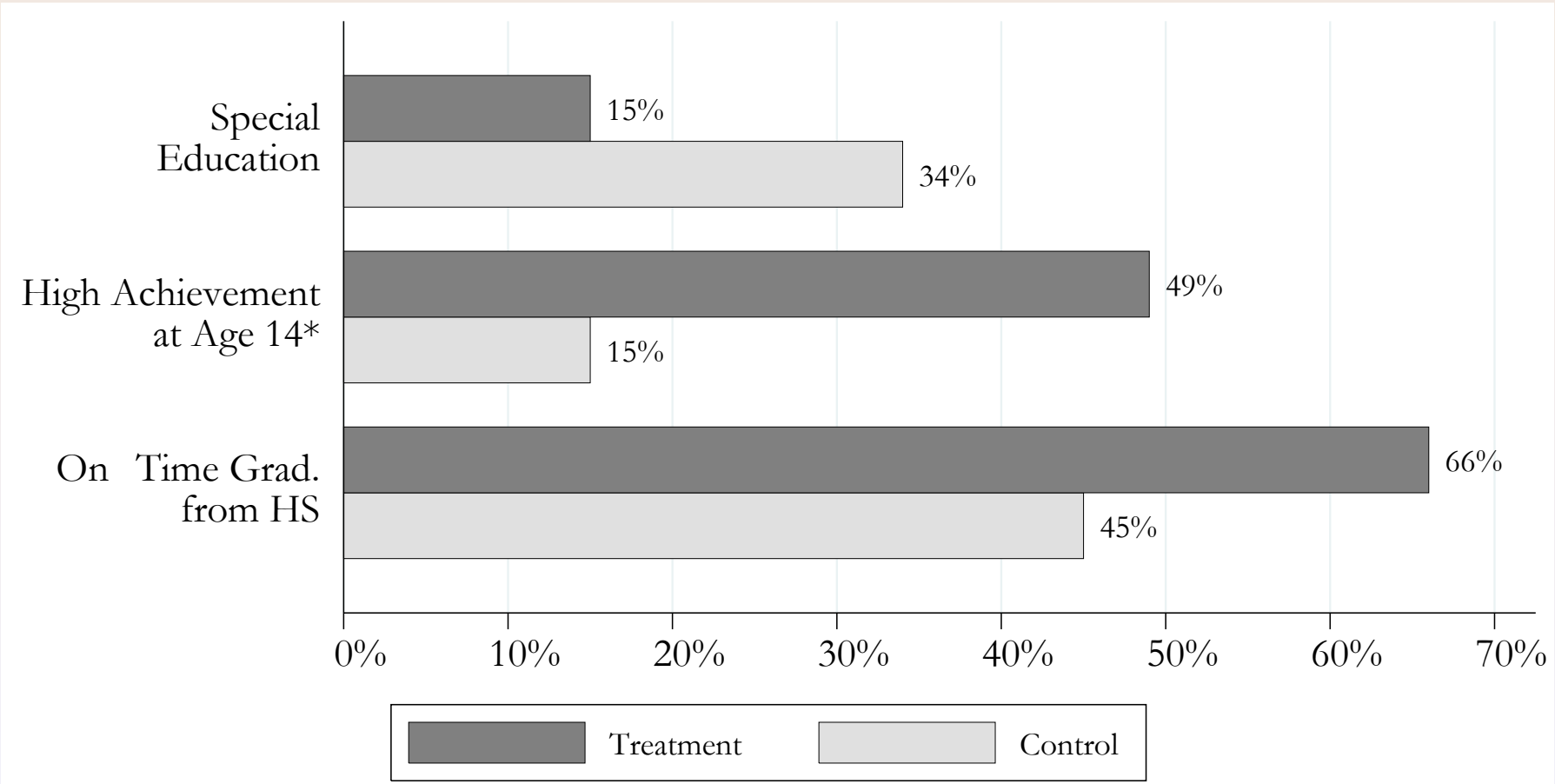

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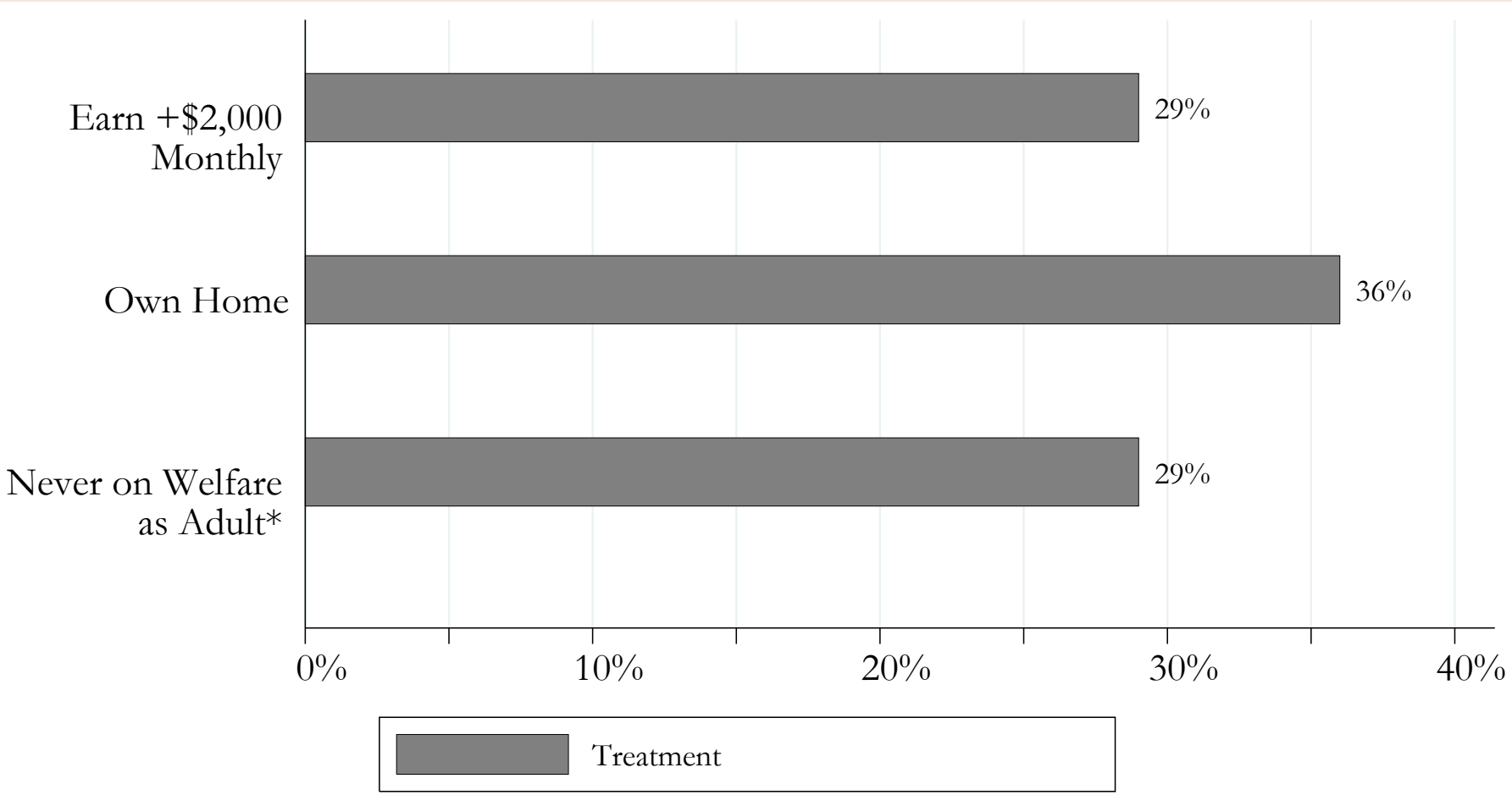
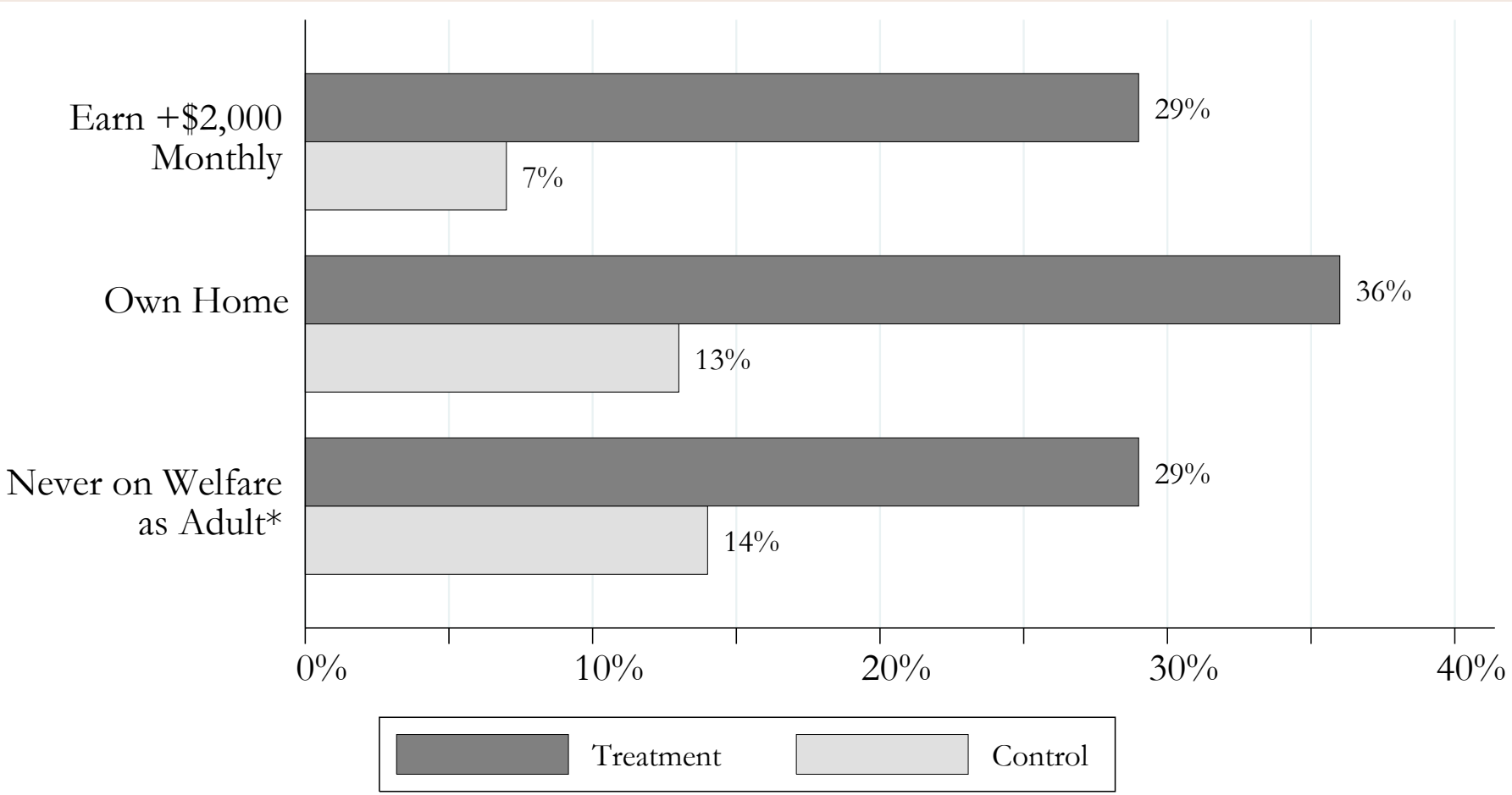
Perry preschool program: economic effects at age 27, by treatment group



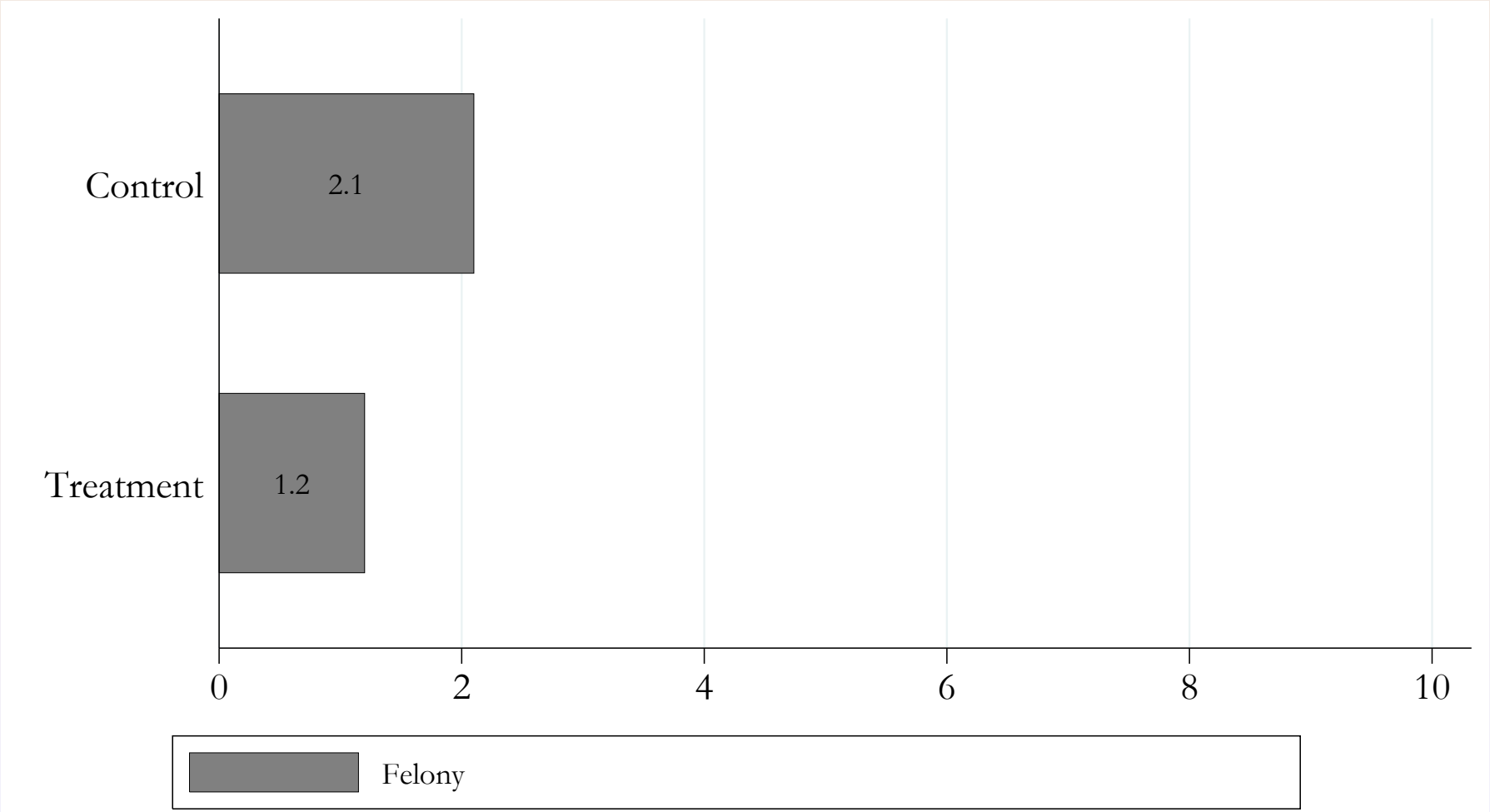
Source: Barnett (2004). *Updated through Age 40 using recent Perry Preschool Program data, derived from self report and all available state records.

Perry preschool program: economic effects at age 27, by treatment group



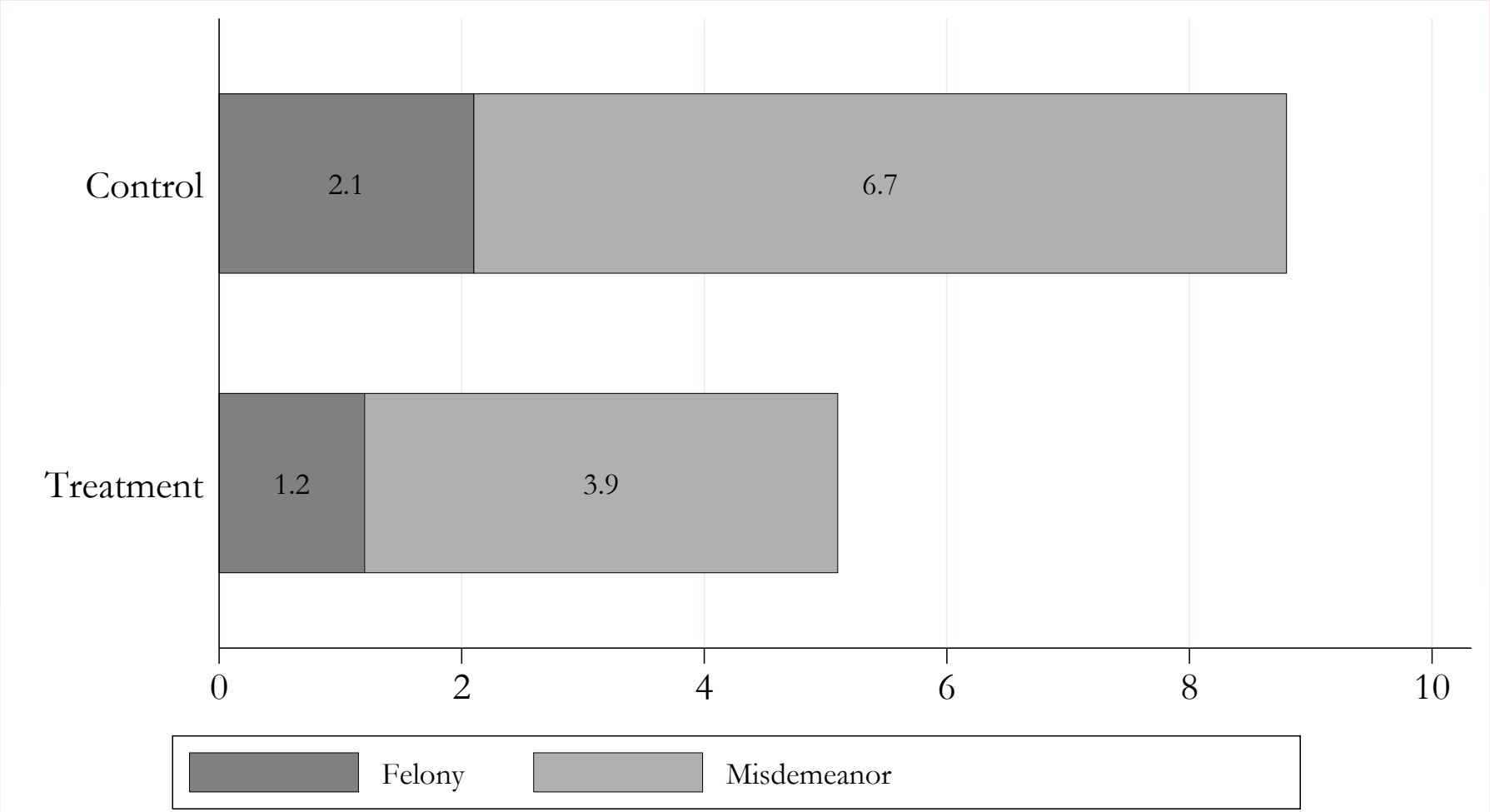
Source: Barnett (2004). *Updated through Age 40 using recent Perry Preschool Program data, derived from self report and all available state records.

Perry preschool program: arrests per person before age 40, by treatment group



Source: Perry Preschool Program. Juvenile arrests are defined as arrests prior to age 19.

Perry preschool program: arrests per person before age 40, by treatment group



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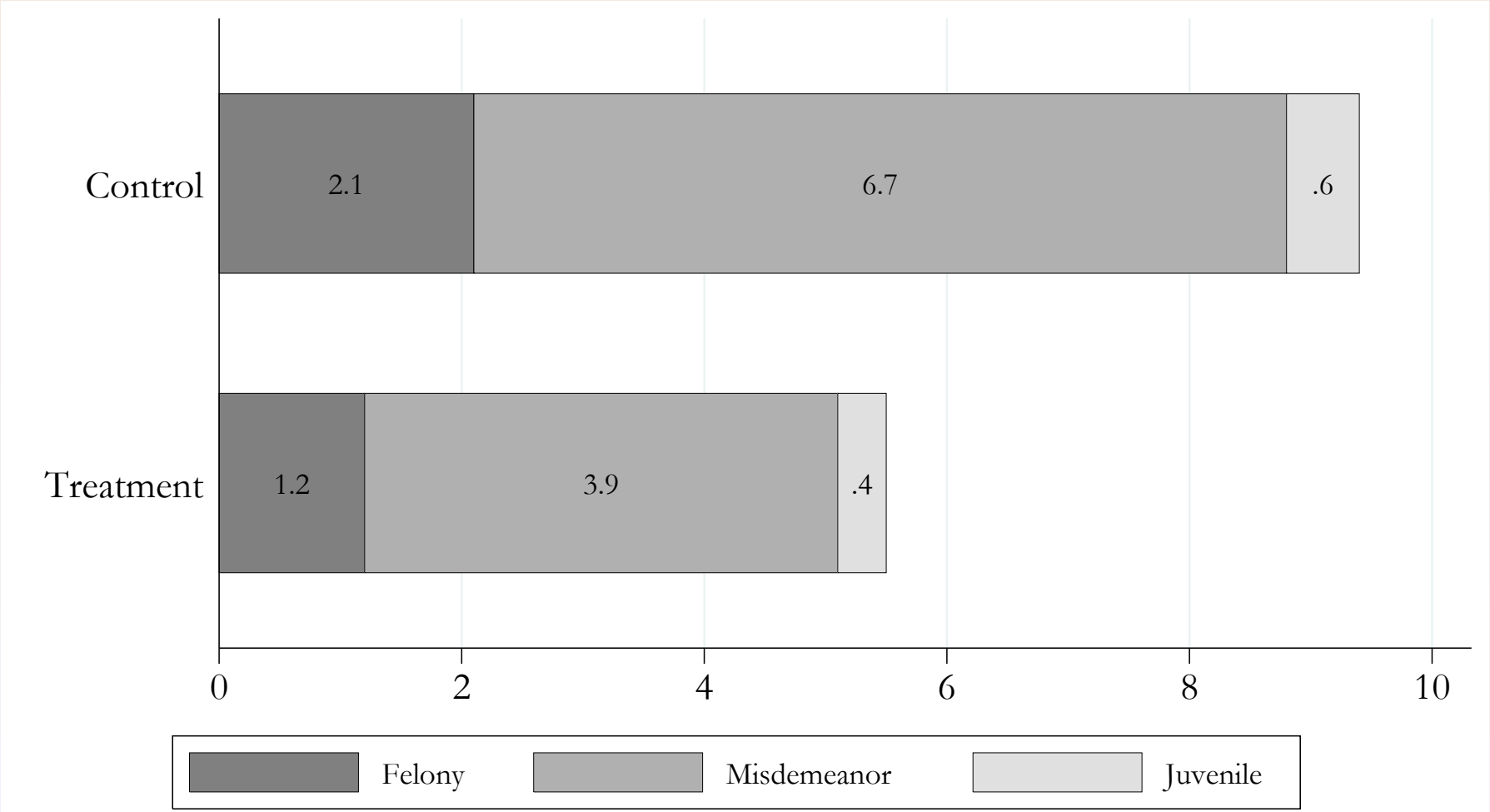
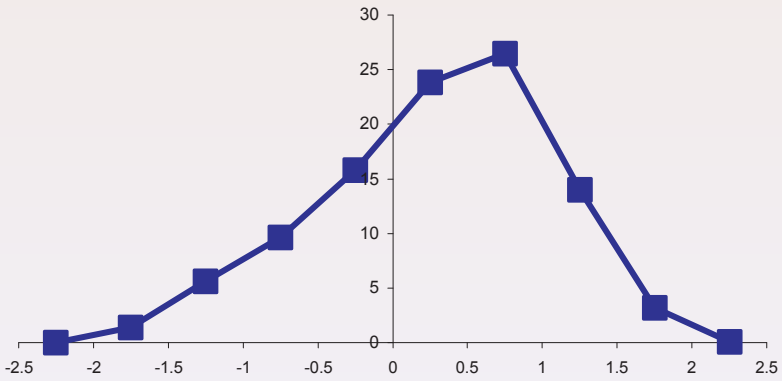


Source: Perry Preschool Program. Juvenile arrests are defined as arrests prior to age 19.

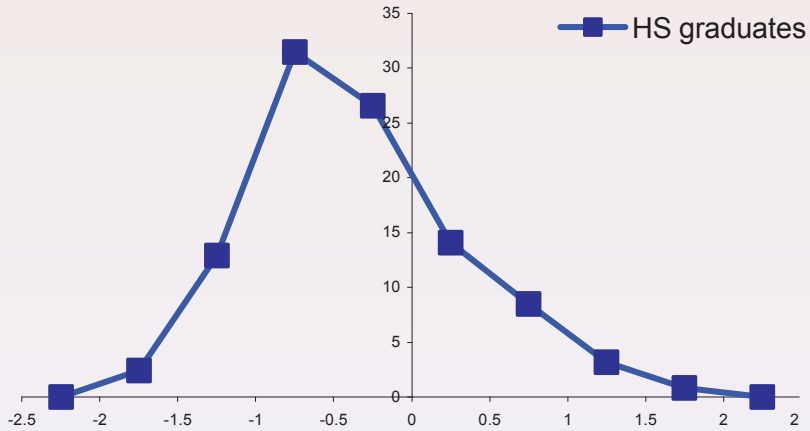
- Evidence from the second chance GED program in America (Heckman and Rubinstein, 2001).

Density of age adjusted AFQT scores, GED recipients and high school graduates with twelve years of schooling

White Males



White Females



Source: Heckman, Hsee and Rubinstein (2001)

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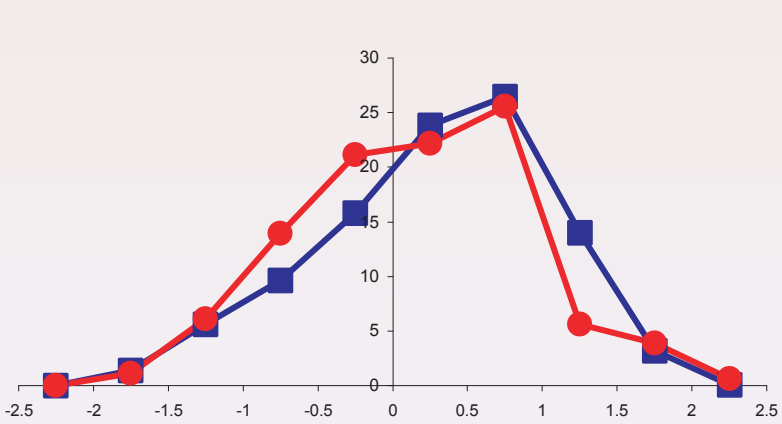

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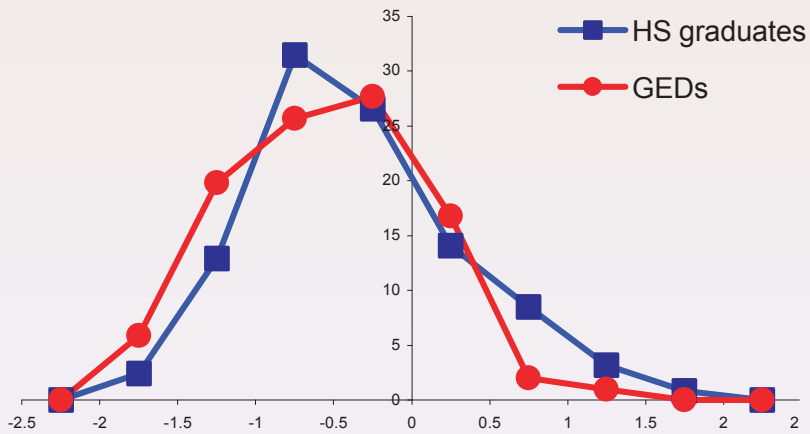
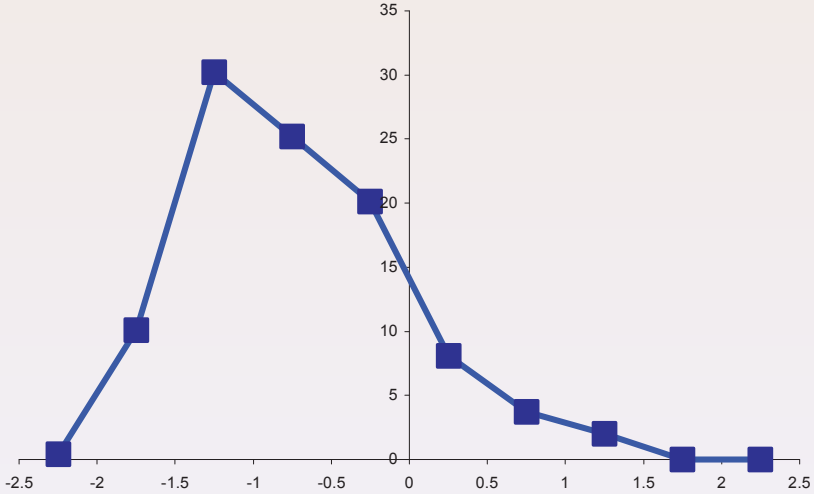


Source: Heckman, Hsee and Rubinstein (2001)

Density of age adjusted AFQT scores, GED recipients and high school graduates with twelve years of schooling

Black Males



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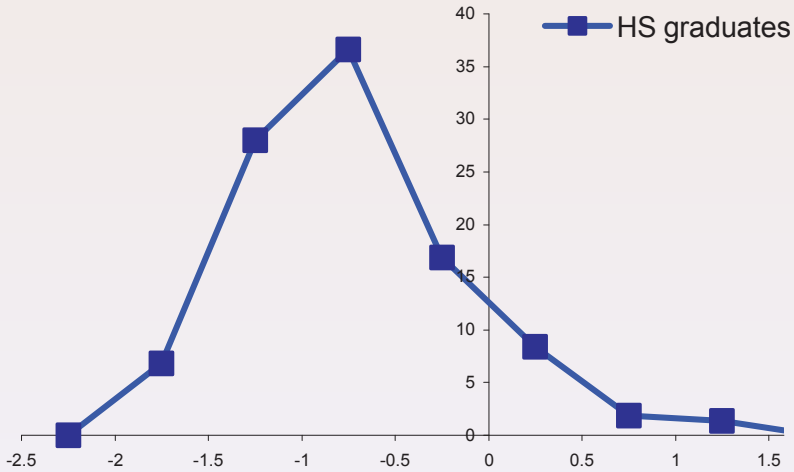

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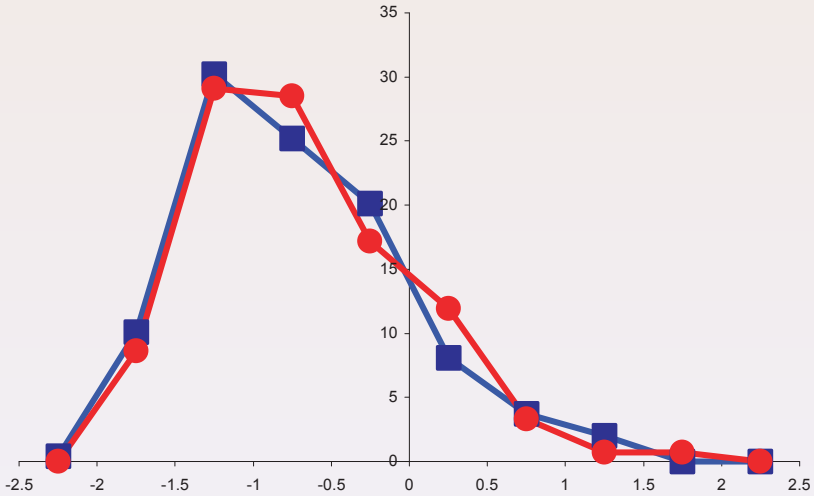

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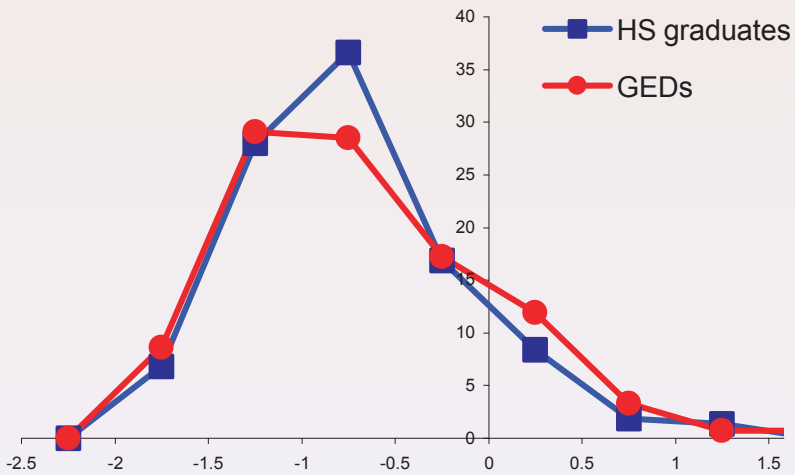

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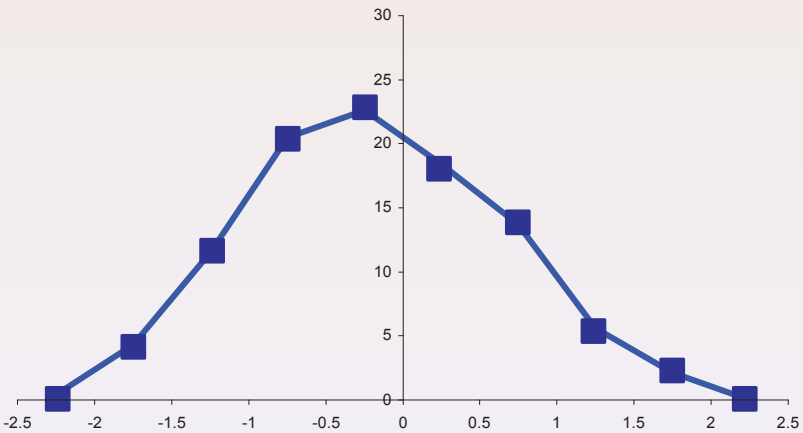
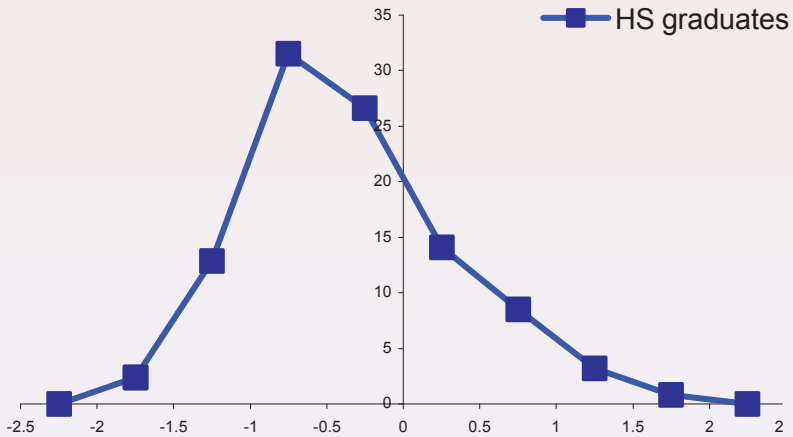
Density of age adjusted AFQT scores, GED recipients and high school graduates with twelve years of schooling

Hispanic Males



Hispanic Females



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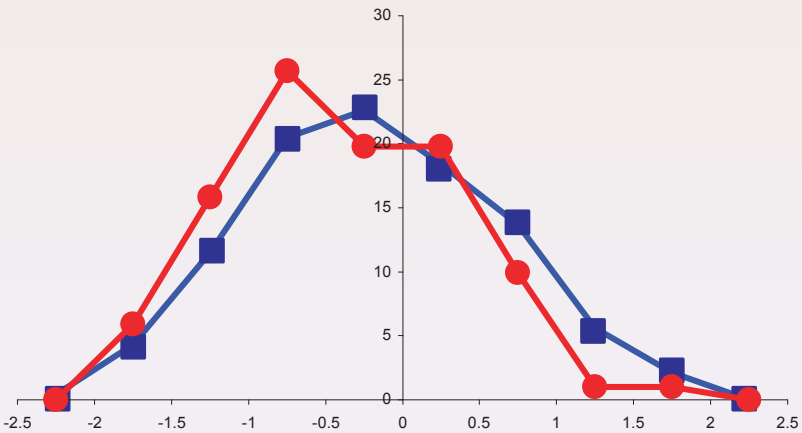

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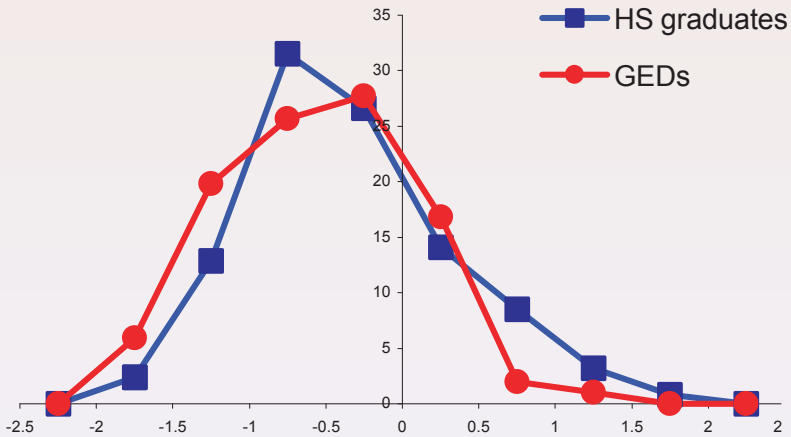


Source: Heckman, Hsee and Rubinstein (2001)

- GEDs earn at the rate of high school dropouts.
- They participate in pathological social behaviors at the same rate or greater than dropouts.
- Dark matter = Noncognitive skills

Is It Conceptually Possible to Separate Cognitive Ability from Personality Traits? Empirically possible?

What Are the Main Measurement Systems in Psychology for Intelligence and Personality, and How Are They Validated?

- 100 years of IQ testing in psychology have produced tests that are less culture bound.
- WAIS
- Raven's progressive matrices
- Personality measurement systems have been developed more recently.

Figure 2: Competing taxonomies of personality

Eysenck Big Three	Costa & McCrae NEO-PRF Big Five	Tellegen MPQ	Zuckerman	Cloninger	Big Nine
Neuroticism	**Neuroticism**	**Negative Emotionality**	**Neuroticism-Anxiety**	**Harm Avoidance**	**Adjustment**
Anxious	Anxiety	Stress reaction			
	Vulnerability				
Depressed	Depression				
Guilt-feeling					
Low self-esteem					
Tense					
Irrational					
Shy	Self-consciousness	Alienation			
Moody					
Emotional	*Impulsiveness*				
Psychotism					
Aggressive	Hostility	Aggression	**Aggression-Hostility**	**Cooperativeness**	**Agreeableness**
Cold					**Rugged Individualism**
Egocentric					
Impersonal	**Agreeableness**				
Anti-social	Altruism				
Unempathic	Compliance				
Tough-minded	Tendermindedness				
	Straightforwardness				
	Trust				
(cont.)	Modesty				

Evsenck Big Three	Costa & McCrae NEO-PRF Big Five	Tellegen MPQ	Zuckerman	Cloninger	Big Nine
Psychotism (cont.)	**Conscientiousness**	**Constraint**		**Self-Directedness**	**Dependability**
	Deliberation				
	Dutifulness				
Impulsive	Self-discipline	Control			**Locus of Control**
	Order				
	Competence			**Persistence**	**Achievement**
	Achievement striving				
		Traditionalism			
Extraversion	**Extraversion**				
Sensation-seeking	Excitement seeking	*Harm avoidance*	**Impulsive Sensation Seeking**	**Novelty Seeking**	
Venturesome					
Active	Activity		**Activity**		
Surgent					
Carefree					
		Positive emotionality			
		Achievement		**Reward Dependence**	
		Social Closeness			
Sociable	Gregariousness		**Sociability**		**Affiliation**
Lively					
Assertive	Assertiveness				
Dominant		Social Potency			**Potency**
	Positive emotions	Well-being			
	Warmth				

Evsenck Big Three	Costa & McCrae NEO-PRF Big Five	Tellegen MPQ	Zuckerman	Cloninger	Big Nine
	Openness			**Self-Transcendence**	
	Fantasy				
	Aesthetics	Absorption			
	Feelings				
	Actions				
	Ideas				
	Values				

A Basic Framework For Measuring and Interpreting Abilities

- Task performance function for person i on task j

$$\underbrace{T_{i,j}}_{\substack{\text{performance} \\ \text{on task } j \\ \text{for person } i}} = \mu_j(X) + \underbrace{\lambda_j f_i}_{\text{latent factors}} + \underbrace{U_{i,j}}_{\text{uniqueness}}, i = 1, \ldots, I,\ j = 1, \ldots, J. \quad (1)$$

- Tasks can be tests; they can also be real-world outcomes.
- Output on tasks is generated in part by latent "traits" or factors.
- f_i has L components so $f_i = (f_{i,1}, \ldots, f_{i,L})$.

- Factor models capture the concept that:
  1. latent traits f_i generate a variety of outcomes
  2. task outputs are imperfect measures of the traits f_i
  3. tasks other than tests may also proxy the underlying traits.

Cognitive Ability

- **Intelligence** (or cognitive ability): *"ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, to overcome obstacles by taking thought."*
(Neisser et al. 1996, p. 77)

- Most psychologists agree that cognitive abilities are organized hierarchically with "g" as the highest-order factor (Spearman 1904).
- The order of a factor indicates its generality in explaining a variety of tests of cognitive ability with different emphases (for example, verbal ability, numeracy, coding speed, and other tasks).
- First-order factors are predictive in all tasks, $j = 1, \ldots, J$.

- Lower order factors are predictive in only some tasks.
- Cattell (1971; 1987): two second-order factors: *fluid intelligence* (the ability to solve novel problems) and *crystallized intelligence* (knowledge and developed skills).

Personality Traits

- A distinction between personality and cognition is not easy to make.
- Consider "quasi-cognitive" traits.
- Include creativity, emotional intelligence, cognitive style, typical intellectual engagement, and practical intelligence.

- The problem of conceptually distinguishing cognitive traits from personality traits is demonstrated in an analysis of executive function which is variously described as a cognitive function or a function regulating emotions and decision, depending on the scholar.
- Many measures of executive function do not correlate reliably with IQ.
- However, measures of one aspect of execution function - working memory capacity - correlate very highly with measures of fluid intelligence.

- This lecture focuses on personality traits that are more easily distinguished from cognitive ability.
- They are distinguished from intelligence, defined as the ability to solve abstract problems.
- Most measures of personality are only weakly correlated with IQ. There are, however, a small number of exceptions.
- IQ is moderately associated with the Big Five factor called openness to experience, with the trait of sensation seeking, and with measures of time preference.
- The reported correlations are of the order $r = .3$ or lower.

Personality Tests

- The Big Five factors are *O*penness to *E*xperience (also called Intellect or Culture), *C*onscientiousness, *E*xtraversion, *A*greeableness, and *N*euroticism (also called Emotional Stability).
- Convenient acronym for these factors is "OCEAN".

The Big Five domains and their facets

Factor	Facets	Definition of Factor	ACL[a] Marker Items for Factor
I. Openness to Experience (Intellect)	Fantasy, Aesthetics, Feelings, Actions, Ideas, Values	The degree to which a person needs intellectual stimulation, change, and variety.	Commonplace, Narrow-interest, Simple- vs. Wide-interest, Imaginative, Intelligent
II. Conscientiousness	Competence, Order, Dutifulness, Achievement striving, Self-discipline, Deliberation	The degree to which a person is willing to comply with conventional rules, norms, and standards.	Careless, Disorderly, Frivolous vs. Organized, Thorough, Precise
III. Extraversion	Warmth, Gregariousness, Assertiveness, Activity, Excitement seeking, Positive emotions	The degree to which a person needs attention and social interaction.	Quiet, Reserved, Shy vs. Talkative, Assertive, Active

IV. Agreeableness	Trust, Straight-forwardness, Altruism, Compliance, Modesty, Tender-mindedness	The degree to which a person needs pleasant and harmonious relations with others.	Fault-finding, Cold, Unfriendly vs. Sympathetic, Kind, Friendly
V. Neuroticism (Emotional Stability)	Anxiety, Angry hostility, Depression, Self-consciousness, Impulsiveness, Vulnerability	The degree to which a person experiences the world as threatening and beyond his/her control.	Tense, Anxious, Nervous vs. Stable, Calm, Contented

Source: Hogan and Hogan (2007)
Note: a. ACL = Adjective Check List (Gough and Heilbrun, 1983)

- Five-factor model is atheoretical.
- The finding that descriptions of behavior as measured by tests, self-reports, and reports of observers cluster reliably into five groups has not so far been explained by a basic theory.
- Research is underway on determining the neural substrates of the Big Five and personality more generally (see Canli 2006).
- **Ignores motivation.**

Measure of "Temperament" for Children

- Compared to adults, there seem to be fewer ways that young children can differ from one another.
- Child psychologists often refer to the "elaboration" or "differentiation" of childhood temperament into the full flower of complex, adult personality.
- Open research question: to attach childhood measures to adult measures.
- Needed to explain life cycle development.

Measurement and Methodological Issues

- Two general types of measurement schemes corresponding to measures used by economists and those used by psychologists:
  1. those that seek to measure or elicit conventional economic preference parameters, and
  2. those that measure personality with self-reports or observer reports.

Schemes used by Personality Psychologists

- Personality psychologists use three types of evidence to establish the validity of their tests:
  1. content-related (qualitative assessment)
  2. construct-related (internal consistency of quantitative measures)
  3. criterion-related evidence (prediction of real world outcomes)
- I focus on (2) and (3).
- (1), based on on qualitative assessment of experts, is not used much

Construct Related Validity: Internal Consistency of Measures of a "Construct"

- Construct quantified by tests or self reports
- "convergent" referring to the intercorrelations *within* a cluster and the "discriminant" referring to lack of correlation across clusters.
- Use the factor model to clarify concepts.

- $M_{i,I}^{n}$: n^{th} measurement (by test or observer report) on trait I for person i.

$$M_{i,I}^{n} = \mu_I^n + \lambda_I^n f_{i,I} + \varepsilon_{i,I}^n, \tag{2}$$
$$n = 1, \ldots, N_I, \; i = 1, \ldots, I, \; I = 1, \ldots L.$$

- $f_{i,l}$ statistically independent of the measurement errors, $\varepsilon_{i,l}^{n}$, $n = 1, \ldots, N_l$.
- Different factors are assumed to be independent (f_l independent of $f_{l'}$ for $l \neq l'$).
- The measurement errors (or "uniquenesses") are assumed to be mutually independent within and across constructs.
- The test has discriminant validity for trait l if λ_l^n is the only nonzero component of f_i.

- Conventional psychometric construct validity of a collection of items or test scores for different constructs has three aspects:
  1. Factor f_l accounts for intercorrelations among the items or tests within a construct l.
  2. Item-specific and random error variance are low (intercorrelations among items are high within a cluster).
  3. Factor f_l for construct l is independent of factor $f_{l'}$ for construct l'.
  4. Criteria (1) and (2) are required for "convergent validity."
  5. Criterion (3) is "discriminant validity."

Approaches Based on Prediction: Criterion Related Validity

- Based on the predictive power of tests for real world outcomes: behaviors measured outside of the exam room or observer system.
- The Hogan Personality Inventory, the California Personality Inventory, and the Minnesota Multiphasic Personality Inventory
- This approach is concrete, yet has major problems.

- First, all measurements of factor $f_{i,I}$ can claim incremental predictive validity as long as each measurement is subject to error $\left(\varepsilon_{i,I}^{n} \neq 0\right)$.
- A second problem is reverse causality.

Benchmark Definition of Personality Traits and the Problem of Situational Specificity

- Measured traits are imperfect proxies for true traits:

$$M_l^n = h_l\left(\underbrace{f_l}_{\text{trait of interest}}, \underbrace{f_{\sim l}}_{\text{other traits}}, R_l^n, W_l^n\right), \; n = 1, \ldots, N_l, \; l = 1, \ldots, L. \tag{3}$$

- R_n^l = reward for manifesting the trait in situation n.
- Other latent traits besides l may affect the manifestation of a trait for l.
- $f_{\sim l}$ is the components of f apart from f_l.
- W_l^n denotes other variables operating in situation n that affect measured performance for l.

- Mischel (1968) claims that h_l does not depend on f_l because there is no f_l (or for that matter $f_{\sim l}$) and indeed that the manifestation M_l^n is solely a function of situational incentives R_l^n and context W_l^n.

- Define measurements on f_l at benchmark levels of R_l^n, $f_{\sim l}$, and W_l^n.
- Define benchmarks as $\bar{R}_l$, $\bar{f}_{\sim l}$, and $\bar{W}_l$.
- **A definition of the level of trait l: f_l**

$$M_l^n = f_l \text{ for } R_l^n = \bar{R}_l,\ f_{\sim l} = \bar{f}_{\sim l},\ W_l^n = \bar{W}_l, \qquad (4)$$
$$n = 1, \ldots, N_l,\ l = 1, \ldots, L.$$

IQ Scores Reflect Incentives and Measure Both Cognitive and Personality Traits

- Virtually all measurements "contaminated" by other factors and situation-specific manifestations of the traits.

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 12 points higher than control group during a second testing on an alternative form of the Stanford Binet (about .eight 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)

Ayllon & Kelly (1972) Sample 1	Within subjects study. 12 mentally retarded children (avg IQ 46.8)	Tokens given in experimental condition for right answers exchangeable for prizes	6.25 points out of a possible 51 points on Metropolitan Readiness Test. t = 4.03	"…test scores often reflect poor academic skills, but they may also reflect lack of motivation to do well in the criterion test…These results, obtained from both a population typically limited in skills and ability as well as from a group of normal children (Experiment II), demonstrate that the use of reinforcement procedures applied to a behavior that is tacitly regarded as "at its peak" can significantly alter the level of performance of that behavior." (p. 483)
Ayllon & Kelly (1972) Sample 2	Within subjects study 34 urban fourth graders (avg IQ = 92.8)	Tokens given in experimental condition for right answers exchangeable for prizes	t = 5.9	
Ayllon & Kelly (1972) Sample 3	Within subjects study of 12 matched pairs of mentally retarded children	Six weeks of token reinforcement for good academic performance	Experimental group scored 3.67 points out of possible 51 points on a post-test given under standard conditions higher than at baseline; control group dropped 2.75 points. On a second post-test with incentives, exp and control groups increased 6.25 and 7.17 points, respectively	

Clingman and Fowler (1976)	Within subjects study of 72 first- and second-graders assigned randomly to contingent reward, noncontingent reward, or no reward conditions.	M&Ms given for right answers in contingent cdtn; M&Ms given regardless of correctness in noncontingent condition	Only among low-IQ (<100) subjects was there an effect of the incentive. Contingent reward group scored about .33 standard deviations higher on the Peabody Picture Vocabulary test than did no reward group.	"…contingent candy increased the I.Q. scores of only the 'low I.Q.' children. This result suggests that the high and medium I.Q. groups were already functioning at a higher motivational level than children in the low I.Q. group."

Zigler and Butterfield (1968)	Within and between subjects study of 40 low SES children who did or did not attend nursery school were tested at the beginning and end of the year on Stanford-Binet Intelligence Test under either optimized or standard conditions.	Motivation was optimized without giving test-relevant information. Gentle encouragement, easier items after items were missed, and so on.	At baseline (in the fall), there was a full standard deviation difference (10.6 points and SD was about 9.5 in this sample) between scores of children in the optimized vs standardconditions The nursery group improved their scores, but only in the standard condition.	"…performance on an intelligence test is best conceptualized as reflecting three distinct factors: (a) formal cognitive processes; (b) informational achievements which reflect the content rather than the formal properties of cognition, and (c) motivational factors which involve a wide range of personality variables. (p. 2) "…the significant difference in improvement in standard IQ performance found between the nursery and non-nursery groups was attributable solely to motivational factors…" (p. 10)

Breuning and Zella (1978)	Within and between subjects study of 485 *special education* 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 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 have pretest IQs between 98 and 120 and did not occur for students having pretest IQs between 121 and 140." (p. 225)

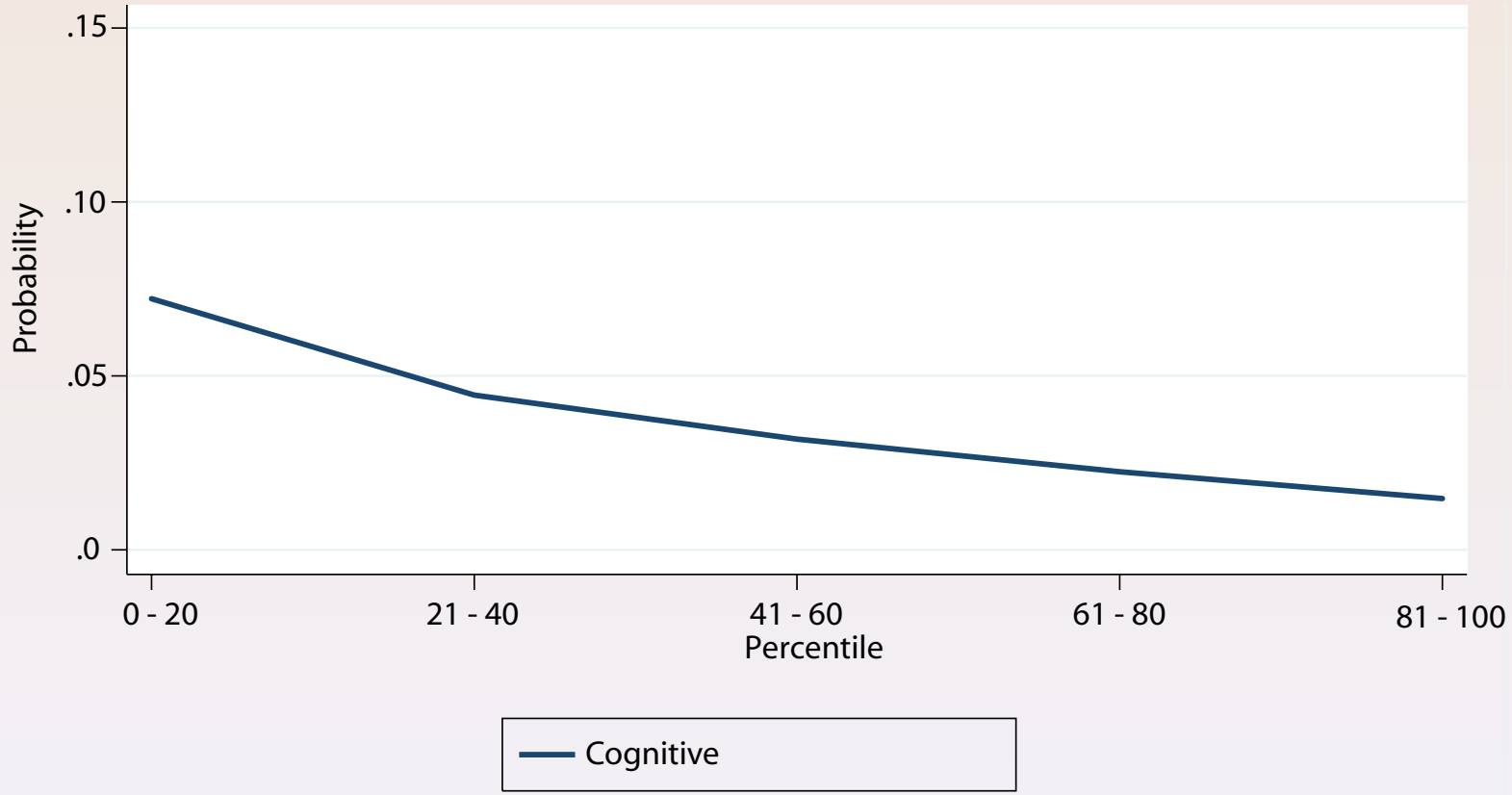
Holt and Hobbs (1979)	Between and within subjects study of 80 delinquent boys randomly assigned to three experimental groups and one control group. Each exp group received a standard and modified administration of the WISC-verbal section.	Exp 1-Token reinforcement for correct responses; Exp 2 – Tokens forfeited for incorrect responses (punishment), Exp 3-feedback on correct/incorrect responses	1.06 standard deviation difference between the token reinforcement and control groups (inferred from t = 3.31 for 39 degrees of freedom0	"Knowledge of results does not appear to be a sufficient incentive to significantly improve test performance among below-average I.Q. subjects…Immediate rewards or response cost may be more effective with below-average I.Q. subjects while other conditions may be more effective with average or above-average subjects." (p. 83)
Larson, Saccuzzo, and Brown (1994)	Between subjects study of 109 San Diego State University psychology students	Up to $20 for improvement over baseline performance on cognitive speed tests	"While both groups improved with practice, the incentive group improved slightly more." → need to calculate effect size, but it was not large	2 reasons why incentive did not produce dramatic increase: 1) few or no unmotivated subjects among college volunteers, 2) information processing tasks are too simple for 'trying harder' to

				matter
Duckworth (2007)	Within subjects study of 61 urban low-achieving high school students tested with a group-administered Otis-Lennon IQ test during their freshman year, then again 2 years later with a one-on-one (WASI) test	Standard directions for encouraging effort were followed for the WASI brief test. Performance was expected to be higher because of the one-on-one environment.	Performance on the WASI as juniors was about 16 points higher than on the group-administered test as freshmen. Notably, on the WASI, this population looks almost "average" in IQ, whereas by Otis-Lennon standards they are low IQ. $t(60) = 10.67$, $p < .001$	The increase in IQ scores could be attributed to any combination of the following 1) an increase in "g" due to schooling at an intensive charter school, 2) an increase in knowledge or crystallized intelligence, 3) an increase in motivation due to the change in IQ test format, and/or 4) an increase in motivation due to experience at high performing school

Predictive Power of Personality Traits

- Look at effects of both cognitive and noncognitive skills on many measures of social performance.

Ever been in jail by age 30, by ability (males)



Note: This figure plots the probability of a given behavior associated with moving up in one ability distribution for someone after integrating out the other distribution. For example, the lines with markers show the effect of increasing noncognitive ability after integrating the cognitive ability.

Source: Heckman, Stixrud, and Urzua (2006).

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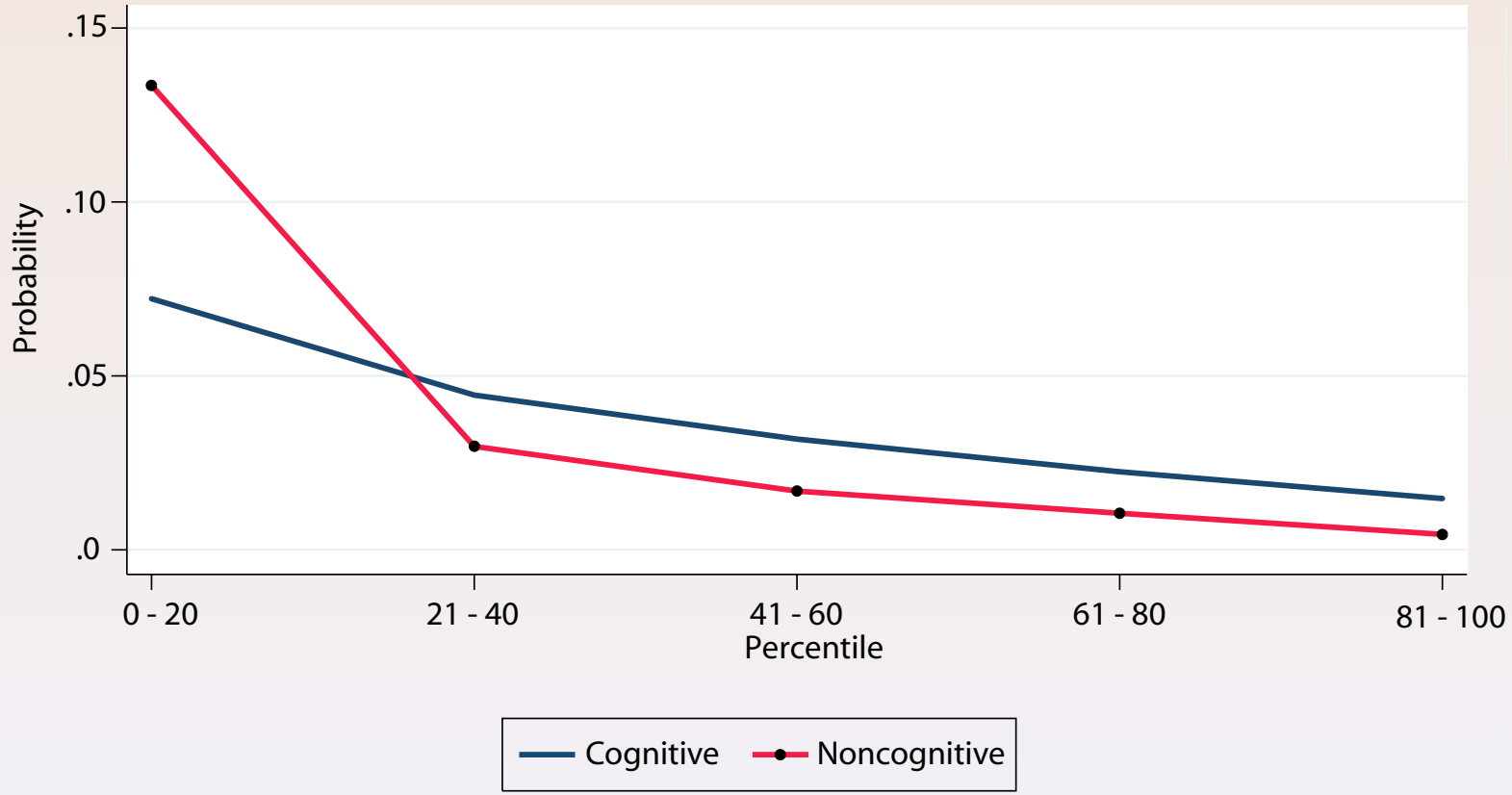

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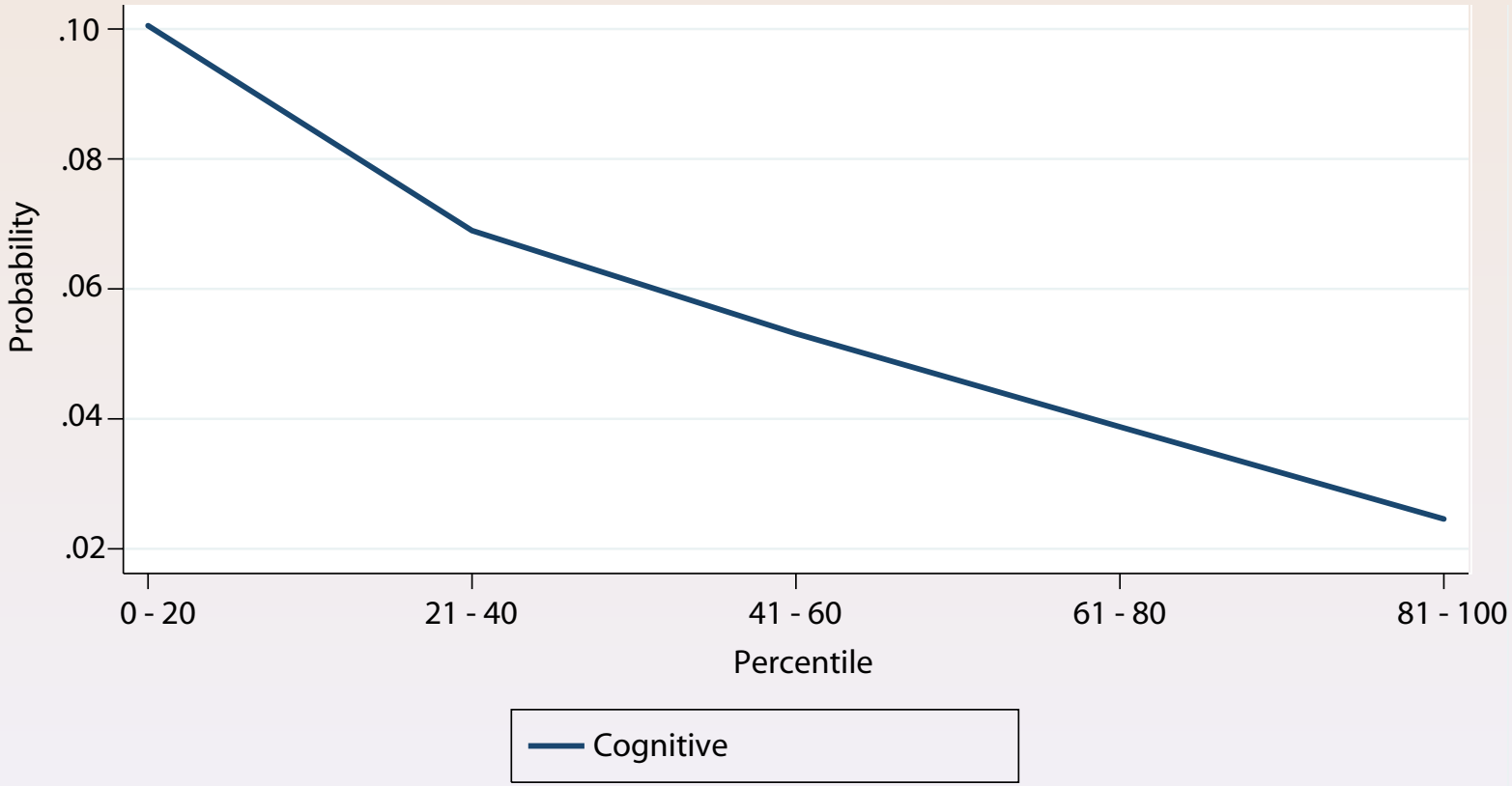
Source: Heckman, Stixrud, and Urzua (2006).

Probability of being single with children (females)



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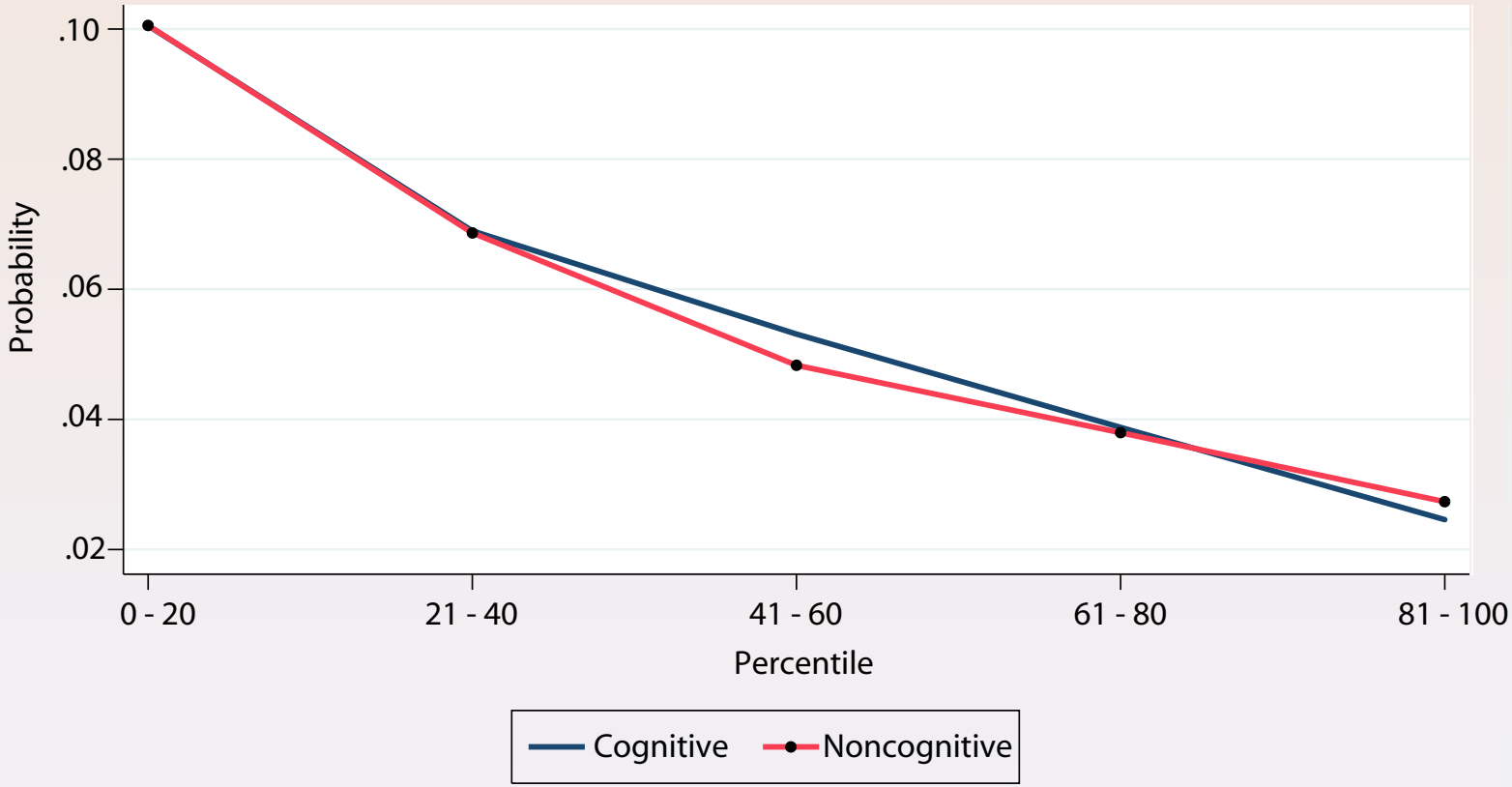

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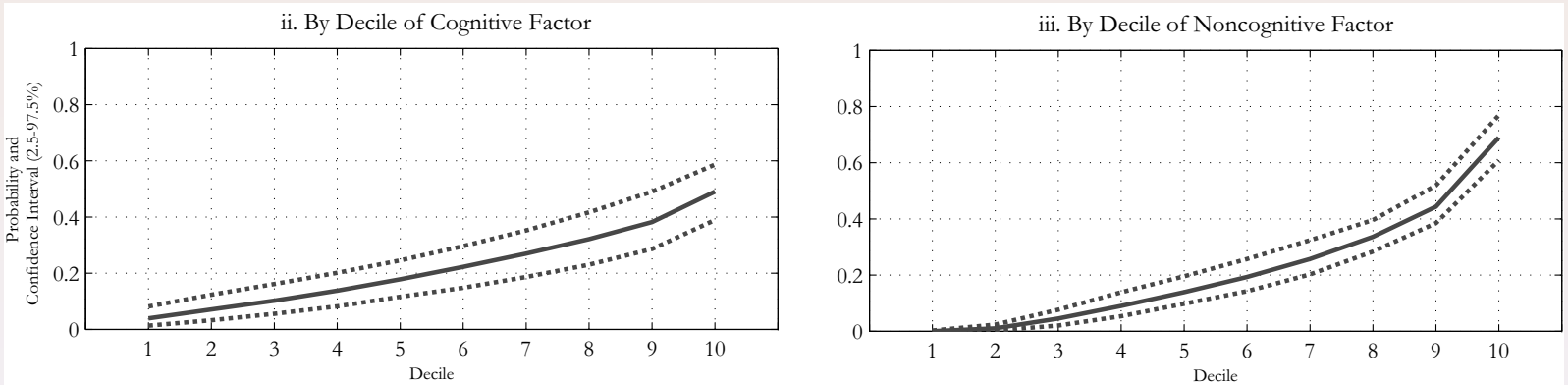
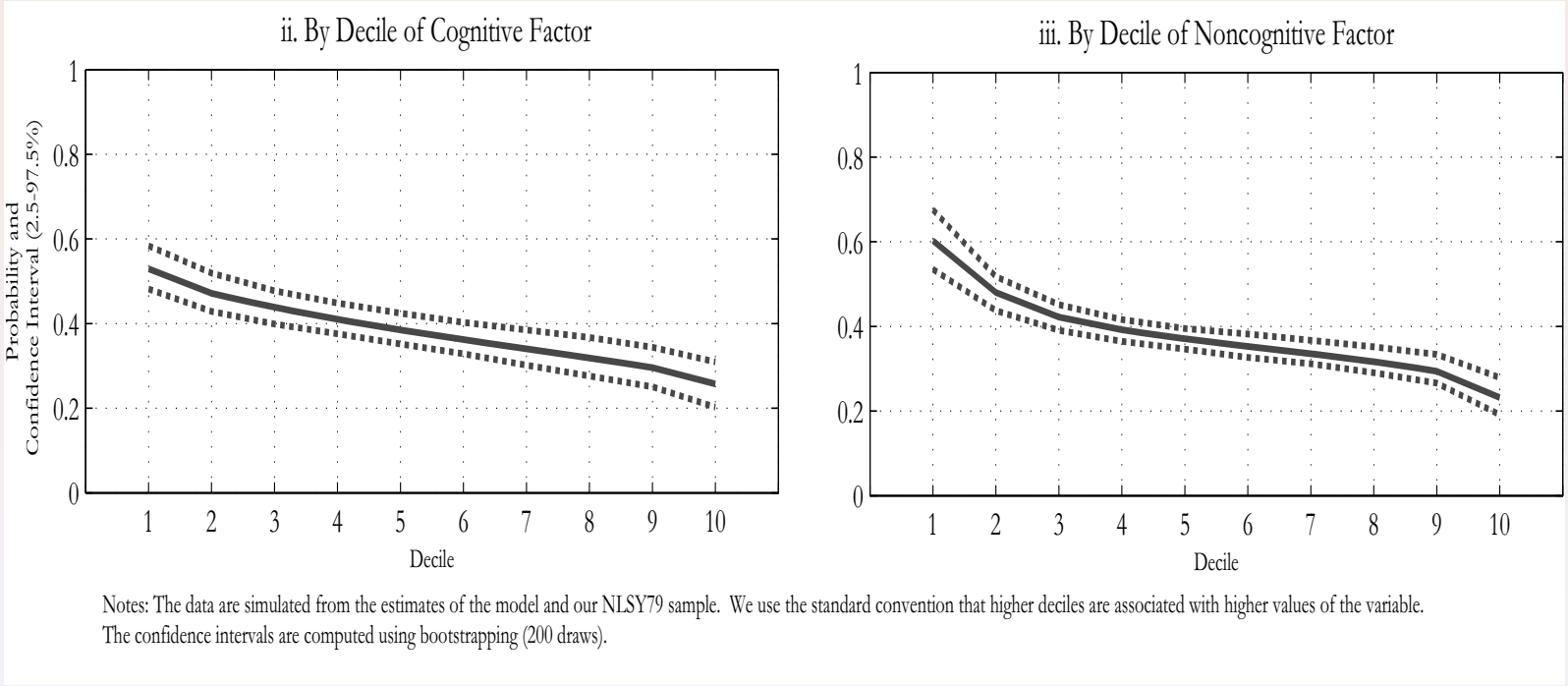
Source: Heckman, Stixrud, and Urzua (2006).

Probability of being a 4-year college graduate by age 30 (males)



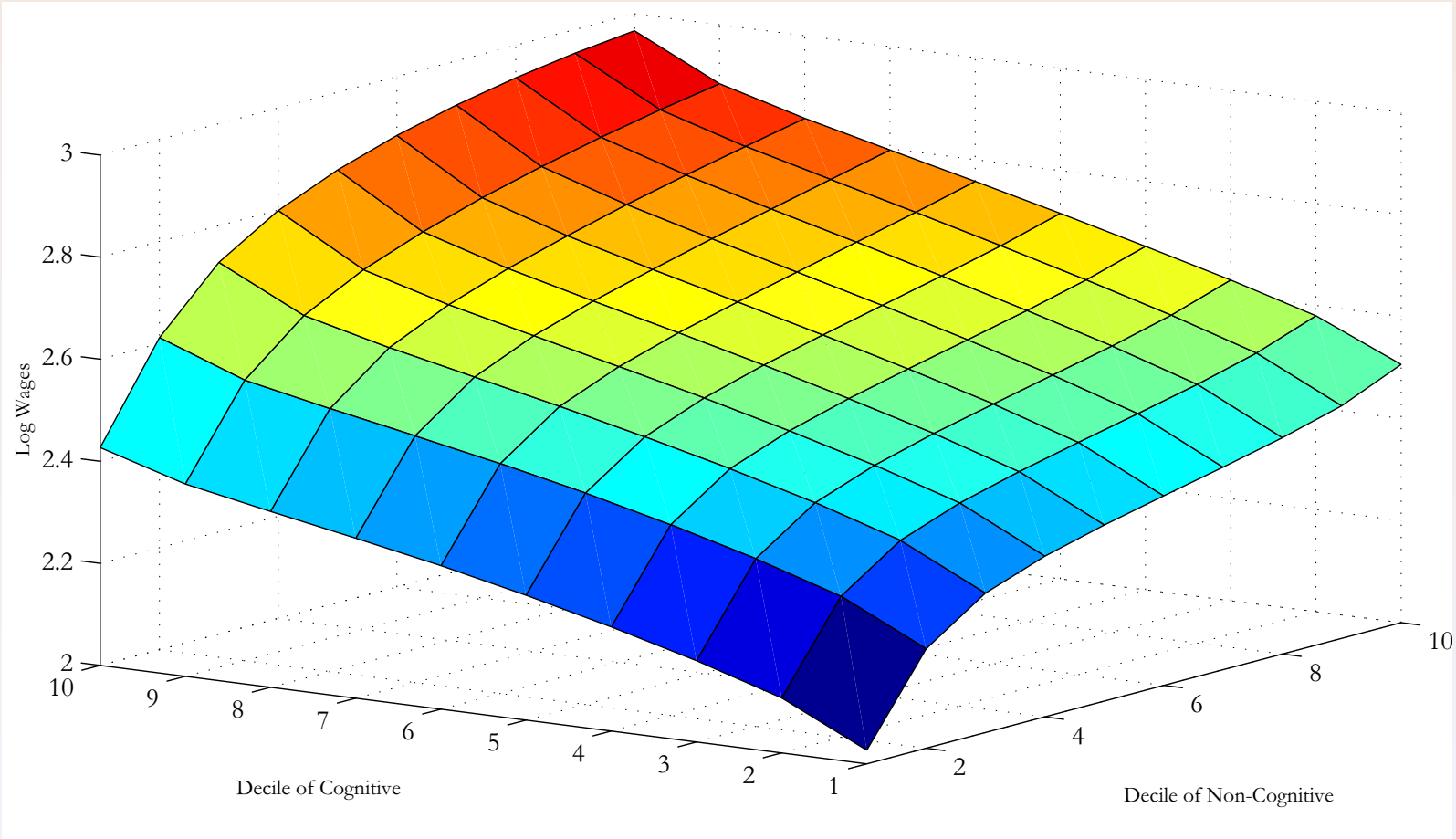
Notes: The data are simulated from the estimates of the model and our NLSY79 sample. We use the standard convention that higher deciles are associated with higher values of the variable. The confidence intervals are computed using bootstrapping (200 draws).

Probability of daily smoking by age 18 (males)

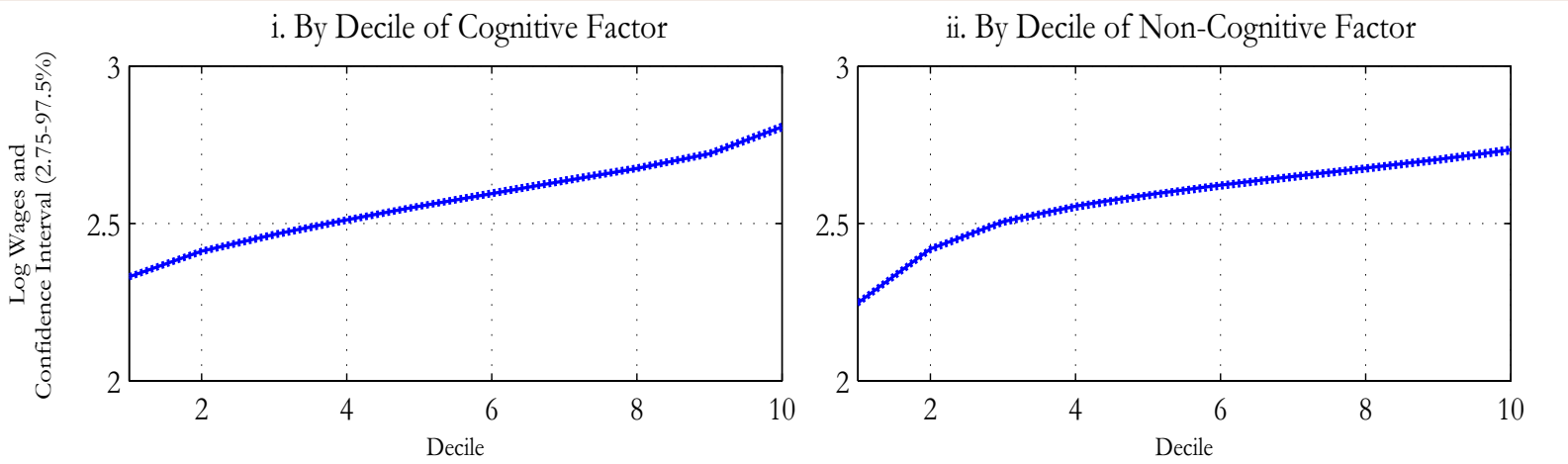


Notes: The data are simulated from the estimates of the model and our NLSY79 sample. We use the standard convention that higher deciles are associated with higher values of the variable. The confidence intervals are computed using bootstrapping (200 draws).

Mean log wages by age 30 (males)

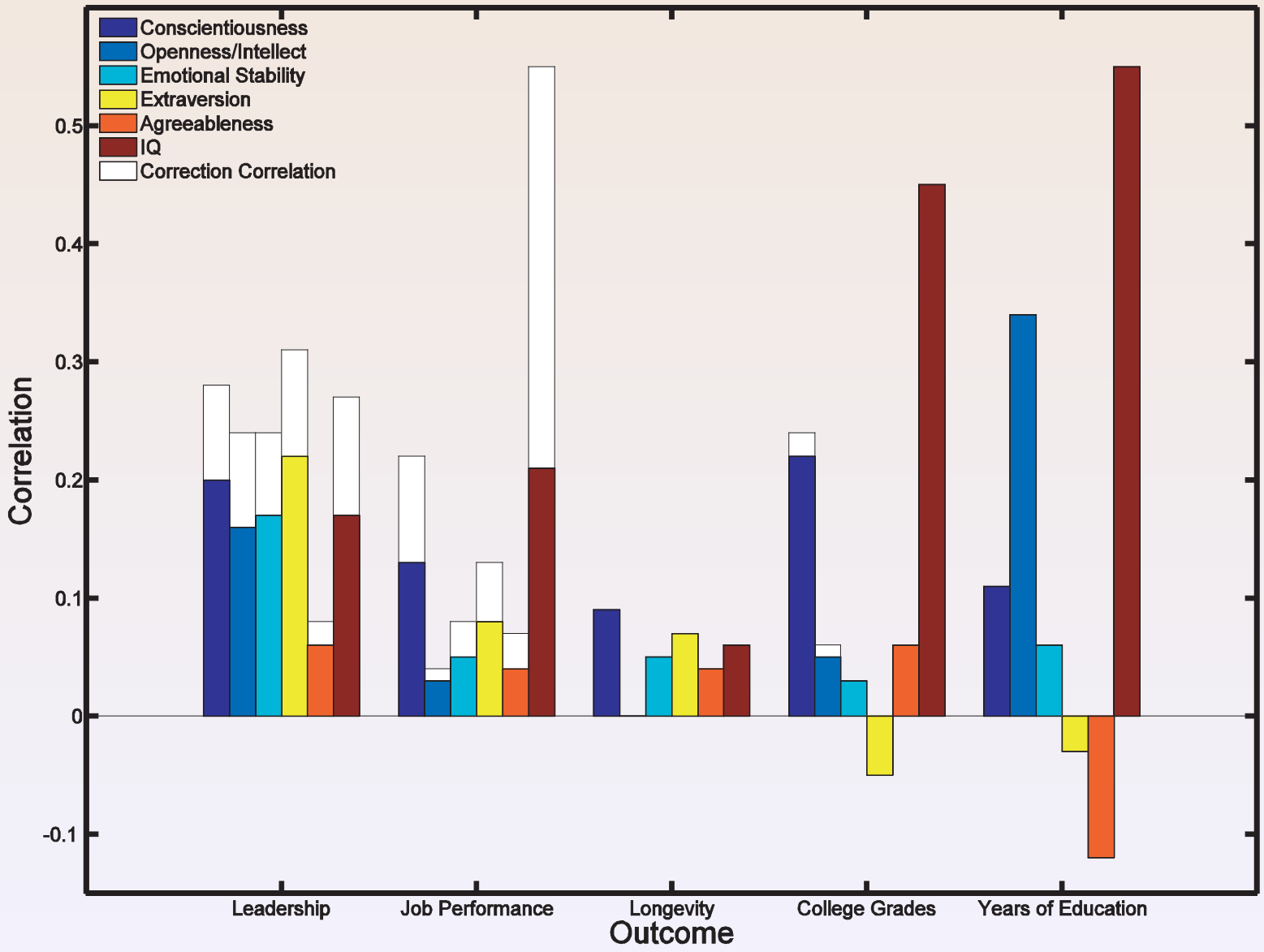


Mean log wages by age 30 (males)



Notes: The data are simulated from the estimates of the model and our NLSY79 sample. We use the standard convention that higher deciles are associated with higher values of the variable. The confidence intervals are computed using bootstrapping (50 draws).

- Correlations for the predictive validity of IQ and Big Five personality factors on leadership ratings, job performance, longevity, college grades, and years of education.


Conscientiousness
Openness/Intellect
Emotional Stability
Extraversion
Agreeableness
IQ
Correction Correlation
Correlation
0.5
0.4
0.3
0.2
0.1
0
-0.1
Leadership
Job Performance
Longevity
College Grades
Years of Education
Outcome

Limitations of the Evidence on Predictive Validity

- Big Five may be too crude. Lower level-facets are predictive
- Personality often measured by brief self-report questionnaires (contextual effects)
- Measurement errors are important

Separate Measurement Systems in Economics

- Time Discounting
- Risk Aversion
- Leisure Preferences
- Altruism and social preferences
- **How to relate the economic measures to the constructs used in personality psychology?**

Many of these measurements do not standardize for incentive and contextual effects.

- Lack of standardization creates a serious problem in isolating true traits and in making comparisons across studies.
- For economic choices, market settings play a crucial role in policing behavior.

Frameworks for Integrating Personality Psychology and Economics

- Psychological variables as constraints
- Psychological variables as preference parameters
- Behaviorial economists focus on preferences
- But constraints and expectations are also important

New Idea: Personality Variables as Constraints

- $U_{i,k}$ = motivation for choice (goal) k by agent i.
- Choice sets, B_i, differ among persons depending on their capacities.
- Agent i chooses $\hat{k}_i$ as the maximal element in the choice set B_i:

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

- $U_{i,k} = V_{i,k} + \varepsilon_{i,k}$
- $V_{i,k}$ is agent i's stable valuation for k
- $\varepsilon_{i,k}$ is a random "taste" shock.

- If $V_{i,k} = V_k$, and $\varepsilon_{i,k}$ is iid extreme value type 1, probability that k is selected from choice set B_i is

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

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

Constraints can capture a variety of aspects of choice behavior.

- Shy person may limit her options in a way an extravert 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.
- Like greater pixel resolution in imaging machines, those with higher IQ may resolve reality in a more fine-grained and less biased way.

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 many personality psychologists and economists.
- One could also think of psychological traits as excludable private goods. (Baumeister)
- More of a trait used in one activity means less of the trait available for use in other activities.

- One might augment, complement or override the supply of a trait to any activity by supplying more time, or energy, to the activity in which the trait is used.
- "Energy," e, may be used to moderate the manifestation of the trait.
- For example, energy may be spent controlling anger in a given activity.

One-period Model

- J activities with outputs Z_j, $j = 1, \ldots, J+1$.
- Augment task functions to include levels of energy, and time, in vector e^j

$$T_j = h_j\left(f^j, e^j\right) \text{ for } j = 1, \ldots, J+1 \tag{5}$$

- f^j distinct from f_j, the j^{th} component of vector f.
- Parallel notation for e^j.

- For a fixed input of psychological traits, higher levels of e^j may raise the output of the task.
- If $e^j = 0$, the trait f^j may be switched off.
- 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

$$Z_j = \varphi_j \left(T_j, X_j \right) \text{ for } j = 1, \ldots, J+1 \tag{6}$$

- 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.
- $$U = U\left(Z_1, \ldots, Z_j, e^1, \ldots, e^{J+1}, f\right) \tag{7}$$
- $Z_{J+1} = \varphi_{J+1}\left(T_{J+1}, X_{J+1}\right)$: hedonic earnings function.

$$\sum_{j=1}^{J+1} P_j X_j = Q + Z_{J+1} \tag{8}$$

- Q is unearned income

Consider a pure private goods case and a pure public goods case

- Assume e is private.

		f	
		Public	Private
e	Private	case I	case II

- Case I, additional constraints,

$$f^j = \bar{f}, \ \sum_{j=1}^{J+1} e^j = \bar{e}, \ \text{for all } j = 1, \ldots, J+1. \tag{9}$$

- Case II:

$$\sum_{j=1}^{J+1} f^j = \bar{f}, \ \sum_{j=1}^{J+1} e^j = \bar{e} \tag{10}$$

Case I: Traits as Public Goods

- Z_j and T_j, $j = 1, \ldots, J+1$, display constant returns to scale in non-public inputs.
- Different levels of $\bar{f}$ produce different productivities in different tasks.

Case II: Traits as Private Goods

- When traits are private goods there is the possibility of different levels of traits being used in different tasks and activities.
- 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 public goods case imposes more constraints on the system than the private goods case.
- Evidence would seem to favor case II. (From factor analysis and other studies)
- Different levels of traits are often found in different activities.
- Most of the estimates in the literature do not adjust for the inputs that affect the manifestation of the traits.
- **One must be cautious in concluding that case II is consistent with the evidence.**

Integrating Psychology into More General Economic Models

- Economic theory at the single agent level separates two distinct aspects of behavior and decision making: preferences and constraints.
- Included among the constraints are:
  a. information acquisition constraints
  b. static budget constraints and endowments that affect the flow of resources available for consumption in any period
  c. dynamic constraints connected with asset, skill and trait formation

- Utility for agent with decision horizon T over bundles of goods (attributes), $X_t, t = 1, ..., T$, in an environment of perfect certainty with cognitive and personality attributes f is

$$U(X_1, \ldots, X_T; f), \tag{11}$$

- Conventional specification of general preference function assumes a constant rate of discount for utility across periods:

$$U(X_1, \ldots, X_T, f) = \sum_{t=1}^{T} \frac{1}{(1+\rho)^{t-1}} U(X_t, f). \qquad (12)$$

- Much evidence against it and other state/time separable models
- Not required for intertemporal consistency.
- Evidence against expected utility (Savage model).

Traits Affect Comparative Advantage in the Labor Market

- Productivity of person in occupation (pursuit) j at time t as $Y_{j,t} = \alpha_{j,t}(f_t^j, e_t^j), j = 1, \ldots, J_t$.
- Different occupations or tasks require (or weight) different traits differently.

- If agents choose or are assigned to tasks on the basis of maximal output $Y_{j,t}$ and pursuit of one occupation precludes pursuit of other occupations, the occupation (task) selected at time t among the possible assignments at time t is j_t^*, defined as

$$j_t^* = \text{argmax}_{j_t} \left\{ Y_{j,t} \right\}_{t=1}^{J_t} . \tag{13}$$

- Hogan (2005) and Hogan and Hogan (2007) show the predictive power of personality traits in different occupations.

Do Personality Parameters and Economic Preference Parameters Correspond?

- It is tempting to try to relate personality traits to conventional economic preference parameters.
- The personality traits analyzed in psychology omit cognition.
- They also omit motivation.
- Big Five captures traits that are not exclusive determinants of economic preference parameters.

- A single agent economic model cannot fully capture the operation of traits that foster social interactions.
- Positive social interactions can produce benefits in terms of learning and information processing.
- Participation in social groups provides a form of insurance and may promote risk taking (through insurance), even if it does not change risk aversion.

Do the traits discussed by personality psychology cause us to rethink the standard economic model?

- Evidence on the predictive power of sociability, effort and conscientiousness and the evidence on altruism and other pro-social preferences should lead to a reemphasis of traditional theory.
- Social interactions tend to be neglected in standard economic theory, although there is a lot of recent research on this topic (see Durlauf and Young 2001, Brock and Durlauf 2001, and the evidence in Fehr and Schimdt, 2006).

Do Conventional Economic Preference Parameters Fully Explain All of the Personality Traits Uncovered by Psychologists?

- Implausible that conventional leisure preference, risk aversion, and time preference parameters explain all of the traits identified by psychologists.
- Utility function U introduces motivation explicitly into economic analysis.

- Low taste for leisure and a low discount rate would contribute to making persons more conscientious.
- The Big Five traits alone cannot explain diligence unless the person has some goal (or goals) or preferences motivating effort and self-discipline in a particular situation.
- Most traits (for example, hostility, warmth, anxiety, trust) are less easily explained by standard economic preferences.

Stability of Preference Parameters: Two Concepts

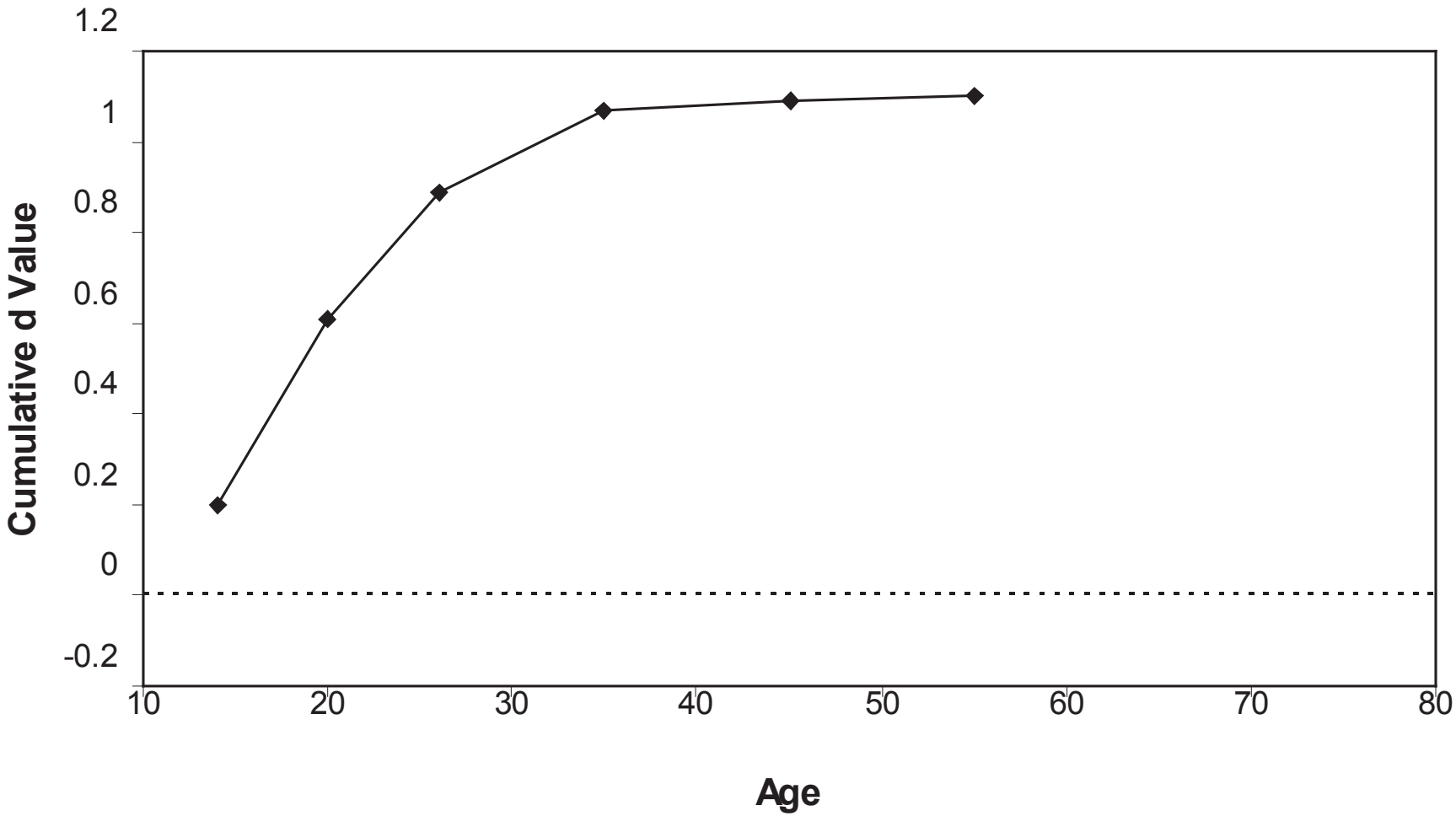
- **Situational specificity and stability**
- **Stability over age in the same situation**

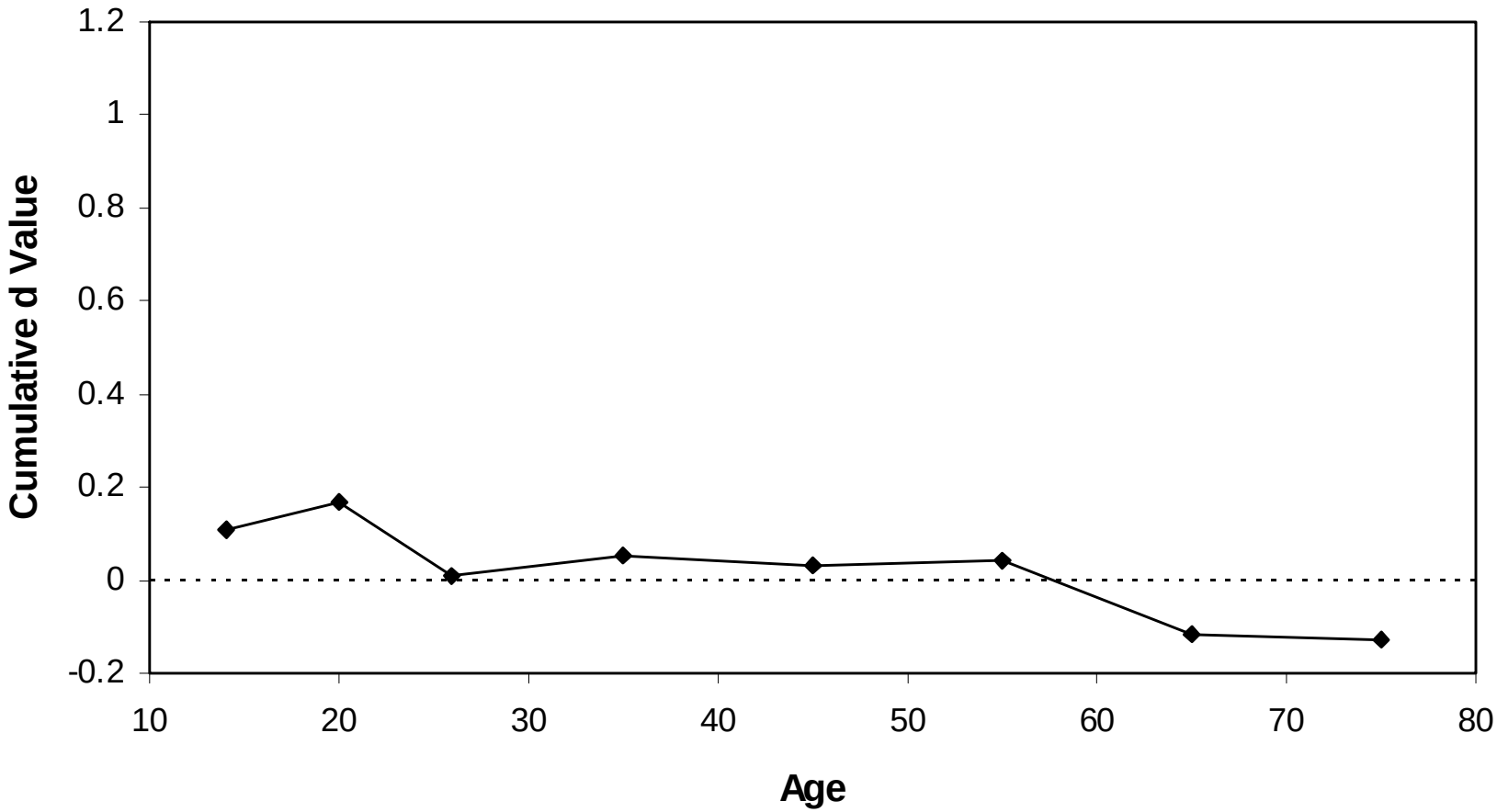
To what extent do environments and parental investments influence the developmental trajectories of personality (and other) traits?

- Mean-level change: change over time in absolute levels of a trait measured by changes in scores over time.
- Rank-order change: changes in the ordinal ranking of a trait in a population 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, especially after age 7.

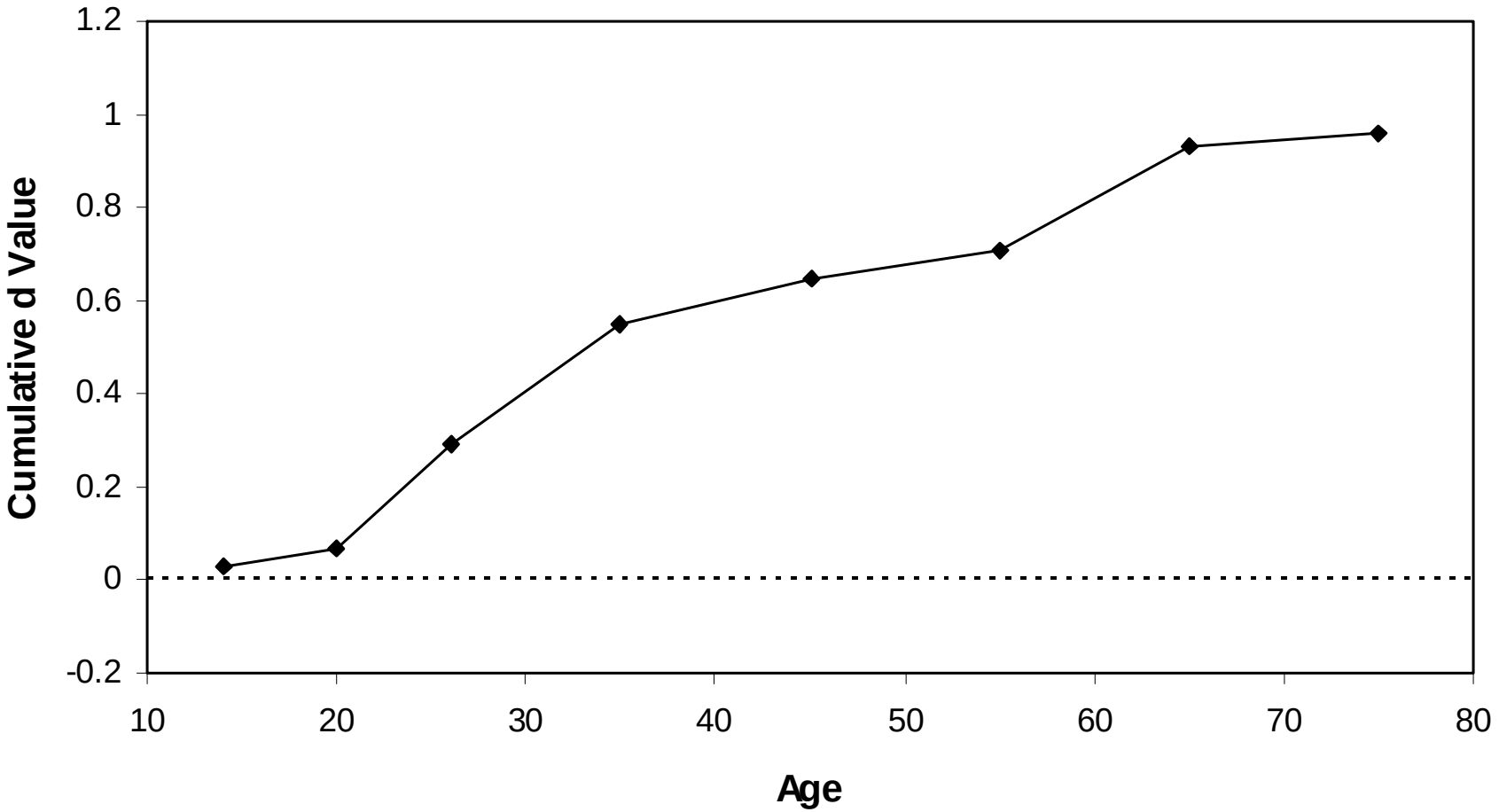
Mean Level Changes

Social Dominance



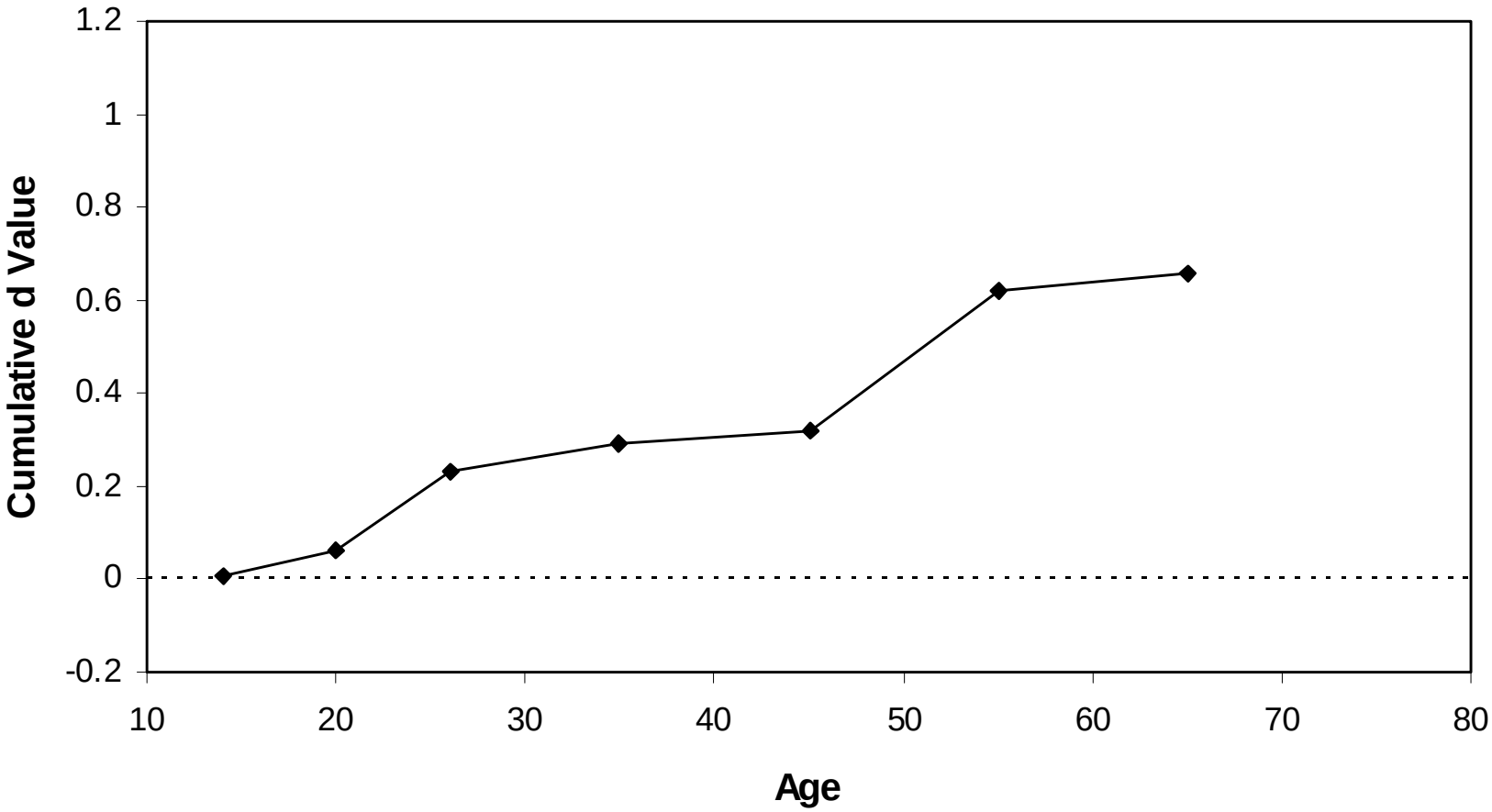

Social Vitality
Cumulative d Value
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
10
20
30
40
50
60
70
80
Age

Conscientiousness




Openness to Experience
Cumulative d Value
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
10
20
30
40
50
60
70
80
Age

Agreeableness



Emotional Stability

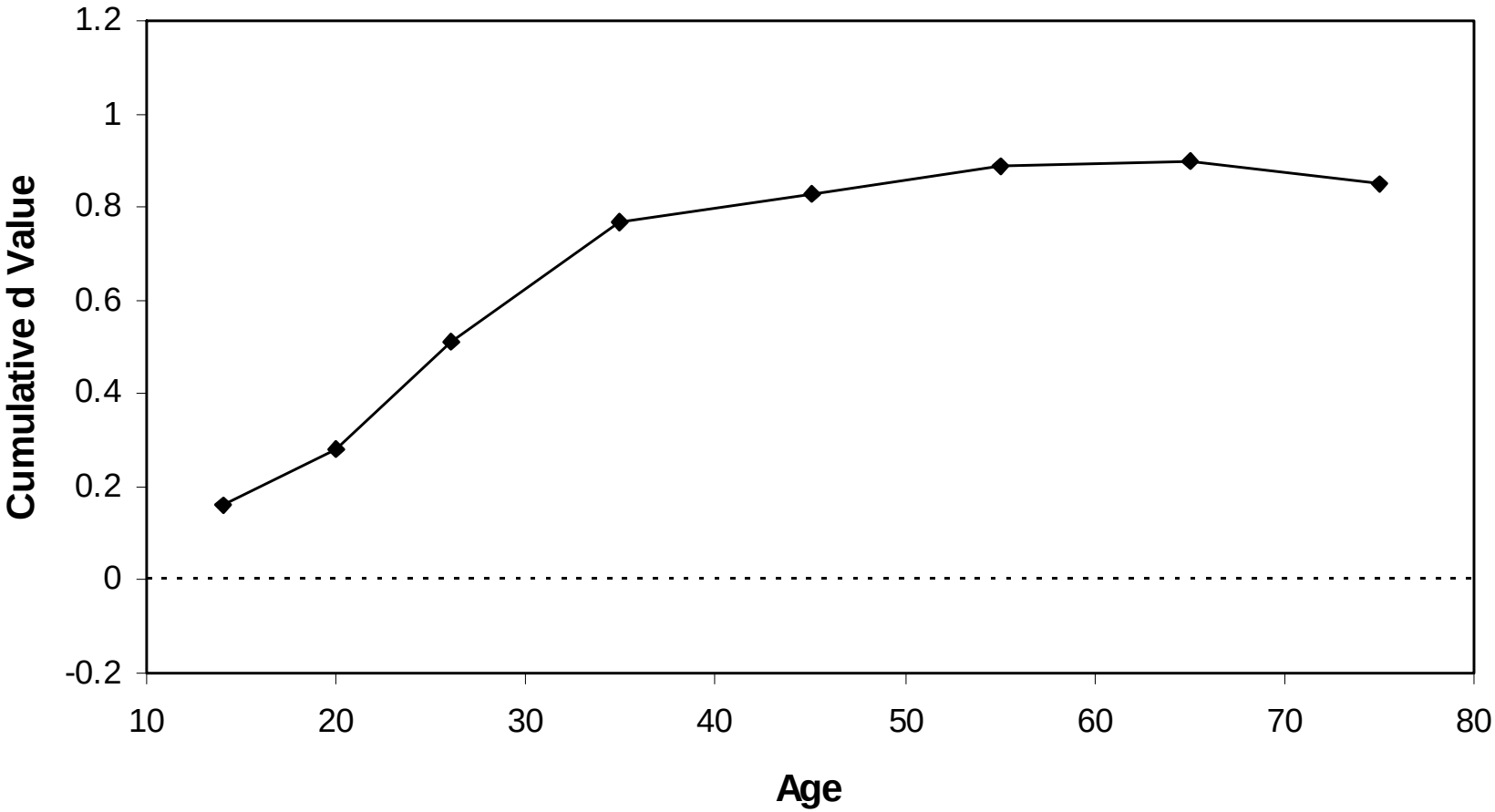


Figure 4(a): Longitudinal Analysis of Mean-Level Changes in Cognitive Skill

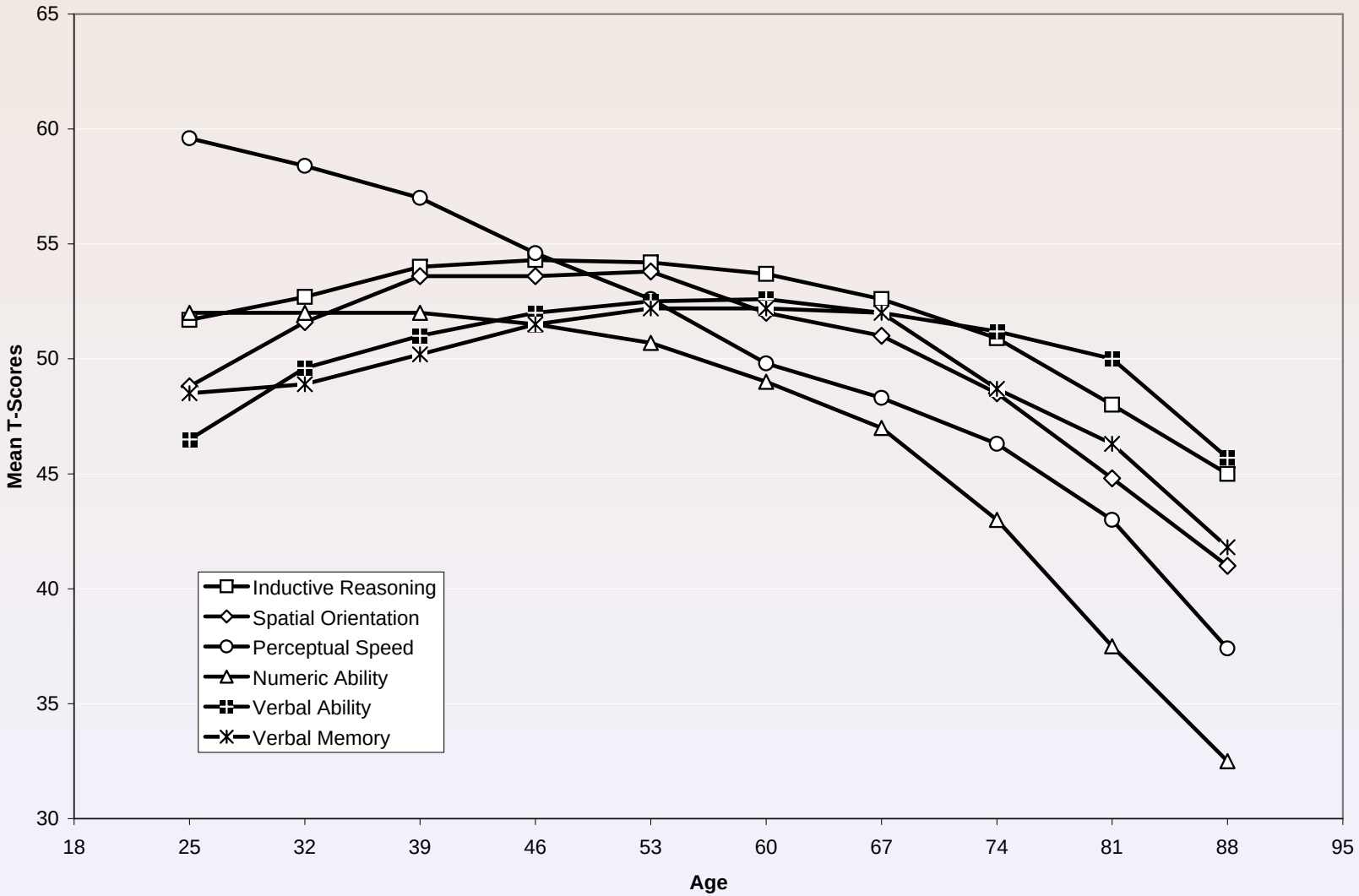


Figure 4(b): Cross-Section Analysis of Mean-Level Changes in Cognitive Skill

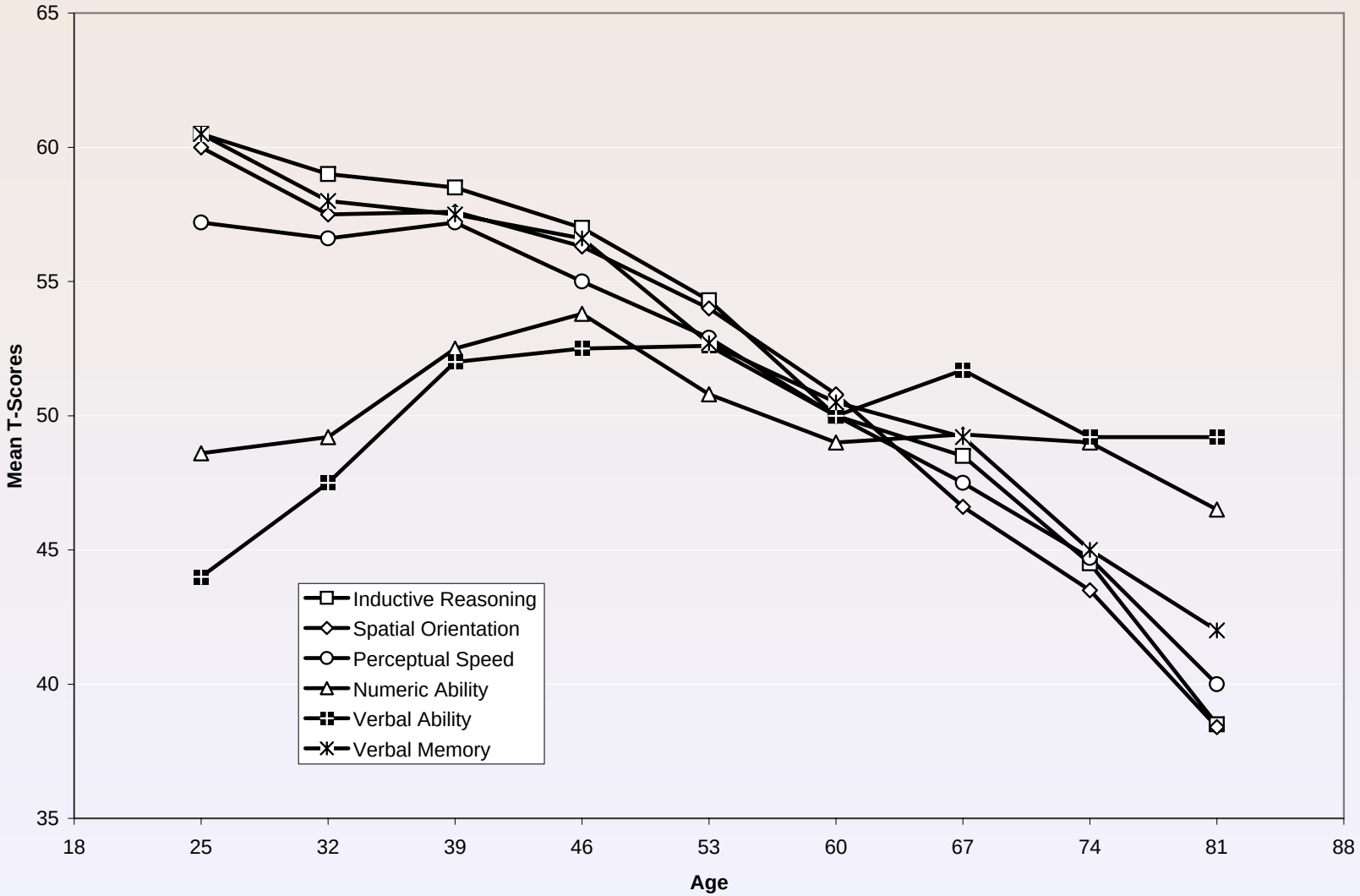
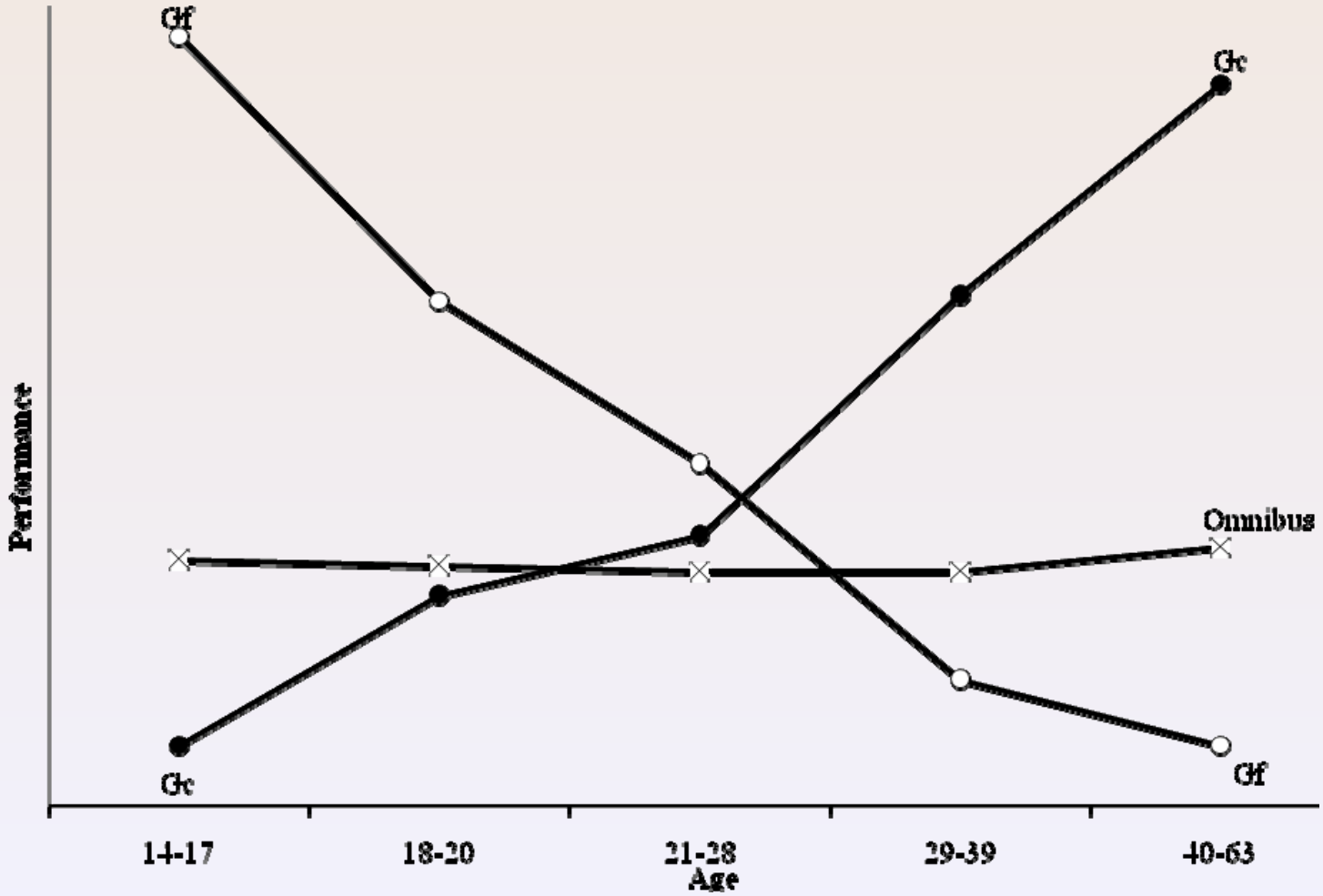


Figure 4(c): Fluid Intelligence Decreases and Crystalized Intelligence Increases



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

Rank-Order Change in Cognitive and Personality Skills

- Figure 5a shows graphs of rank order stability of personality by age.
- Figure 5b shows rank order stability of IQ over broad age ranges.

Figure 5(a): Rank Order Stability of Personality by Age

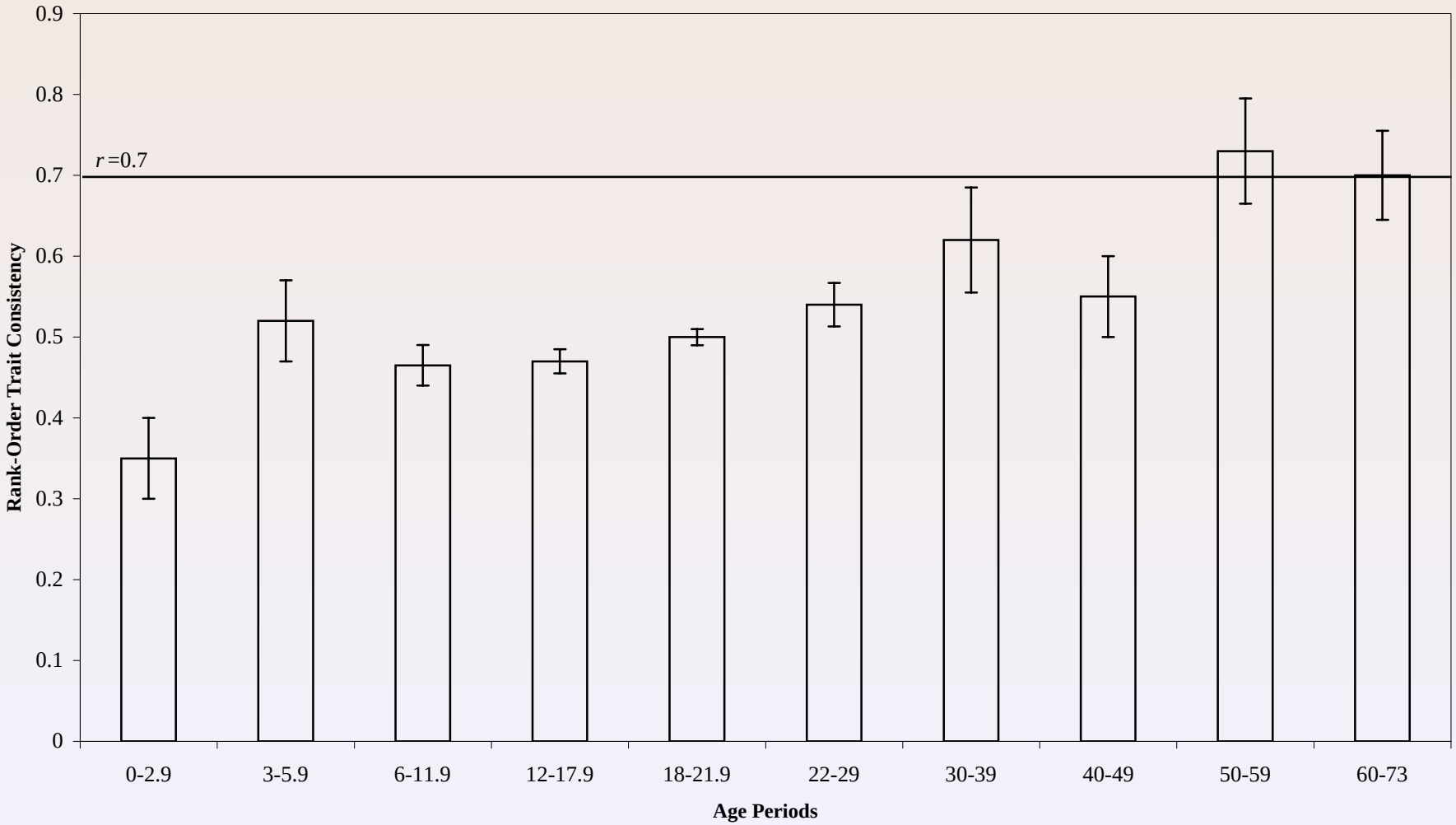
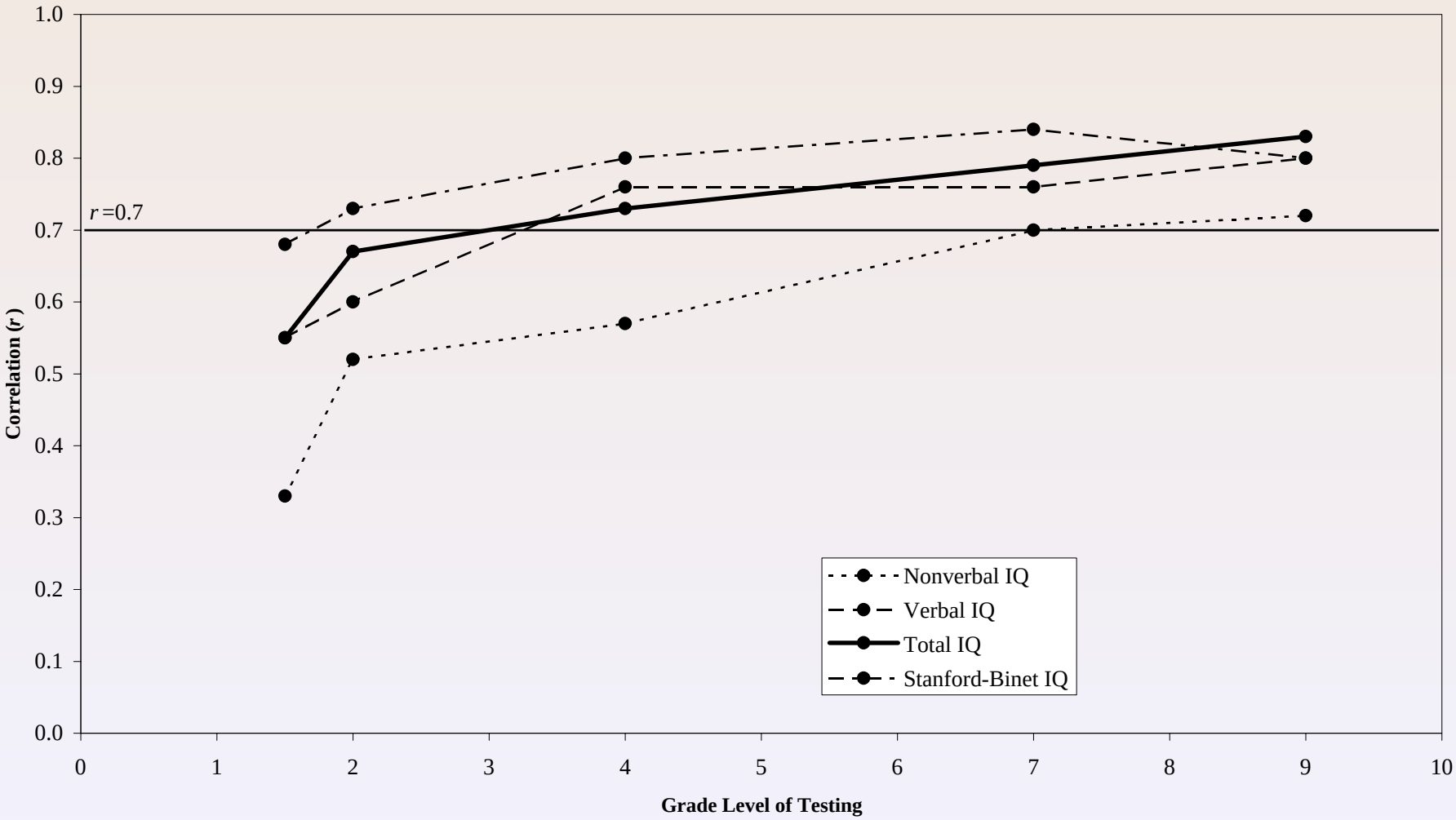


Figure 5(a): Rank Order Stability of IQ Over Broad Age Ranges



What Causes Change in Abilities Over Time in the Same Situation?

- Personality change in adulthood may be precipitated by major shifts in social roles (for example, getting a job for the first time, becoming a parent).
- Clausen and Gilens (1990) claim that female labor force participation increases self-confidence.
- Gottschalk (2005) presents experimental evidence that women forced to work due to welfare reform showed gains in self-confidence and self-esteem.

Observations on the evidence from longitudinal and intervention studies:

- First, skills beget skills.
- All capabilities are built on a foundation of capacities that are developed earlier.
- This stems from two characteristics that are intrinsic to the nature of learning:
  (a) early learning confers value on acquired skills, which leads to self-reinforcing motivation to learn more and
  (b) early mastery of a range of cognitive, social, and emotional competencies makes learning at later ages more efficient and therefore easier and more likely to continue.

- Second, early intervention lowers the cost of later investment.
- Public job training programs, adult literacy services, prisoner rehabilitation programs, and education programs for disadvantaged adults at current levels of expenditure produce low economic returns.

- A large body of research shows that early endowments and environments matter.
- But what happens later also matters.
- Remediation is costly.
- It is **not**, however, impossible, except when persons get to very low levels of initial conditions.
- Resilience–"desistance"–is an important phenomenon in adolescence and early adult years.

- Cunha and Heckman (2008) and Cunha, Heckman, and Schennach (2007) estimate technologies of skill formation to understand how the skills of children evolve in response to
  (1) the stock of skills children have already accumulated;
  (2) the investments made by their parents; and
  (3) the stock of skills accumulated by the parents themselves.
- C_t = cognitive skills at age t
- N_t = noncognitive skills at age t
- H_t = health at age t
- C_m = maternal cognition
- N_m = maternal noncognitive skills
- H_m = health of mother

- Technology for the production of cognitive skills:

$$C_{t+1} = F_{C,t}(N_t, C_t, H_t, I_t, C_M, N_M, H_m).$$

- Technology for the production of non-cognitive skills:

$$N_{t+1} = F_{N,t}(N_t, C_t, H_t, I_t, C_M, N_M, H_m).$$

- Technology for health skills:

$$H_{t+1} = F_{H,t}(N_t, C_t, H_t, I_t, C_M, N_M, H_m).$$

- Allow for proxy nature of inputs and outputs

- Technologies recognize intergenerational transmission and dynamic multipliers.
- Capture the effect of critical and sensitive periods on development.
- Capture cross-effects of one type of skill on fostering other types of skills.

A More General Setup

Assume that childhood lasts two periods "1" and "2".

- Contrary to a huge body of literature in economics and social policy that collapses childhood into a single period.

A More General Setup

Assume that childhood lasts two periods "1" and "2".

- Contrary to a huge body of literature in economics and social policy that collapses childhood into a single period.
- Relaxing assumption has important policy implications.

A More General Setup

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- Contrary to a huge body of literature in economics and social policy that collapses childhood into a single period.
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- Skills S are both cognitive and noncognitive. (A vector.)
- I_1 is investment in period "1".
- I_2 is investment in period "2".
- θ are environmental/genetic factors determined at birth.

S_1 is the skill produced in period "1" according to:

$$S_1 = g\left(I_1; \theta\right)$$

S_2 is the skill produced in period "2" according to:

$$S_2 = k\left(S_1, I_2; \theta\right)$$

h is adult human capital,

$$h = S_2, \text{ a vector.}$$

Investments may be qualitatively different at different stages.

Self-Productivity and Complementarity

Complementarity:

$$\frac{\partial^2 S_2}{\partial I_2 \partial S_1'} > 0$$

(Early Investment facilitates later investment.)
Can be true componentwise.

Example. Attainment of noncognitive skills through mother's warmth and encouragement raises effectiveness of both cognitive and noncognitive investments.

Self-Productivity and Complementarity

Self-Productivity:

$$\frac{\partial h}{\partial I_1} = \frac{\partial S_2}{\partial I_1} = \frac{\partial k}{\partial S_1}\frac{\partial S_1}{\partial I_1} > 0$$

(Early investment raises the stock of second period skills.)

Example. Those who attain higher first period skills are better able to progress to period two and produce skills more effectively.

- This explains the higher returns to education for more able individuals that is found in the literature.

Self-Productivity and Complementarity

To simplify notation, assume a scalar investment in each period.

Two skills $S_2 = (S_2^C, S_2^N)$, cognitive and noncognitive.

Final human capital is an aggregate that consists of cognitive and noncognitive components:

$$h = h(S_1, S_2).$$

Self-Productivity and Complementarity

Cunha and Heckman establish conditions under which one can express the technology as:

$$h = \left\{ \gamma I_1^{\phi} + (1 - \gamma) I_2^{\phi} \right\}^{\frac{1}{\phi}}$$

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- Period 1 is sensitive if $.5 < \gamma < 1$
- ϕ is a measure of how easily one can substitute late for early investments.

Consider two polar cases of these technologies

- One case: early and late investments are perfect substitutes (assumed in most economic analyses and public policy).
  - Early deficits can be perfectly remedied by later interventions.
- A second case: early investments critical for later investments to be effective.
  - In the extreme, early deficits cannot be remedied.
- Neither case is correct, but the second is closer to the truth than the first.

- Case 1: h: adult human capital

$$h = \gamma I_1 + (1 - \gamma) I_2$$

- I_1 is early investment; I_2 is late investment.
- Remediation is always possible. (However, it may not be cost effective.)
- At odds with the evidence from Neuroscience and Developmental Psychology.
- Standard model in economics.

The Technology in an Intuitive Framework

- Timing of investment is not an important issue.
- As a consequence, remediation is possible.
- However, even though it may be feasible to remediate, it may be very costly (especially if γ is close to 1).

The Technology in an Intuitive Framework

$$\text{If } \frac{\gamma}{1+r} < 1-\gamma \text{ invest later}$$
$$> 1-\gamma \text{ invest earlier}$$

- If $\gamma = 1/2$, invest later.
- May be more efficient to give the child a bank account to finance its schooling.

Case 2: I_1 and I_2 are perfect complements ($\phi \to -\infty$) $\Rightarrow$

$$h = [\min\{I_1, I_2\}]$$

Then:

$$I_1 = I_2 = \frac{1+r}{2+r}$$

Complementarity has a dual face:

1. Early investments increase returns to late investments.
2. Late investments are needed to make early investments pay off.

In this case, timing of investments matter. In particular, no remediation is possible.

A poor initial environment cannot be offset.

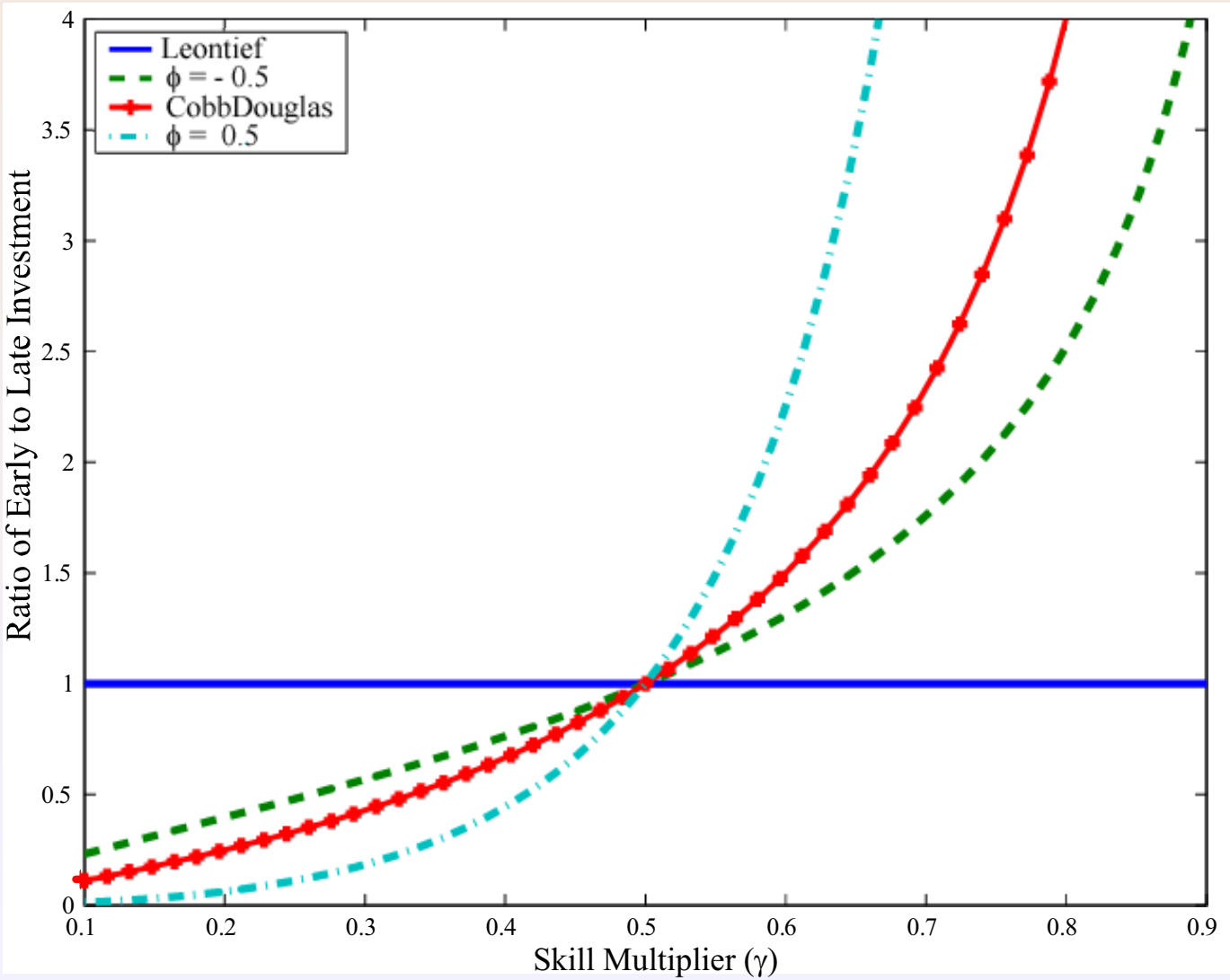
Case 3: smooth case: $-\infty < \phi < 1$.

$$\log\left(\frac{l_1}{l_2}\right) = \left(\frac{1}{1-\phi}\right)\log\left(\frac{\gamma}{1-\gamma}\right) - \left(\frac{1}{1-\phi}\right)\log\left(1+r\right).$$

- r increases $\Rightarrow \left(\frac{l_1}{l_2}\right)$ decreases;

  γ increases $\Rightarrow \left(\frac{l_1}{l_2}\right)$ increases

Ratio of early to late investment in human capital as a function of the skill multiplier for different values of complementarity



Econometric Work

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Econometric Work

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- Technology has elasticities of substitution below 1 (Cobb-Douglas).
- The elasticity of intertemporal substitution parameter governs the early-late trade-off of investment.
- Cunha and Heckman estimate both linear and nonlinear models.

- Find much stronger yields of investment in the early years, especially for cognitive skills.

Anchored Stage Specific Technology Equations, Anchor: Log Earnings of the Child Between Ages 23-28, Measurement Error is Classical, No Omitted Inputs Correlated with θ_t, White Males, CNLSY/79

Linear Technology

Dependent Variable	Noncognitive Skill			Cognitive Skill		
	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
Lagged Noncognitive Skill, θ_t^N	0.9849	0.9383	0.7570	0.0216	0.0076	0.0005
	(0.014)	(0.015)	(0.010)	(0.0043)	(0.0029)	(0.0029)
Lagged Cognitive Skill, θ_t^C	0.1442	−0.1259	0.1171	0.9197	0.8845	0.9099
	(0.1204)	(0.1148)	(0.1148)	(0.023)	(0.021)	(0.019)
Parental Investment, θ_t^I	0.0075	0.0149	0.0064	0.0056	0.0018	0.0019
	(0.0018)	(0.0031)	(0.0027)	(0.0016)	(0.0007)	(0.0007)
Maternal Education, S	0.0005	−0.0004	0.0019	−0.0003	0.0007	0.0001
	(0.0010)	(0.0010)	(0.0011)	(0.0005)	(0.0006)	(0.0006)
Maternal Cognitive Skill, A	0.0001	−0.0011	−0.0019	0.0025	0.0002	0.0010
	(0.0001)	(0.0001)	(0.0003)	(0.0007)	(0.0004)	(0.0004)

Different stages of the life cycle are sensitive periods for different outcomes.

The Percentage Impact on Log Earnings at Age 23 of an Exogenous Increase by 10% in Investments at Different Periods (This technology omits health impacts).

Total Percentage Impact, Percentage Impact Through Cognitive Skill Only, and Percentage Impact Through Noncognitive Skill Only
White Males, CNLSY/1979

Total Percentage Impact on Earnings	% Impact on Log Earnings Exclusively Through Cognitive Skills	% Impact on Log Earnings Exclusively Through Noncognitive Skills

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		Total Percentage Impact on Earnings	% Impact on Log Earnings Exclusively Through Cognitive Skills	% Impact on Log Earnings Exclusively Through Noncognitive Skills
Period 1	Mean	0.2487%	0.1247%	0.1240%
	Standard Error	0.0302%	0.0151%	0.0150%

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	Standard Error	0.0302%	0.0151%	0.0150%
Period 2	Mean	0.3065%	0.0445%	0.2620%
	Standard Error	0.0358%	0.0052%	0.0306%

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	Standard Error	0.0358%	0.0052%	0.0306%
Period 3	Mean	0.2090%	0.0540%	0.1550%
	Standard Error	0.0230%	0.0059%	0.0170%

Nonlinear Estimates

The Technology Equations: Nonlinear Technology
Unanchored Model

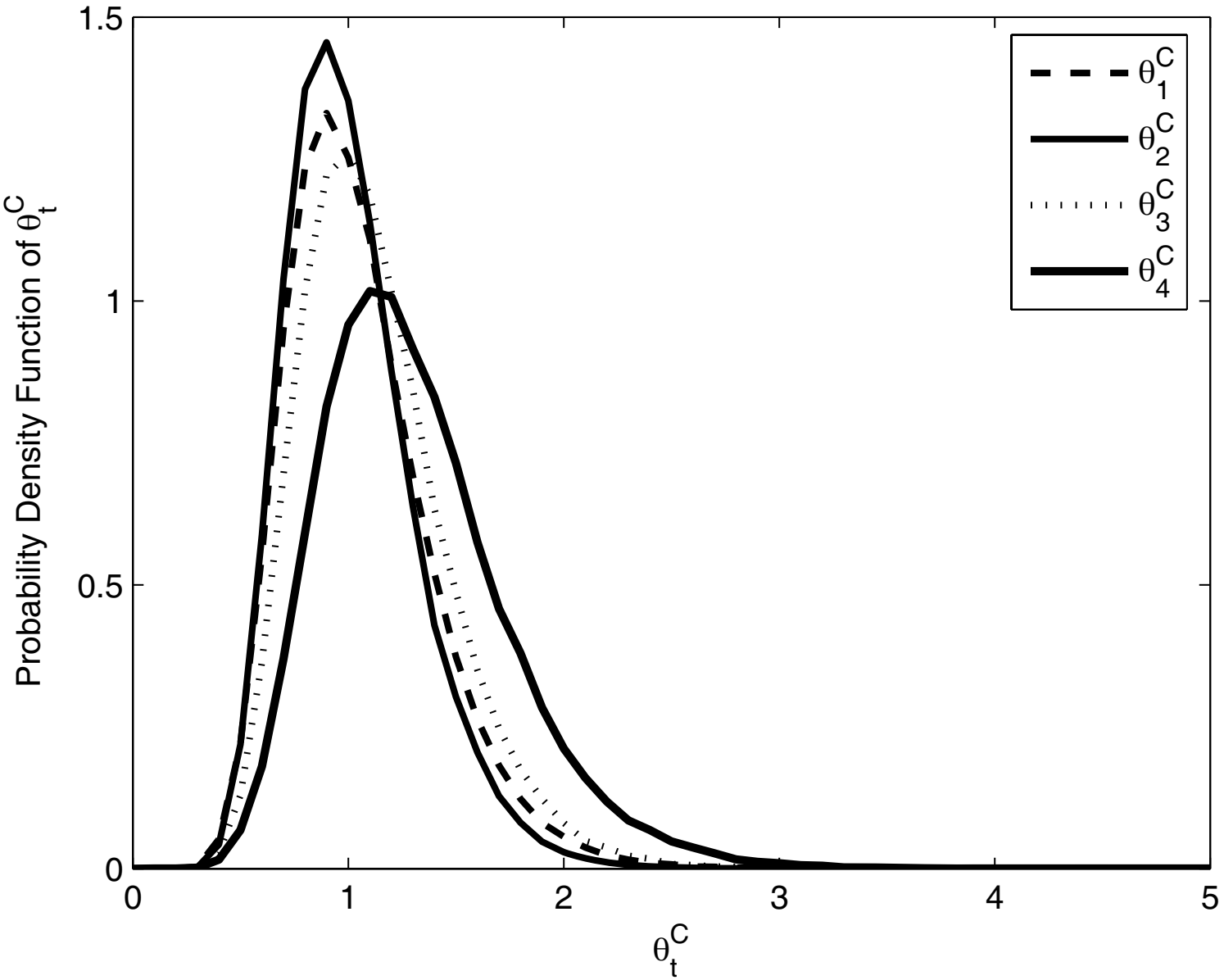
	Next Period Noncognitive Skills		Next Period Cognitive Skills	
	Mean	Standard Error	Mean	Standard Error
Constant	0.6932	0.0374	1.0541	0.0834
Current Period Noncognitive Skills	0.7912	0.0297	0.0213	0.0103
Current Period Cognitive Skills	0.0372	0.0178	0.8673	0.0423
Current Period Investments	0.0828	0.0269	0.0599	0.0217
Mother's Cognitive Skills	0.0250	0.0105	0.0314	0.0139
Current Period Noncognitive Skills	0.0639	0.0207	0.0201	0.0102
Parameter of the Elasticity of Substitution	**-0.1710**	**0.0322**	**-0.8961**	**0.0763**
Variance of Shocks	0.2921	0.0221	0.0585	0.0131

1. Both cognitive and noncognitive skills show strong persistence over time;
2. Noncognitive skills affect the accumulation of the next period's cognitive skills and cognitive skills affect the accumulation of the next period's noncognitive skills;
3. The estimated parental investment factor affects noncognitive skills slightly more strongly than cognitive skills, although the differences are not statistically significant;
4. The mother's ability affects both the child's cognitive and noncognitive ability;
5. The mother's noncognitive skills also affect test outcomes.

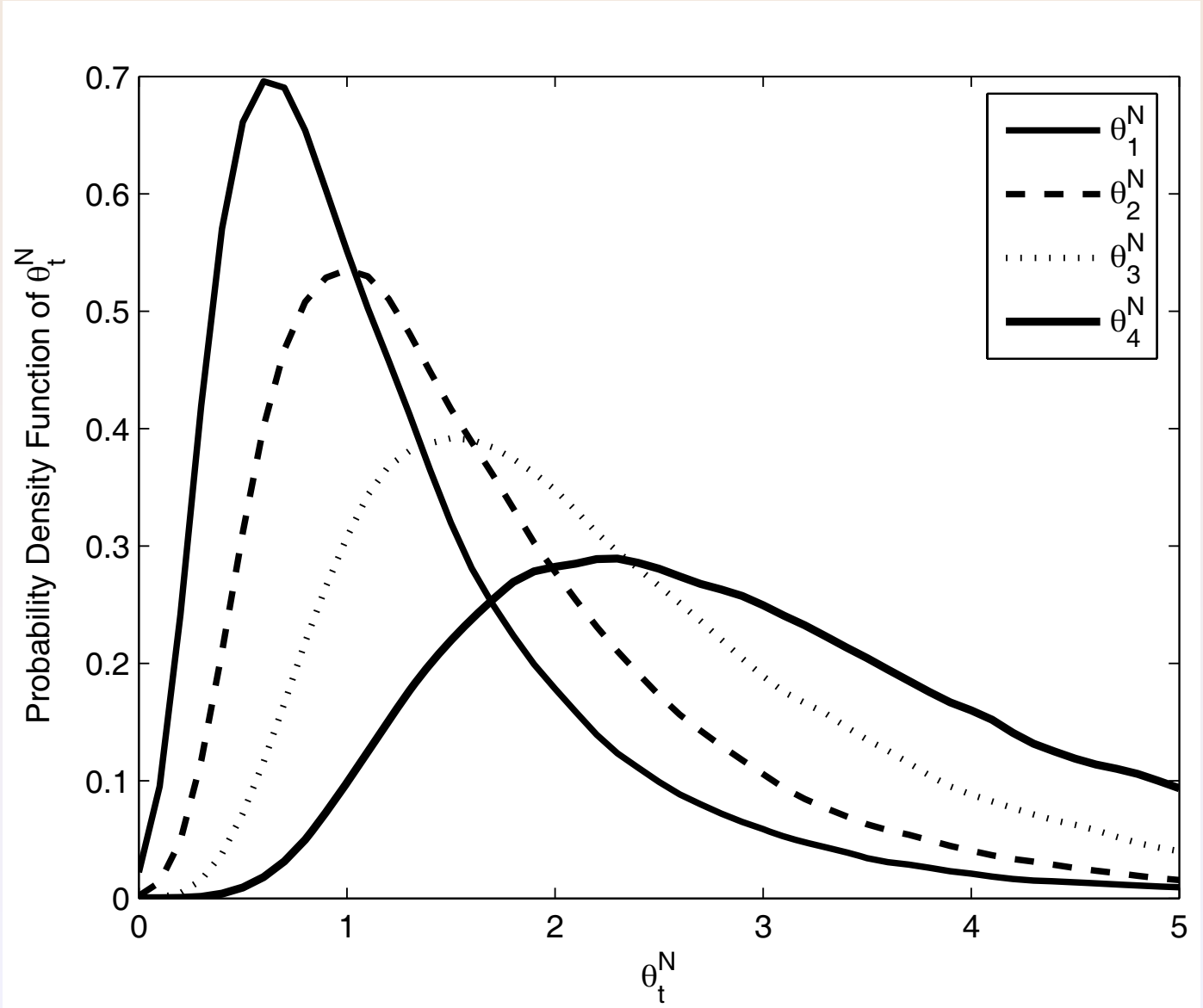
Simulating the Estimated Model

- Let θ denote unobserved skills
- θ^C, θ^N cognitive and noncognitive
- θ_1^C cognitive skill in Period 1, etc.

Probability Density Function of Stock of Cognitive Skills by Age



Probability Density Function of Stock of Noncognitive Skills by Age



Probability of Graduating from High School
As A Function of Endowments At School Entry ("Initial Conditions")
And Parental Investments at 8-9 (Period 1), 10-11 (Period 2), and 12-13 (Period 3)*

	Low Initial Conditions	High Initial Conditions
Low I_1, Low I_2, Low I_3	0.291	0.534
Low I_1, Low I_2, High I_3	0.423	0.685
Low I_1, High I_2, High I_3	0.537	0.789
High I_1, High I_2, High I_3	0.627	0.855

*"Low" refers to bottom 10^{th} percentile of the relevant distribution.

"High" refers to the top 10^{th} percentile of the relevant distribution.

I_1 is investment in period 1 (children are 8-9 years-old), I_2 is investment in period 2 (children are 10-11 years-old), I_3 is investment in period 3 (children are 12-13 years-old).

Mother's cognitive and noncognitive skills are fixed at the bottom 10^{th} percentile level throughout.

Summary and Suggestions for Future Research

Answer to Stated Questions: 1

- Cognitive and personality traits are conceptually distinct if one defines cognitive traits to mean general intelligence and specific cognitive abilities.
- Aspects of personality-shyness, sociability, time preference, impulsivity, extraversion, agreeableness, empathy, sense of humor, and so on-involve cognitive processes but can be separated from raw problem-solving abilities for abstract problems.

Answer to Stated Questions: 2

- Distinguishing cognitive and personality traits empirically is a difficult task. Measurements of IQ and achievement are affected not only by the knowledge of the test taker, but also by their motivation.
- Responses on self-report personality questionnaires are affected by strategic responses of the persons being examined which depend, in part, on their perceptions of gain from a response and hence their basic intelligence.

- Econometric methods have been developed to isolate "pure" intelligence and personality from the effects of environment and experience and to account for measurement error.
- Their application will enable both psychologists and economists to isolate relevant psychological traits as well as test among competing specifications of how personality traits should enter economic models.

Answer to Stated Questions: 3

- We distinguish *a priori* definitions of personality traits constructed using factor analyses from predictive definitions.
- Definitions of personality traits based on internal consistency of clusters of test scores are widely used in personality psychology.
- The tests used in these exercises are devised on a priori grounds to "tap" certain trait spaces that are intuited to be important.
- Clusters of traits arrived at through factor analysis are less appealing than definitions based on the predictive power of tests in real world settings.
- Each approach has its limitations.

Answer to Stated Questions: 4

- The concordance between the measures of personality psychology and the parameters of economic theory is far from perfect.
- Personality psychology instructs us that many traits, even those beyond altruism and social preferences, are important factors that should be given more emphasis in the economic theory of preferences and constraints.
- Motivation and effort deserve a renewed emphasis applied to broader aspects of social life than just the labor market.
- Economists typically model motivation through preferences.
- The evidence suggests that performance on tests can be affected by incentives but only for certain personality types.

- While the lessons from personality psychology are provocative, they have not yet changed the way most economists go about their business.
- Recent attacks by psychologists on conventional preference specifications in economics have not been productive because the straw men attacked - expected utility and additively separable models for intertemporal choice - have long been abandoned by economists at the frontier of knowledge.
- What is needed are more focused studies that suggest specific generalizations of standard models that are empirically fruitful for a range of questions and that have empirical content.

Answer to Stated Questions: 5

- Many economists and psychologists assume that preference and personality parameters are fixed early in life.
- The evidence suggests otherwise.
- Both cognitive and personality traits evolve, albeit at different rates at different ages.
- Rank-order stability of cognitive skills emerges much earlier than rank-order stability of personality skills.
- Recent research shows how cognitive and personality skills are affected by parental investments and life experiences.
- The dynamics are mutually affected by stocks of other skills.

- While an assumption of complete stability is analytically convenient, it is not found in the data.
- Evidence of change in preferences suggests that consistent life cycle planning may be difficult.
- Agents may, or may not, know if their future preferences will be like their current preferences.
- Even though parameters change, they are not purely situational-specific.

- In addition, many psychological measurement schemes assume that the persons being assessed face common choice environments.
- Our analysis shows that contexts and incentives affect manifest personality traits (effort, for example) and may also affect self-reported traits.
- This point has important lessons for the measurement and interpretation of personality traits that have not yet made their way into psychological or economic survey-based schemes.
- It would be very informative to measure personality and cognitive traits under a broader array of different incentive arrangements than have been explored to date, and to benchmark measurements of personality and preference traits at common baselines and tools exist to make these adjustments

Avenues for Future Research

- Economic preference measures should be subject to the same psychometric standards as personality measures.
  - These include: evidence of internal reliability, test-retest stability (over short periods), convergent validity, discriminant validity, and predictive validity.
  - Subjecting economic preference measures to these standards will increase their validity and improve their ability to predict outcomes.
  - At the same time, psychologists should better recognize that the contexts and incentives faced by agents affect measurements of both cognitive and personality traits.

- Economic preferences are likely multidimensional.
  - Time preference, for example, may have different components (for example, the inability to inhibit an impulse, the tendency not to consider or imagine the future, comfort with ambiguity, and the like).
  - A hierarchical view (as there is for IQ) may organize a large, currently disorganized literature and unite inconsistent findings across studies and low intercorrelations among measures in a given study.
  - In addition, recognition that certain traits may be allocated differently across tasks, and adjusting for this, will likely improve consistency of the evidence across studies.

- Econometric methods that account for measurement error and that anchor measurements in real world behavior hold substantial promise in both fields.
  - Econometric methods can move the study of personality and its effects from purely predictive analyses to causal models.
  - Econometric methods also hold promise in modeling the formation and evolution of traits over the life cycle.

- New studies should incorporate validated personality, IQ, and preference measures, as well as outcome measures.
  - Prospective, longitudinal designs are best suited to this task.
  - They should measure volatility of traits at a given age (depending on contexts and incentives faced by agents) as well as the effects of experience on the evolution of personality.
  - An open question, not fully addressed in this paper, is the situational and cultural specificity of personality measures.
  - More careful measurements are required to resolve this issue.
  - The evidence presented here is consistent with stability of traits with age but not their constancy.
  - At a point in time, incentives and situations affect levels of performance, but personality is not entirely situation-specific.

- A topic not addressed in this paper but important for future work is the relation of cognitive and personality traits to neural substrates and biological factors.
  - Such a mapping would establish a firm basis for distinguishing among these classes of traits, and also clarify distinctions among personality traits.
  - The evidence assembled thus far suggests that the executive function is localized to the prefrontal cortex and its afferent and efferent connections (Miller and Cohen, 2001).
  - Fear is localized to the amygdala (Calder, Lawrence, and Young, 2001).
  - Recently, the interest of neuroscientists has been extended to time preference (Glimcher, Kable, and Louie, 2007; McClure et al., 2004).

- While much remains to be discovered, the evidence presented here suggests that the systematic empirical and theoretical study of personality is likely to be very fruitful for economics.
- Personality traits are predictive of socioeconomic success.
- They can be influenced by interventions and investment more readily than IQ, at least after the early years.
- A deeper understanding of personality traits promises to enrich economic theory and to understand the sources of, and solutions for, human inequality.