The Economics and Psychology of Personality Traits

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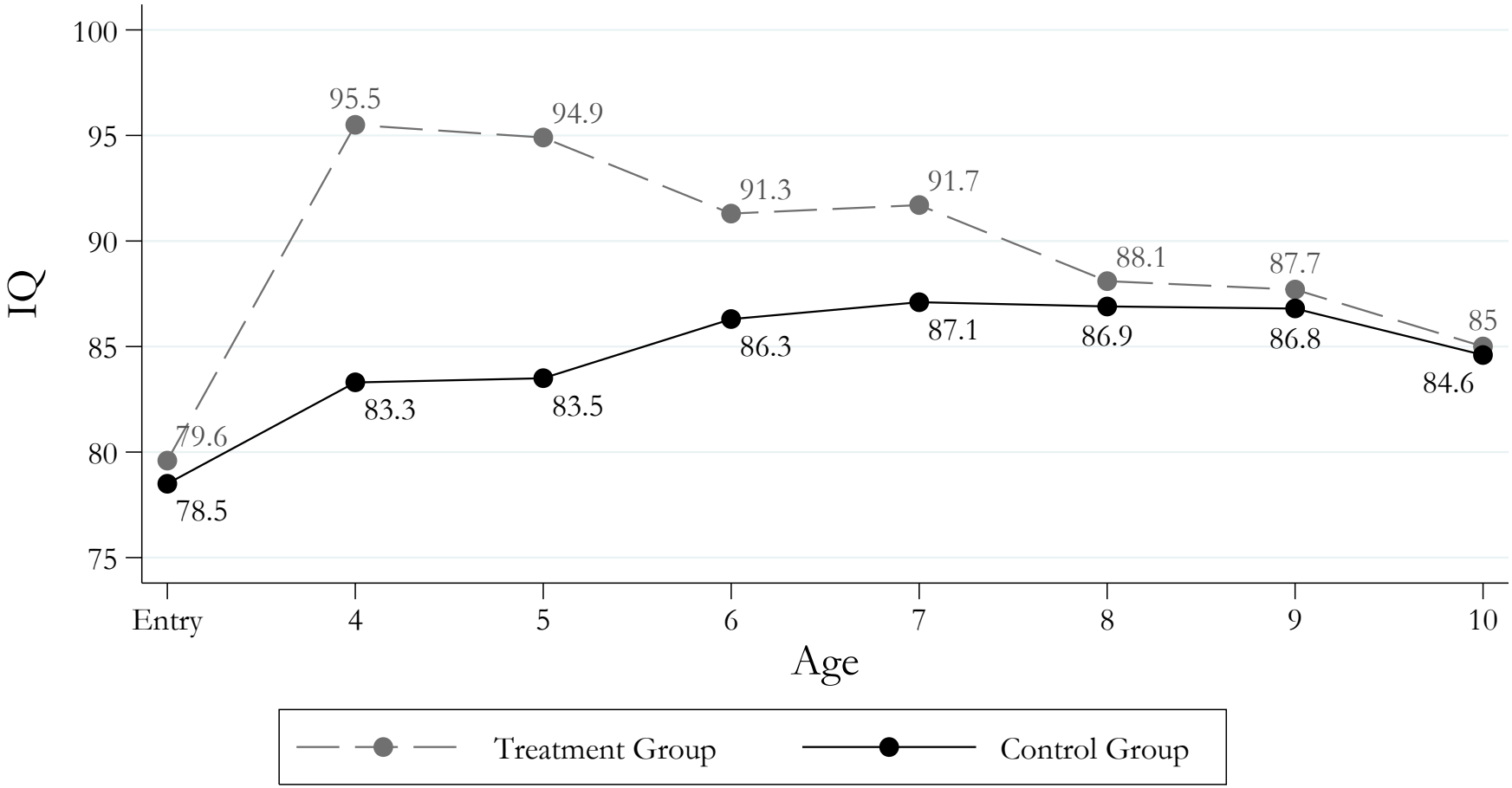
Introduction

- There is ample evidence from economics and psychology that cognitive ability is a powerful predictor of economic and social outcomes.
- The power of traits other than cognitive ability for success in life is vividly demonstrated by the Perry Preschool study.
- As demonstrated in Figure 1, by age ten, treatment group mean IQs were the same as control group mean IQs.

Figure 1: Perry Preschool Program: IQ, by Age and Treatment Group

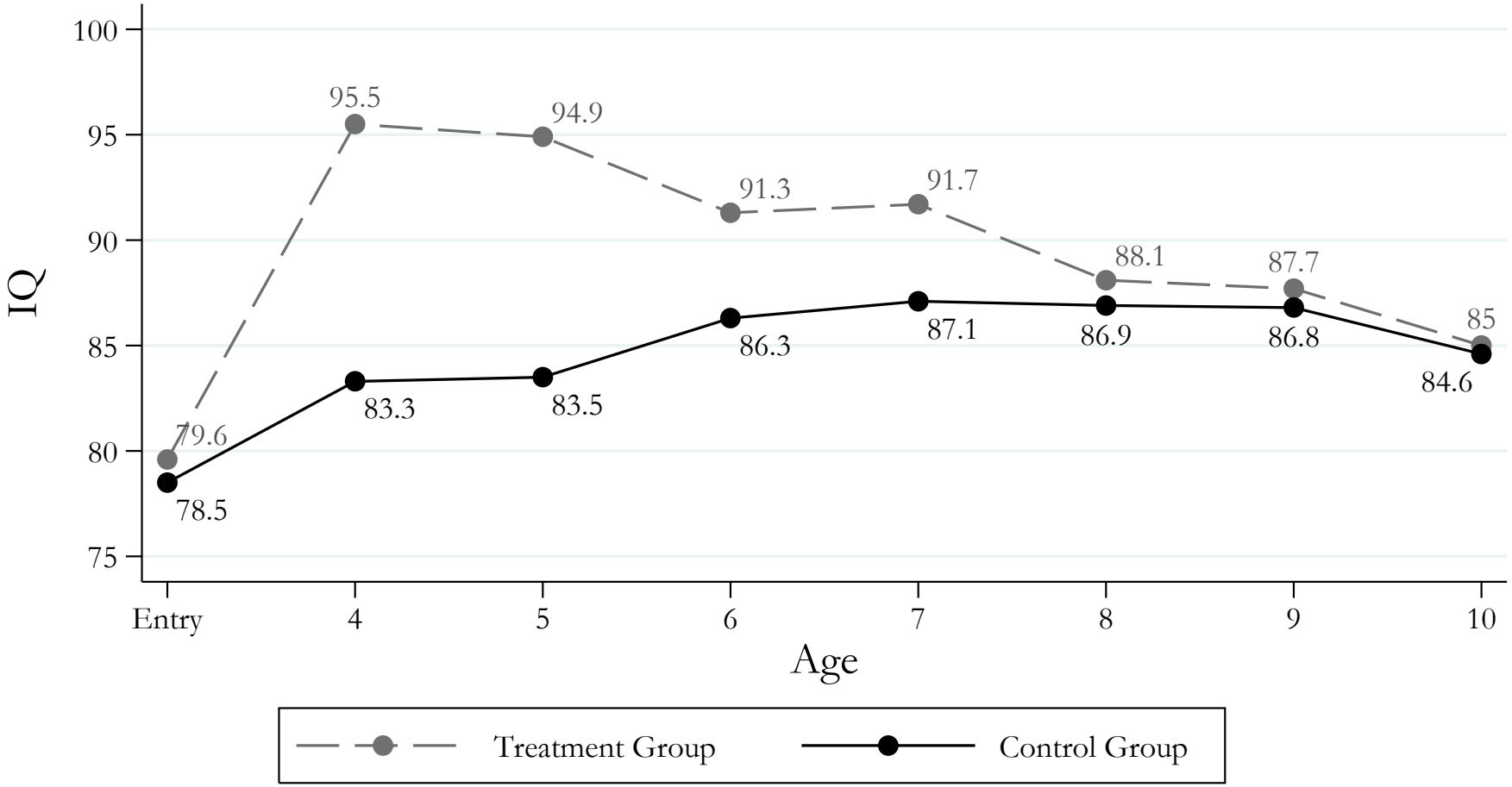


Source: Perry Preschool Program. IQ measured on the Stanford Binet Intelligence Scale (Terman & Merrill, 1960). Test was administered at program entry and each of the ages indicated.

Heckman and Masterov (2007).

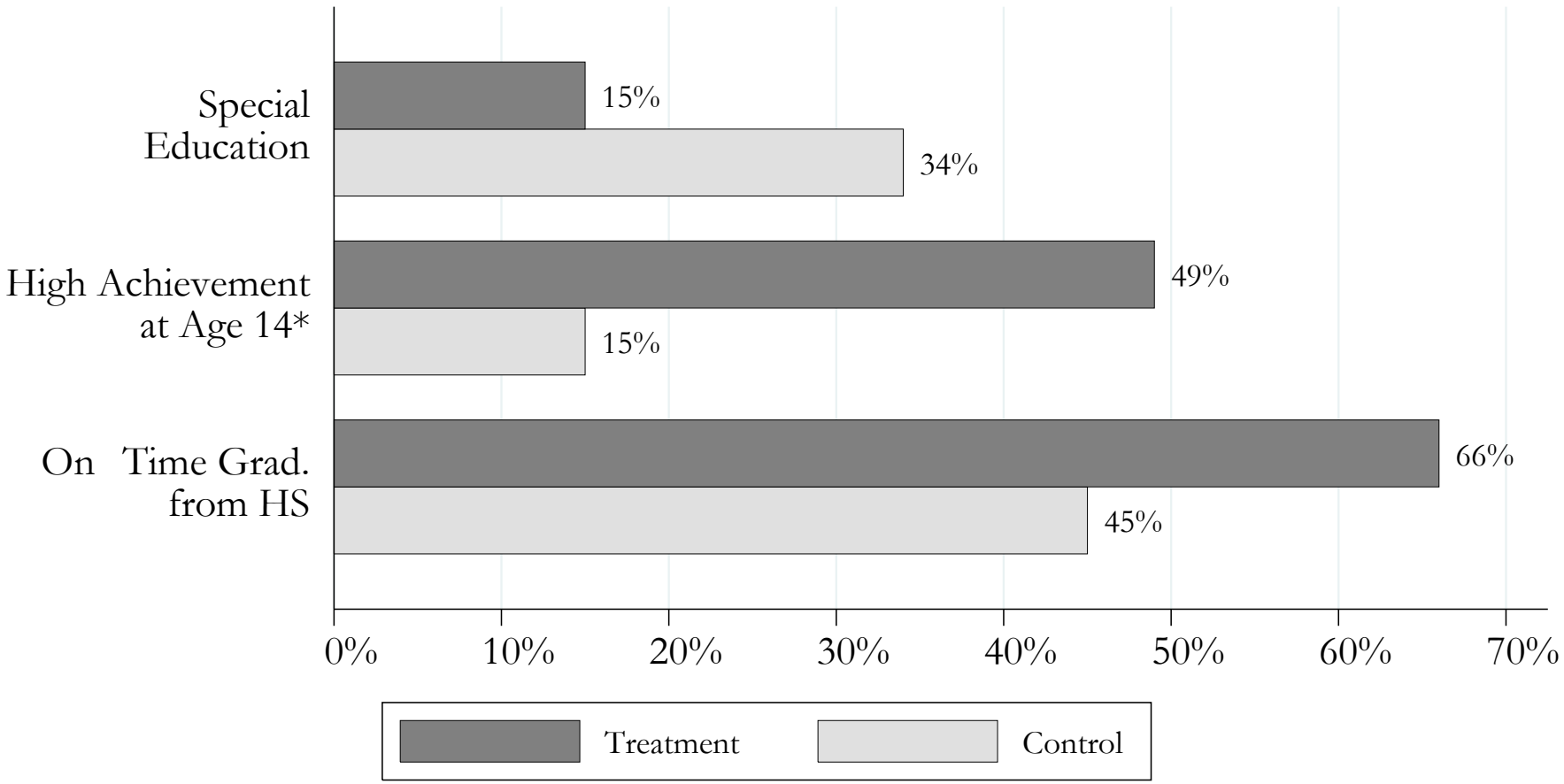
- Perry did not raise IQ.
- It raised noncognitive skills.

Perry preschool program: IQ, by age and treatment group



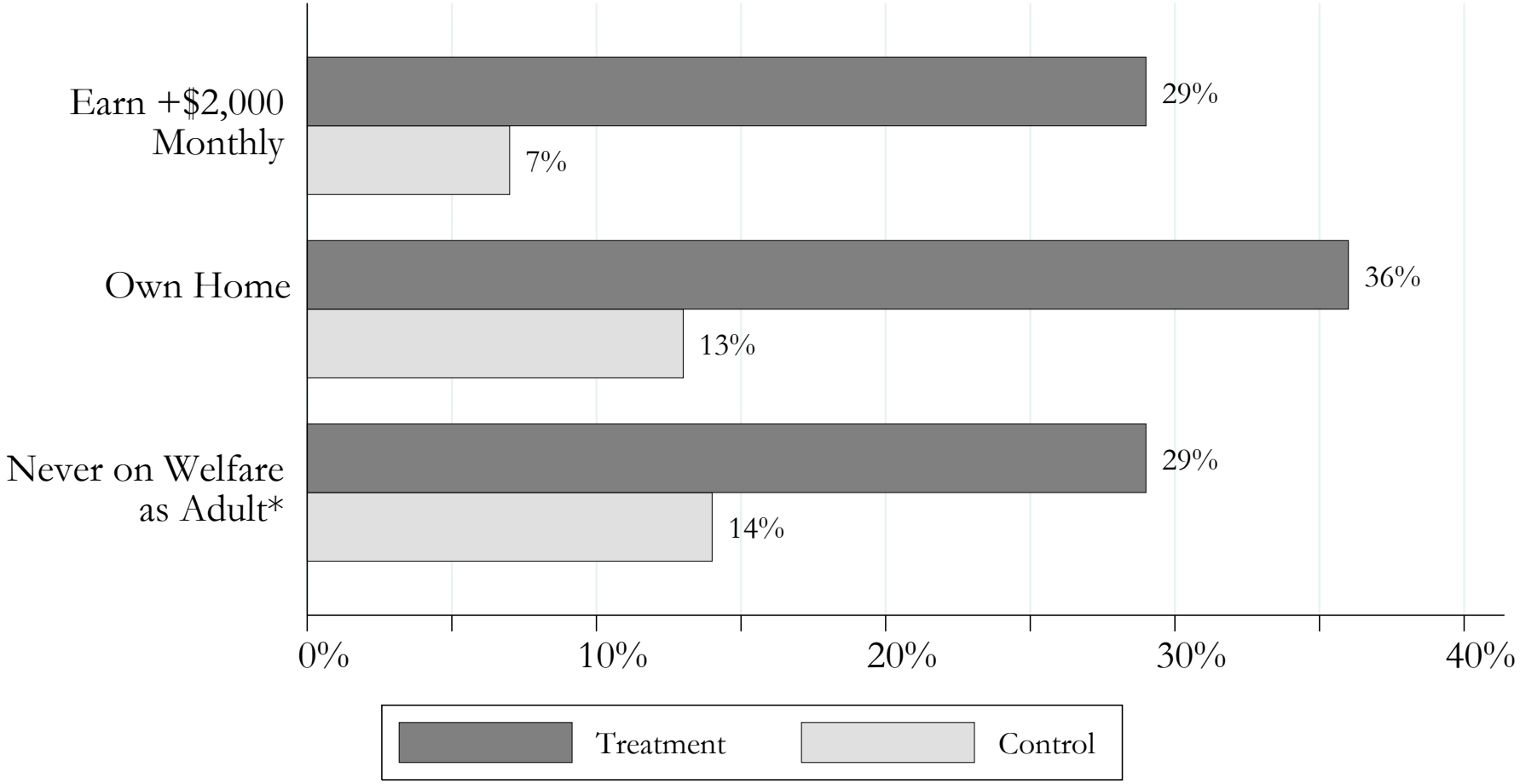
Source: Perry Preschool Program. IQ measured on the Stanford Binet Intelligence Scale (Terman & Merrill, 1960). Test was administered at program entry and each of the ages indicated.

Perry preschool program: educational effects, by treatment group



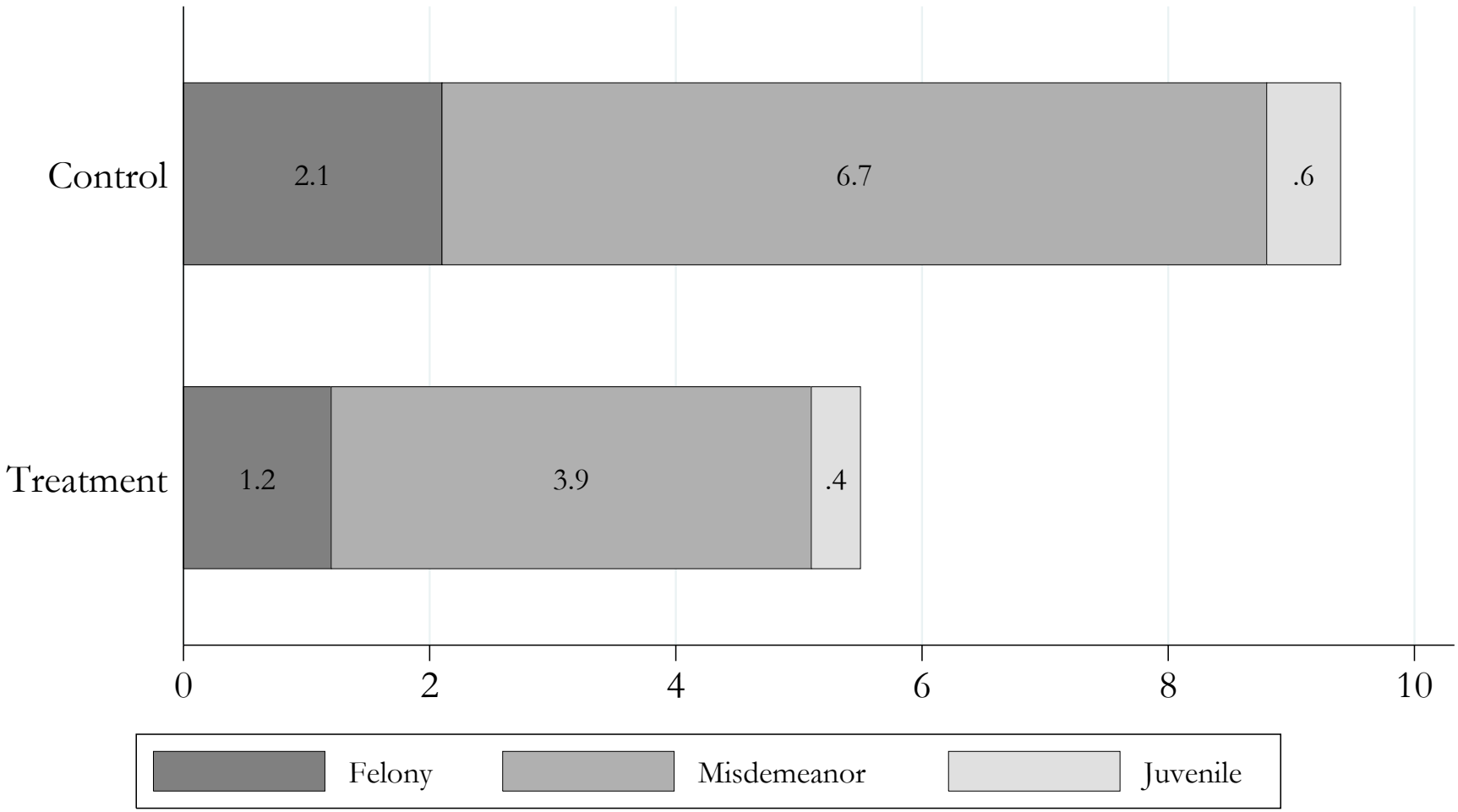
Source: Barnett (2004).
Notes: *High achievement defined as performance at or above the lowest 10th percentile on the California Achievement Test (1970).

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.

Scope of the Analysis

- Focus analysis on personality traits, defined as patterns of thought, feelings, and behavior.
- Do not discuss motivation, values, interests, and attitudes which give rise to personality traits.

- Personality psychologists have developed measurement systems for personality traits which economists have begun to use.
- Most prominent is the "Big Five" personality inventory.

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

- Many aspects of personality are a consequence of cognition, and cognition depends on personality. Nonetheless, one can separate those two aspects of human differences.

Is It Possible to Empirically Distinguish Cognitive from Personality Traits?

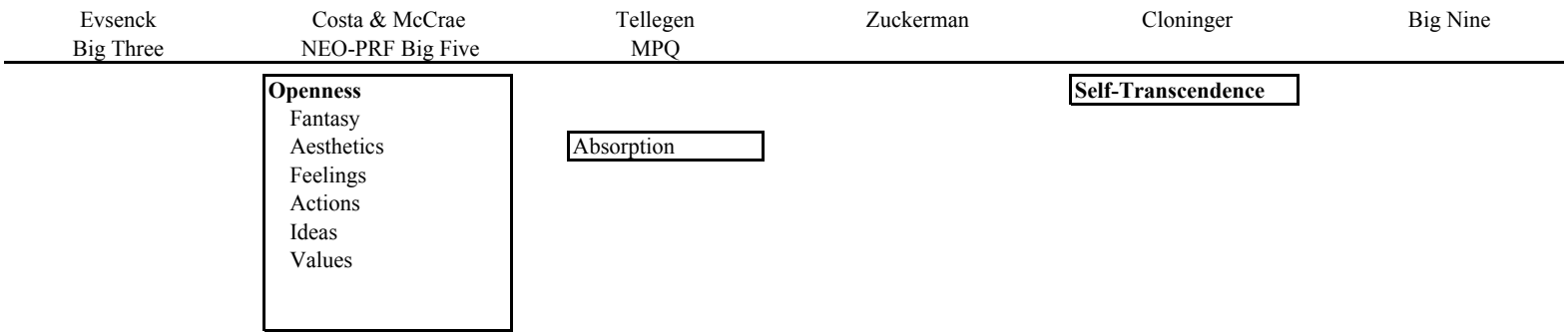
- Measures of economic preferences are influenced by numeracy and intelligence. IQ test scores are determined not only by intelligence, but also by factors such as motivation and anxiety.
- Moreover, over the life cycle, the development of cognitive ability is influenced by personality traits such as curiosity, ambition, and perseverance.

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

Figure 2: Competing taxonomies of personality

Evsenck 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					
Egocentric					**Rugged Individualism**
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				



Note: Figure reproduced from Bouchard and Loehlin (2001), with kind permission from Springer Science and Business Media.

What is the Evidence on the Predictive Power of Cognitive and Personality Traits?

- Personality traits are important in explaining performance in specific tasks, although different personality traits are predictive in different tasks.
- The classical model of factor analysis, joined with the principle of comparative advantage, helps to organize the evidence in economics and psychology.

How Stable Are Personality Traits Across Situations and Across The Life Cycle? Are They More Sensitive than Cognitive Traits to Investment and Intervention?

- We present evidence that both cognitive and personality traits evolve over the lifecycle-but to different degrees and at different stages of the life cycle.
- Cognitive processing speed, for example, tends to rise sharply during childhood, peak in late adolescence, and then slowly decline.
- In contrast, some personality traits, such as conscientiousness, increase monotonically from childhood to late adulthood.
- We develop models in which traits are allocated differentially across tasks and activities.

Do the Findings from Psychology Suggest That Conventional Economic Theory Should Be Enriched? Can Conventional Models of Preferences in Economics Explain the Body of Evidence from Personality Psychology? Does Personality Psychology Merely Recast Well-Known Preference Parameters into Psychological Jargon, or is There Something New for Economists to Learn?

- Conventional economic theory is sufficiently elastic to accommodate many findings of psychology.
- However, our analysis suggests that certain traditional concepts used in economics should be modified and certain emphases redirected.
- Some findings from psychology cannot be rationalized by standard economic models and could fruitfully be incorporated into economic analysis.

- The evidence from personality psychology suggests a more radical reformulation of classical choice theory than is currently envisioned in behavioral economics which tinkers with conventional specifications of preferences.
- *More fundamentally, conventional economic preference parameters can be interpreted as consequences of these constraints.*
- For example, high rates of measured time preference may be produced by the inability of agents to delay gratification, interpreted as a constraint, or by the inability of agents to imagine the future.
- We develop a framework that introduces psychological variables as constraints into conventional economic choice models.

Definitions And A Basic Framework Of Measurement And Interpretation

- We distinguish between *cognitive ability* on the one hand and personality traits on the other.

Factor Analysis

- Let $T_{i,j}$ denote performance on task j for person i. There are J tasks.
- Output on tasks is generated in part by latent "traits" or factors.
- Factors or psychological traits for individual i are represented in a vector f_i, $i = 1, , I$, where I is the number of individuals.
- The vector has L components so $f_i = (f_{i,1}, \ldots, f_{i,L})$.
- $U_{i,j}$ is other determinants of productivity in task j for person i.

- The task performance function for person i on task j

$$T_{i,j} = \mu_j + \lambda_j f_i + U_{i,j}, i = 1, \ldots, I, \; j = 1, \ldots, J. \qquad (1)$$

-

- Linear factor models

$$T_{i,j} = \mu_j + \lambda_j f_i + U_{i,j}, \; i = 1, \ldots, I, \; j = 1, \ldots, J. \qquad (2)$$

- The number of components in f_i, L, has to be small relative to J ($L \ll J$) if the factor model is to have empirical content.

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

Cognitive Ability

- Intelligence (or cognitive ability) has been defined by an official taskforce of the American Psychological Association as the "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).
- In this context, 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).
- A first-order factor is predictive in all tasks, $j = 1, \ldots, J$ in equation (1).

- A lower order factor is predictive in only some tasks. There is less agreement about the number and identity of lower-order factors.
- Cattell (1971; 1987) contrasts two second-order factors: *fluid intelligence* (the ability to solve novel problems) and *crystallized intelligence* (knowledge and developed skills).
- The relative weighting of fluid versus crystallized intelligence varies among tests according to the degree to which prior experience is crucial to performance.
- These factors operate in addition to the first-order factor, g.
- Achievement tests, like the Armed Forces Qualifying Test used by economists and psychologists alike, are heavily weighted towards crystallized intelligence, whereas tests like the Raven Progressive Matrices (1962) are heavily weighted towards fluid intelligence.

Personality Traits

- A distinction between personality and cognition is not easy to make. Consider, for example, so-called "quasi-cognitive" traits.
- These 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 in particular - correlate very highly with measures of fluid intelligence.
- Currently there is a lively debate among psychologists as to the precise relationship among working memory, other aspects of executive function, and intelligence.

- This paper 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.

Operationalizing Concepts

- Intelligence tests are routinely used in a variety of settings including business, education, civil service, and the military.

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). A convenient acronym for these factors is "OCEAN". See John (1990) and Costa and McCrae (1992a).

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)

- The most stinging criticism of the five-factor model is that it 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 (see Canli 2006).

- The five-factor model is silent on an important class of individual differences that do not receive much attention in the recent psychology literature: motivation.
- A practical problem facing the analyst who wishes to measure personality is the multiplicity of personality questionnaires.

Measure of Temperament

- The question of how to measure personality in adults leads naturally to a consideration of personality traits in childhood.
- 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.

Measurement and Methodological Issues

- There are two general types of measurement schemes:
  1. those that seek to measure or elicit conventional economic preference parameters, and
  2. those that measure personality with self-reports or observer reports.
- Personality psychologists focus primarily on the latter.

- Personality psychologists marshal three types of evidence to establish the validity of their tests:
  1. content-related,
  2. construct-related, and
  3. criterion-related evidence.

Convergent and Discriminant Validity

- "convergent" referring to the intercorrelations *within* a cluster and the "discriminant" referring to lack of correlation across clusters.

The Factor Model for Test Scores

- Let $M_{i,l}^n$ be the nth measurement (by test or observer report) on trait l for person i. Using a linear factor representation,

$$M_{i,l}^n = \mu_l^n + \lambda_l^n f_{i,l} + \varepsilon_{i,l}^n, \qquad (3)$$
$$n = 1, \ldots, N_l, \;\; i = 1, \ldots, I, \;\; l = 1, \ldots L.$$

- $f_{i,l}$ is assumed to be 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.

- In general

$$M_{i,l}^n = \mu_l^n + \lambda_l^n f_i + \varepsilon_{i,l}^n, \;\; n = 1, \ldots, N_l, \tag{4}$$

- λ^n is a vector with possibly as many as L nonzero components.
- $\varepsilon_{i,l}^n$ are assumed to be independent of f_i and mutually independent within and across constructs (l and l' are two constructs).
- The test has discriminant validity if λ_l^n is the only nonzero component of f_i. The μ_l^n and λ_l^n can depend on measured characteristics of the agent, Q_i.

The Psychometric Approach and Its Limits

- The standard approach to defining constructs in personality psychology is based on factor analysis.
- $f_{l,i}$, $l = 1, \ldots, L$

- Conventional psychometric validity of a collection of item or test scores for different constructs thus has three aspects.
  1. A factor f_l is assumed to account for the 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."

- An alternative approach to constructing 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.
- The Hogan Personality Inventory, the California Personality Inventory, and the Minnesota Multiphasic Personality Inventory were all developed with the specific purpose of predicting real-world outcomes. Decisions to retain or drop items during the development of these inventories were based, at least in part, upon the ability of items to predict such outcomes.
- This approach has an appealing concreteness about it.
- Yet this approach has major problems.

- First, all measurements of factor $f_{i,l}$ can claim incremental predictive validity as long as each measurement is subject to error $\left(\varepsilon^{n}_{i,l} \neq 0\right)$.
- Proxies for $f_{i,l}$ can appear to be separate determinants (or "causes") instead of surrogates for an underlying one-dimensional construct or factor.
- As long as there are measurement errors for construct l, there is no limit to the number of proxies for $f_{i,L}$ that will show up as statistically significant predictors of an outcome.

- A second problem is reverse causality.
- Measurements of latent factors may be corrupted by "faking."
- There are at least two types of false responses: those arising from impression management and those arising from self-deception.

A Benchmark Definition of Traits

- f is a vector of latent traits and f_l is a particular trait in the list of L traits (extraversion, for example).
- The manifestation of trait l, as opposed to the trait itself f_l, is obtained by measurement n, $n = 1, \ldots, N_l$ and may depend on incentives to manifest the trait.
- Let R_n^l be the reward for manifesting the trait in situation n.
- Other latent traits besides l may affect the manifestation of a trait for l.
- Let $f_{\sim l}$ be the components of f apart from f_l. Let w_l^n denote other variables operating in situation n that affect measured performance for l.

- Measured traits are imperfect proxies for true traits:

$$M_l^n = h_l\left(f_l, f_{\sim l}, R_l^n, W_l^n\right), \; n = 1, \ldots, N_L, \; l = 1, \ldots, L. \quad (5)$$

- 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.

- Only meaningful to define measurements on f_l at benchmark levels of R_l^n, $f_{\sim l}$, and W_l^n.
- Define these benchmarks as $\bar{R}_l$, $\bar{f}_{\sim l}$, and $\bar{W}_l$.respectively.
- At these benchmark values, one can define f_l:

$$M_l^n = f_l \text{ for } R_l^n = \bar{R}_l,\ f_{\sim l} = \bar{f}_{\sim l},\ W_l^n = \bar{W}_l,\ n = 1, \ldots, N_l,\ l = 1, \ldots, L. \quad (6)$$

IQ Scores Reflect Incentives and Measure Both Cognitive and Personality 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	

			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*	Incentives such as record albums, radios (<$25) given for	Scores increased by about 17 points. Results were consistent across the	"In summary, the promise of individualized incentives on an

	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.	improvement in test performance	Otis-Lennon, WISC-R, and Lorge-Thorndike tests.	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

Contextualizing Personality

The Evidence On Preference Parameters

- Many economists and some psychologists estimate the traditional preference parameters in economics: time preference, risk aversion and preference for leisure.
- More recently, altruism and social preferences have been studied.

- Many of the measurements we survey in this and next section do not standardize for incentive and contextual effects.
- This lack of standardization creates a serious problem in isolating true traits and making comparisons across studies.
- In economic choices, market settings play a crucial role in policing behavior.
- Even if individuals seek to exhibit irrational behavior, they must live within their constraints.
- Different incentives and context act on agents (R_l^n and W_l^n in Equation (5)).

Time Discounting

- Evidence from animal and human experiments suggests that future rewards are discounted non-exponentially as a function of delay.
- Under hyperbolic discounting, future utility A is discounted to current utility value V:

$$V = \frac{A}{1 + kd}$$

  where d is the delay and k is the discount rate parameter.
- Under exponential discounting, $V = \frac{A}{(1+\rho)^d}$, where d is the discount rate.

- Frederick, Loewenstein, and O'Donoghue (2002) point out that such field data may be complicated by the effects of factors such as imperfect information on the part of the subject about future rewards or credit constraints.
- These limitations build the case for experimental elicitations, but they have their own set of problems.

- The most widely-used experimental approach to the measurement of discount rates poses a series of choices between smaller, immediate and larger, delayed monetary rewards.
- "Would you choose $1500 now or $4000 in five years?" (Fuchs 1982).
- These choices are typically among hypothetical items, but it is unclear whether discount rates for real and hypothetical rewards are identical.

- Frederick, Loewenstein, and O'Donoghue (2002) survey methods for measuring discount rates.
- They document that across studies, estimated discount rates of adult respondents range from -6 percent to infinity.
- No attempt is made to standardize for incentives, market forces, personality, cognitive traits, and context in this literature.

- A meta-analysis by Shamosh and Gray (2007) of 24 studies in which both IQ and discount rates were measured shows the two traits are inversely related (r = -.23).
- If the cost of making calculations exceeds the expected benefit of such deliberation, the individual may choose by default the immediate, certain reward.

- Discount rates vary inversely with the size of reward.
- Insofar as estimates of discount rates are sensitive to context or framing effects, they may fail the definitional requirements for separable economic preferences

- Frederick et al. suggest that time preference is tri-dimensional, comprising three separate underlying motives:
  1. *impulsivity*, the tendency to act spontaneously and without planning,
  2. *compulsivity*, the tendency to stick with plans, and
  3. *inhibition*, the ability to override automatic responses to urges or emotions.

- A parallel effort to define impulsivity and to decompose this trait into its constituent components is underway in the psychology literature.
- An uninvestigated empirical question is whether estimates of the constituent components that give rise to time preference will prove more useful for economic models than currently used specifications.

Risk Preference

- The risk preference parameter (also referred to as "risk aversion" or "risk tolerance") represents the curvature of the utility function.

- Survey questions assessing risk preference usually pose a series of questions involving the choice between a lottery and a certain outcome:
- "Which would you prefer: $100 dollars today, or a 50 percent chance of receiving nothing and a 50 percent chance of receiving $200?"
- Two recent studies have introduced measures of risk preferences in field experiments.
- Harrison, Lau, and Rutstrom (2007) use real stakes to elicit risk preferences on a representative sample of 253 people in Denmark.

- Dohmen et al. (2005) use a lottery experiment with a representative sample of 450 German adults to validate survey responses on risk preference from the Socioeconomic Panel (SOEP).
- Also, such a general question is free from framing effects that shape behavior in presence of risk (Kahneman 2003).
- As for time preference, in fact, there appears to be an inverse relationship between cognitive ability and risk aversion, where higher IQ people have higher risk tolerance (Benjamin, Brown, and Shapiro 2006; Dohmen et al. 2007).

- Risk preference also varies with socioeconomic characteristics.
- No general consensus on the direction of such differences: some studies find a negative relationship between education and risk aversion.
- Most of the studies find that women are more risk averse than men.
- Parents and their children are similarly risk averse, and this effect is stronger among children with fewer siblings and first-born children.

- The empirical findings summarized in this section assume that risk preference can be modelled with a single parameter across situations.
- Yet, like time preference, risk preference may be multidimensional rather than unitary.
- Weber (2001) shows that risk preference varies by domain, and a scale that assesses risk taking in five different domains shows low correlations across these domains (Weber, Blais, and Betz 2002).
- One can be quite risk-averse when it comes to financial decisions but risk-loving when it comes to health decisions (Hanoch, Johnson, and Wilke 2006).
- Weber's risk-return model of risk taking (Weber and Milliman 1997; Weber and Hsee 1998) finds that low correlations among risk taking preference across domains can be explained by domain-specific perceptions of riskiness and return.

- A behavioral task and self-report measure from the psychology literature are of interest.
- Lejuez and colleagues' (2002, 2003) Balloon Analogue Risk Task (BART) is a computer game in which participants make repeated choices between keeping a certain smaller monetary reward and taking a chance on an incrementally larger reward.
- Scores on the BART correlate with real-world risk behaviors such as smoking, stealing, and not wearing a seatbelt.

- BART scores also correlate with sensation seeking, a trait proposed by Zuckerman (1994) and defined as "the tendency to seek novel, varied, complex, and intense sensations and experiences and the willingness to take risks for the sake of such experience."
- More than 2000 published articles have incorporated sensation seeking self-report questionnaires, and collectively these studies have established that sensation seeking predicts risky driving, substance use and abuse, smoking, drinking, unprotected sex, juvenile delinquency, and adult criminal behavior.
- Unfortunately, few, if any studies, have included typical risk preference propositions of the sort relevant to economic decision making when sensation seeking is estimated.

Preference for Leisure

- There is a large literature on estimating leisure preferences.
- Survey-based estimates of preferences for leisure are less common, probably because direct measurement is complicated.

- Most omnibus measures of personality include scales closely related to preference for leisure or, more frequently, the obverse trait of preference for work.
- The widely used Big Five (or NEO-PI-R, Costa and McCrae 1992b), whose components and facets are summarized in Table 1, includes an Achievement Striving subscale of Conscientiousness, which describes ambition, the capacity for hard work, and an inclination toward purposeful behavior.

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)

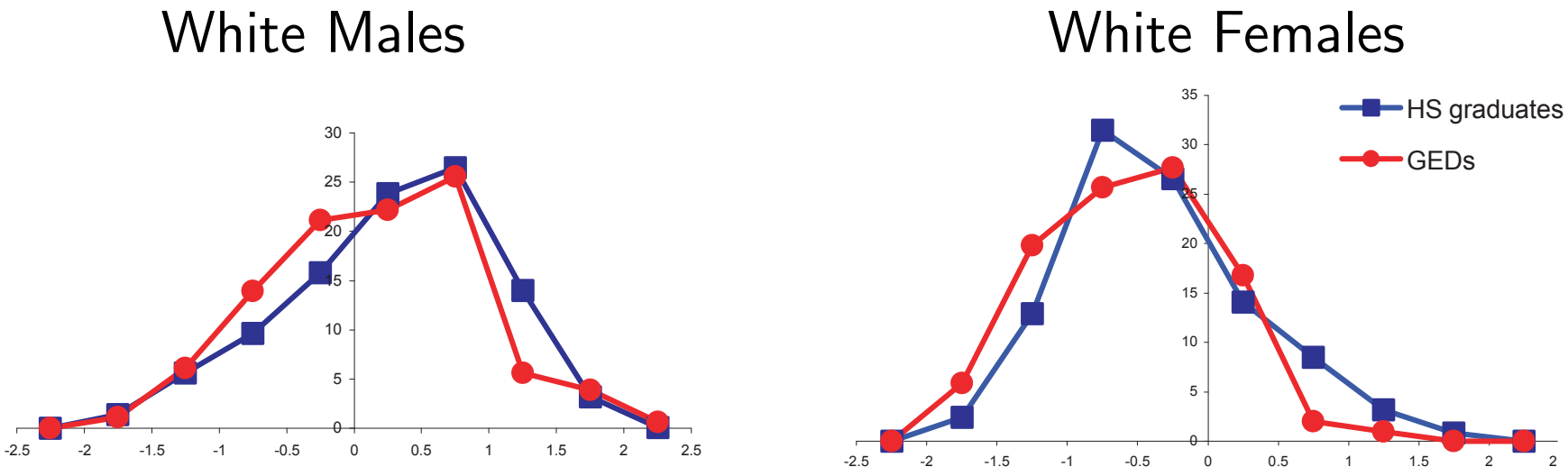
Altruism and Social Preferences

- 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 his evidence.
- Villanueva (2005) and Laferrre 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 Gachter (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.

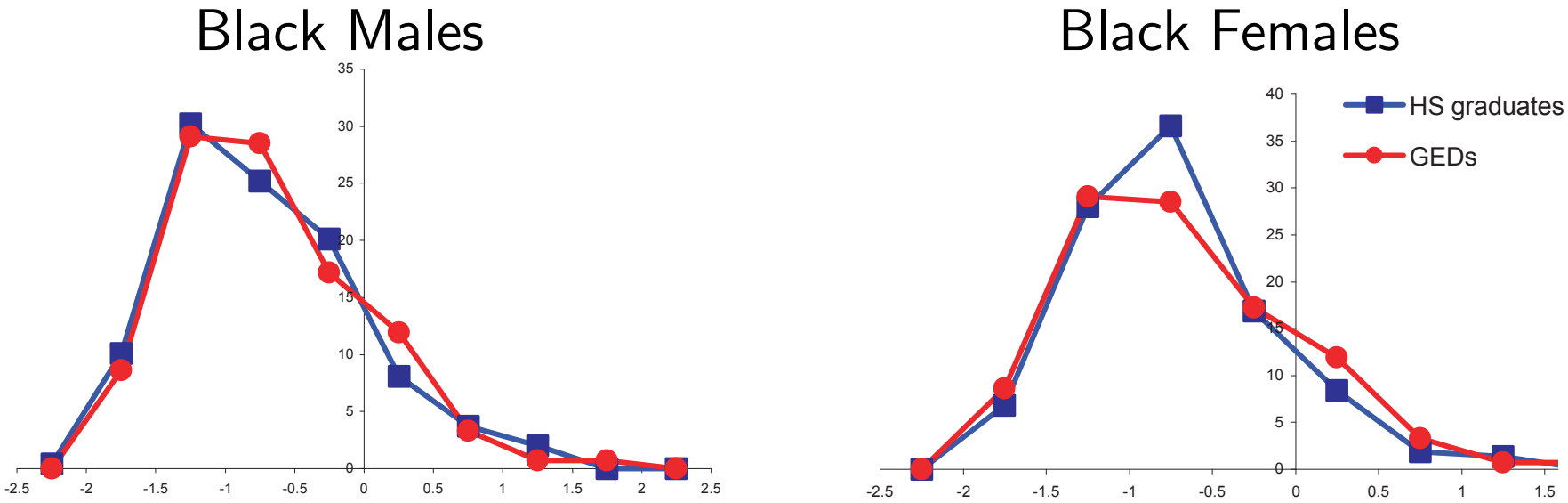
- Both cognitive and socio-emotional abilities explain many features of economic and social performance and the emergence of health differentials.
- Evidence from the second chance GED program in America (Heckman and Rubinstein, 2001).

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



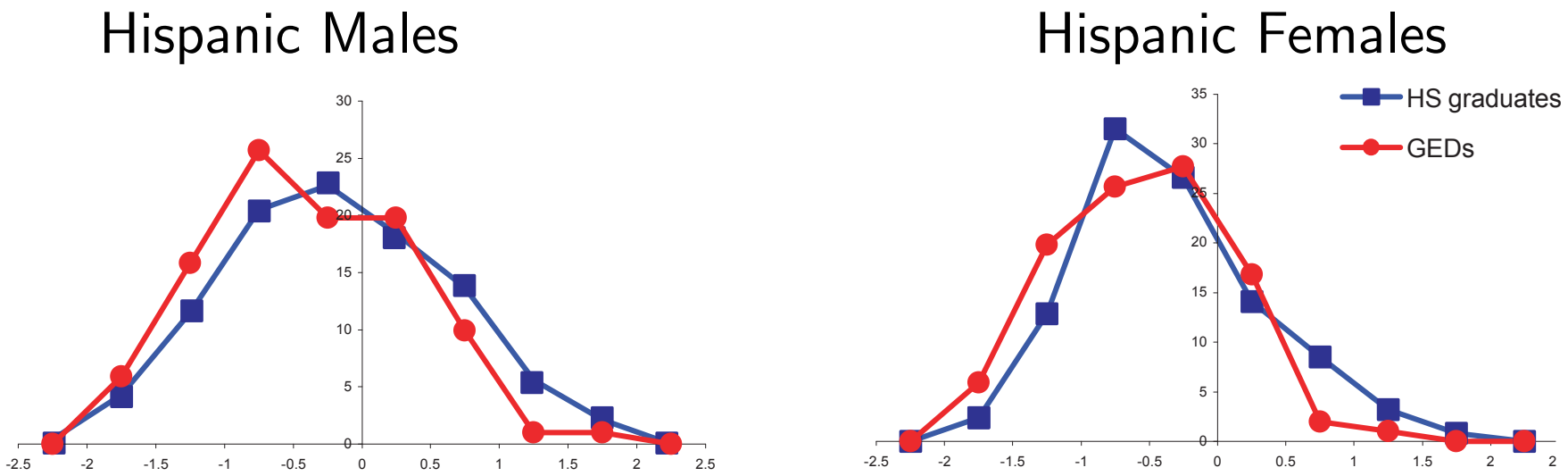
Source: Heckman, Hsee and Rubinstein (2001)

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



Source: Heckman, Hsee and Rubinstein (2001)

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

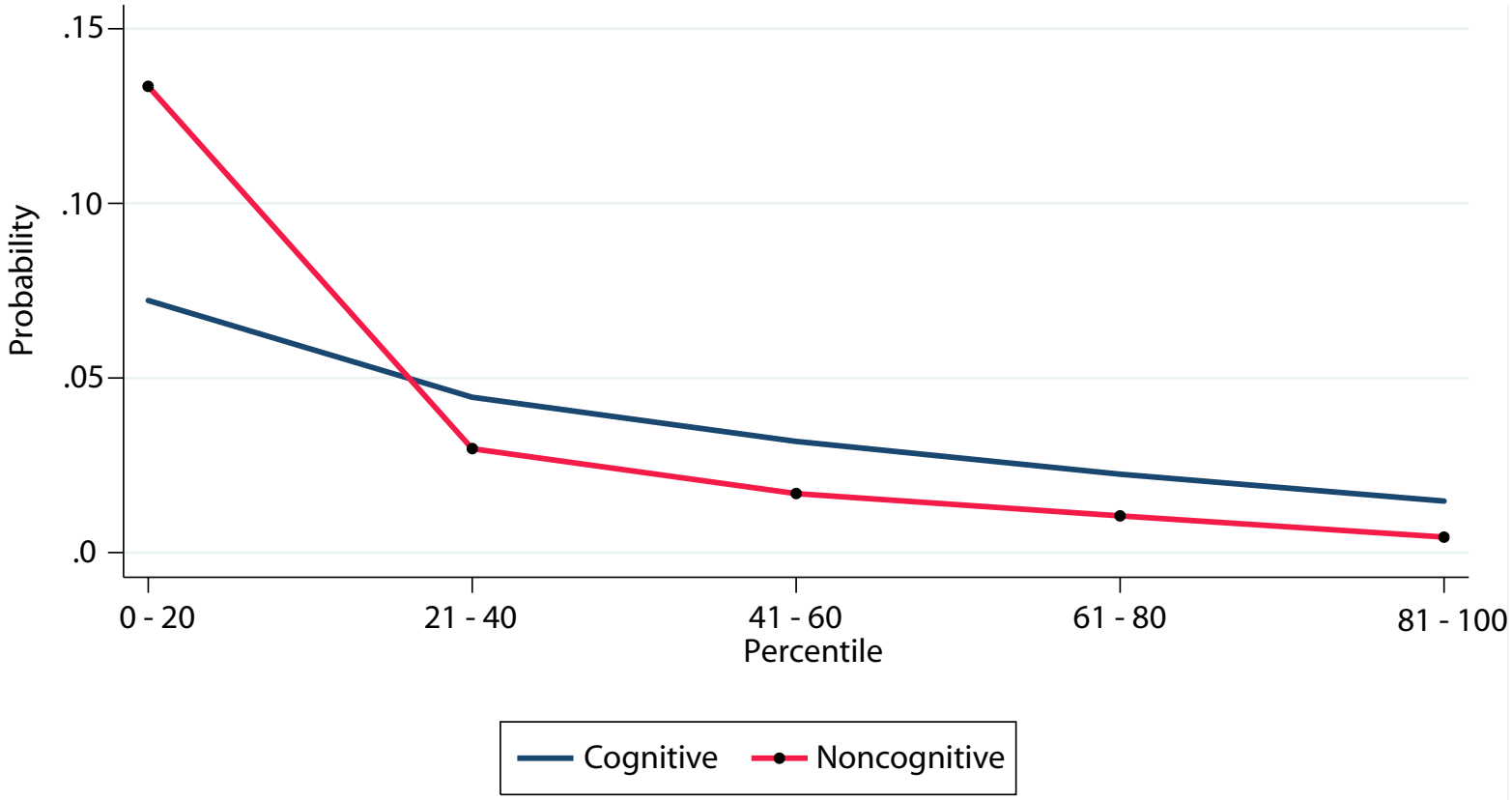


Source: Heckman, Hsee and Rubinstein (2001)

- GEDs earn at the rate of high school dropouts.

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

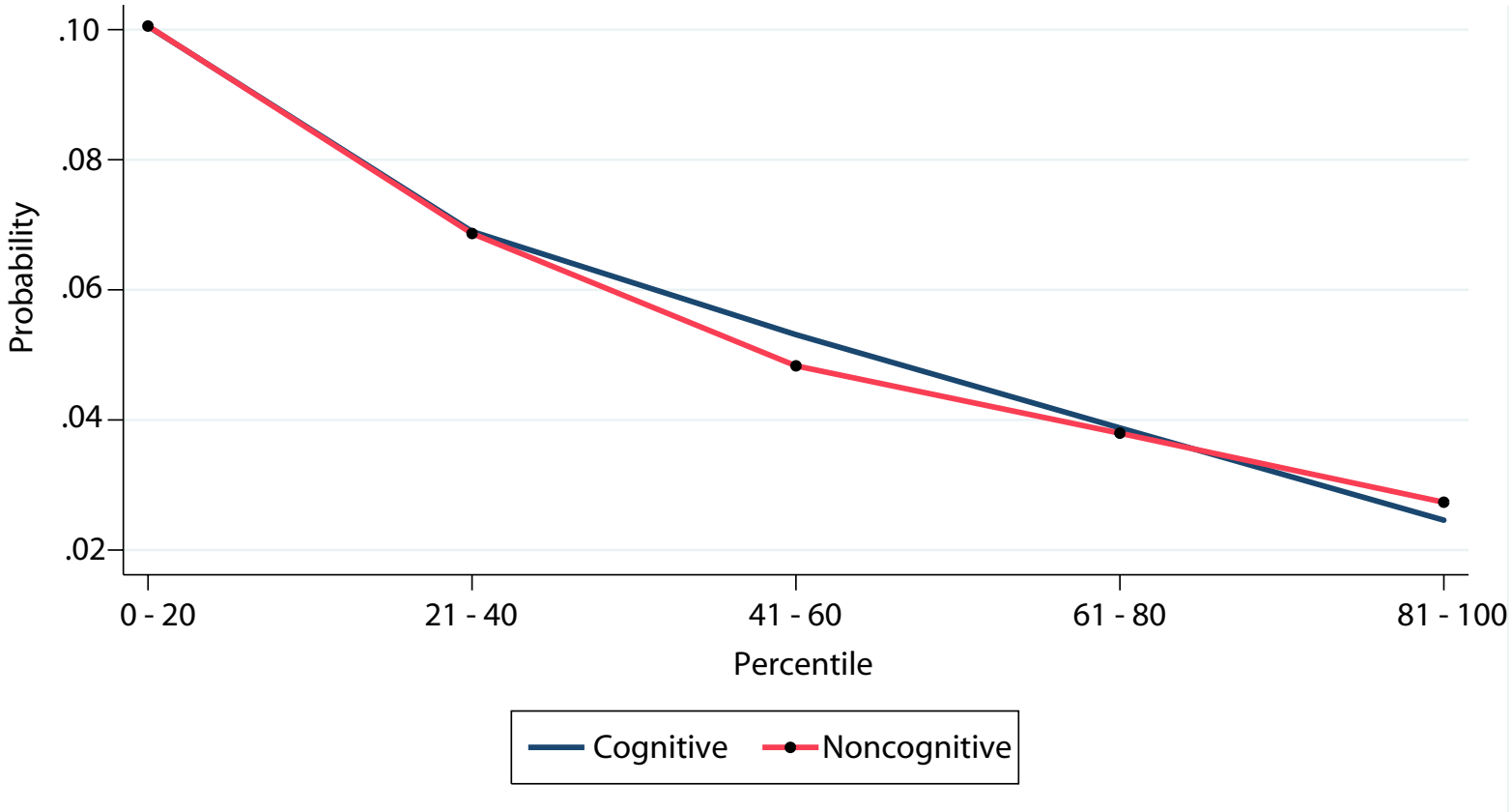
Ever been in jail by age 30, by ability (males)



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).

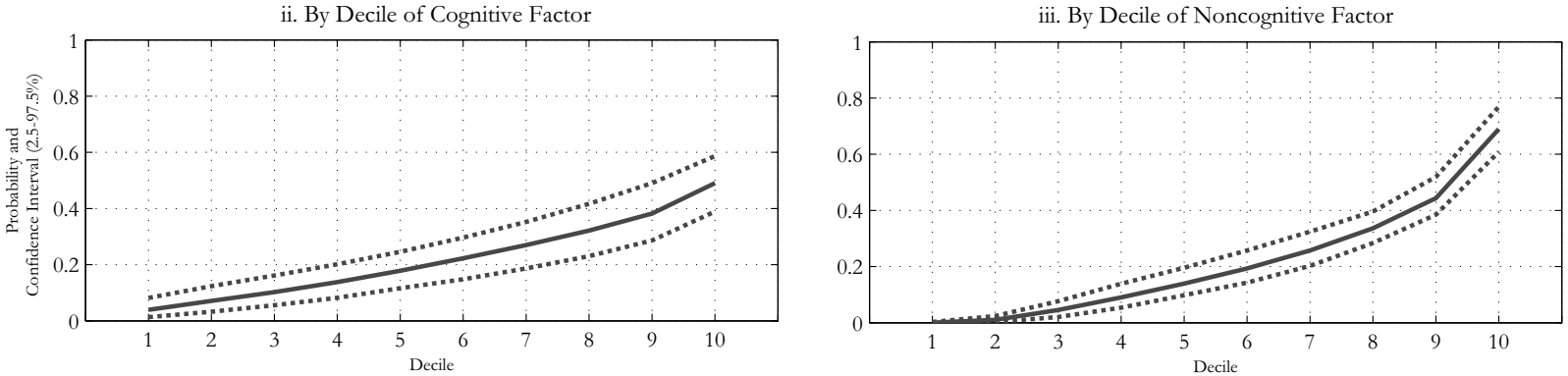
Probability of being single with children (females)



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.

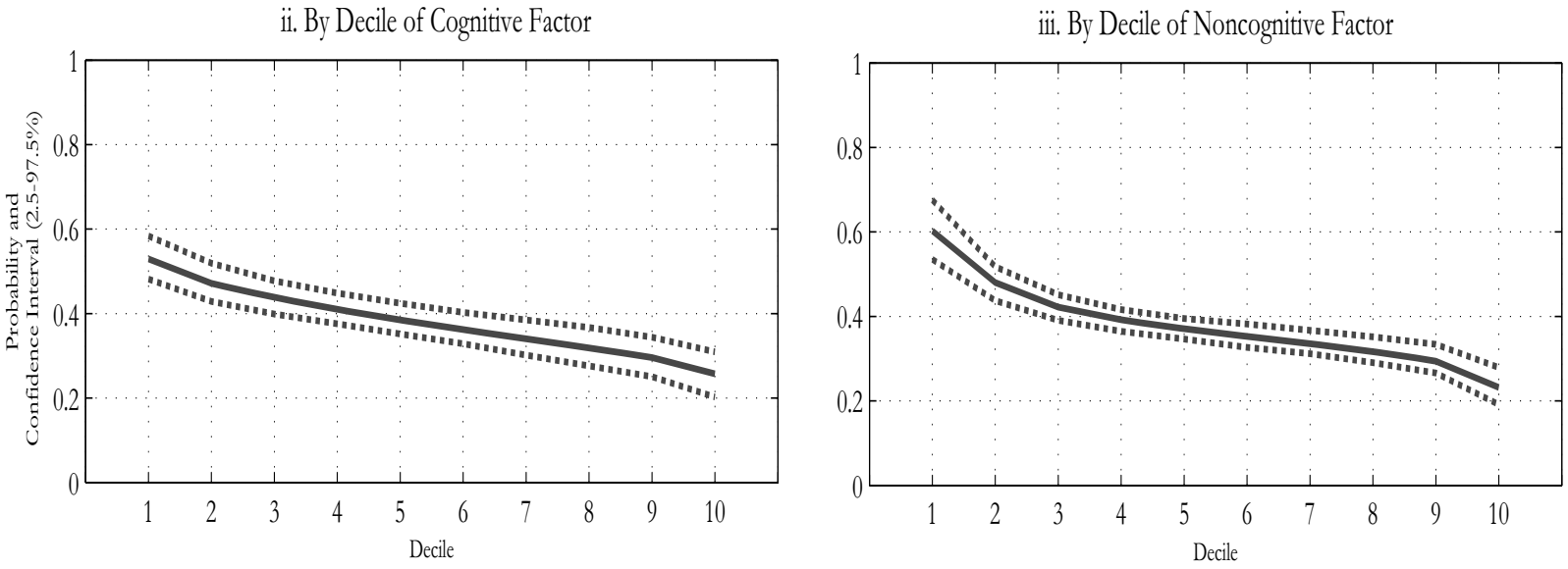
Source: Heckman, Stixrud, and Urzua (2006).

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



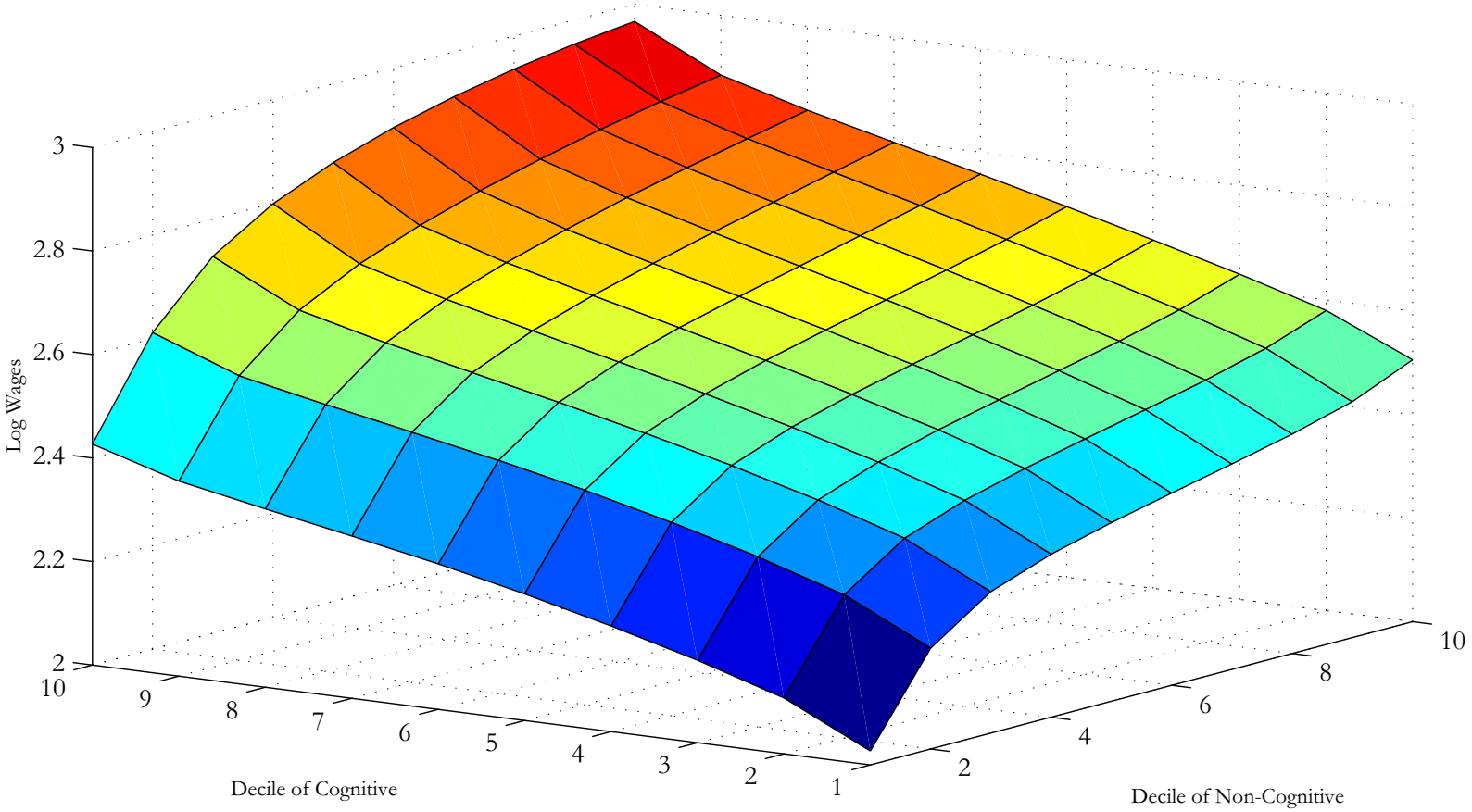
Notes: The data are simulated from the estimates of the model and our NLSY79 sample. We use the standard convention that higher deciles are associated with higher values of the variable. The confidence intervals are computed using bootstrapping (200 draws).

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)

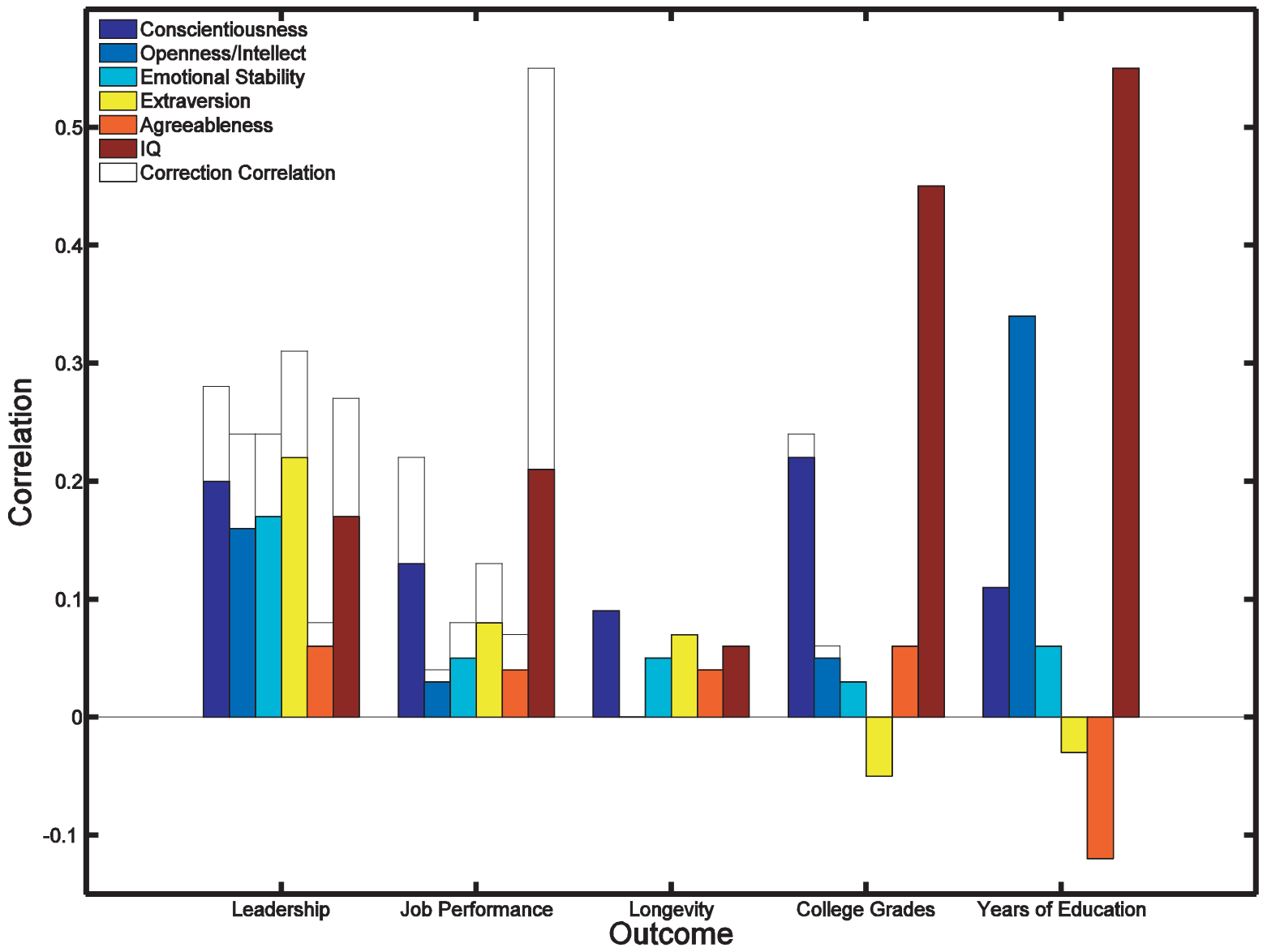


Predictive Power of Personality Traits

- The importance of personality traits can be inferred from the failure of cognitive measures to predict certain outcomes. Heckman and Rubinstein (2001) use evidence from the General Education Development (GED).

- Figure 3 summarizes correlations for the predictive validity of IQ and Big Five personality factors on leadership ratings, job performance, longevity, college grades, and years of education.

- IQ surpasses any single Big Five personality factor in the prediction of the two academic outcomes, college grades ($r = .45$) and years of education ($r = .55$).


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

- Contemporary psychologists suggest that self-control, perseverance, and other aspects of conscientiousness as the major personality contributors to success in school and in life.

- As Heckman, Stixrud, and Urzua (2006) and Judge and Hurst (2007) show that among participants in the NLSY 1979 cohort, positive self-evaluations measured in young adulthood (with self-report questions of self-esteem, locus of control, and related traits) predict income in mid-life and, further, enhance the benefits of family socioeconomic status, and academic achievement on mid-life income.

Limitations of Current Evidence on Predictive Validity

- There are five reasons why effect size estimates summarized in Figure 3 may underestimate the impact of personality traits.
- First, whereas the benefits of IQ are monotonically increasing (that is, more is always better), the optimal level of most personality traits may lie somewhere between the two extremes (see Benson and Campbell 2007 and LaHuis, Martin and Avis 2005).

- Second, short-term personality measures that yield a single score for each Big Five domain are too blunt an instrument to capture relationships between personality and outcomes.
- Stronger relationships between personality and outcomes often emerge when more narrowly defined facets are used (Paunonen and Ashton 2001).
- Roberts et al. (2005a) show that lower-level facets of Conscientiousness (for example, the traits of industriousness, self-control) have differential relationships with labor market and other outcomes, and, further, that these traits considered individually may predict outcomes better than a broad measure of Conscientiousness.

- An example of the dramatic impact of a very specifically defined and carefully measured personality trait comes from Mischel and colleagues, who show that delay of gratification (measured as the number of seconds children can wait for a larger treat in lieu of a smaller, immediate treat) at age four predicts higher academic and social functioning in adolescence
- Hogan (2005) makes a related point regarding the specificity and appropriateness of outcome variables: "Researchers often fail to align predictors with criteria; this results in using measures of conscientiousness to predict service orientation, or measures of extraversion to predict training performance . . ."

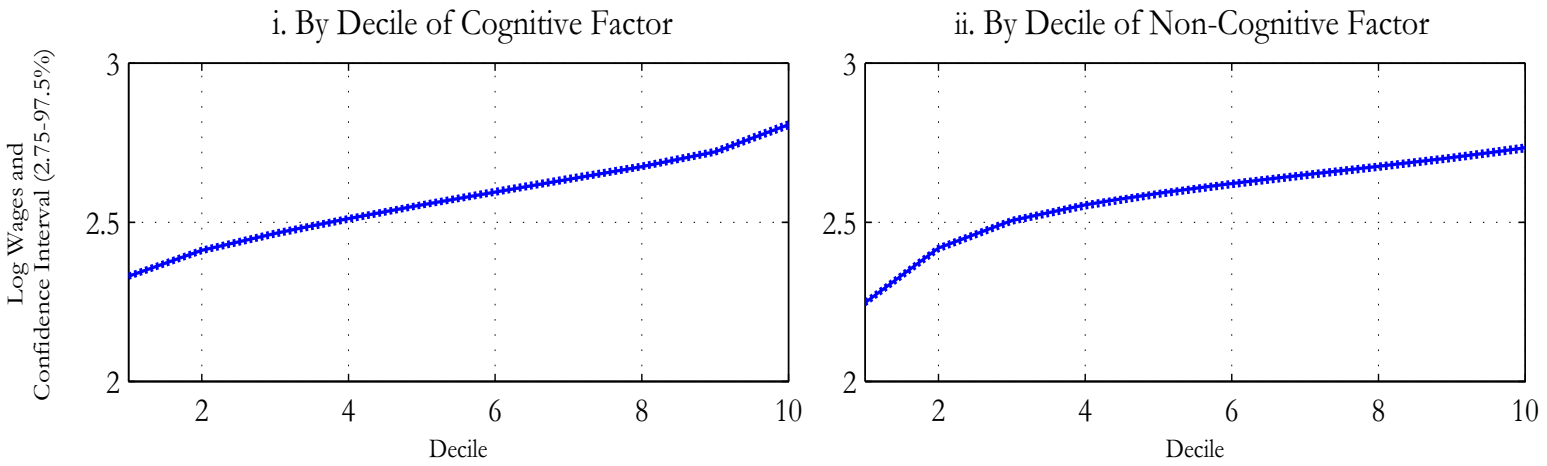
- Third, personality in large-sample studies is almost invariably measured by brief, self-report questionnaires, and this approach yields less reliable and less precise estimates of the effects of personality on outcomes than do IQ tests.
- Dunning, Heath, and Suls (2004) show that the limitations of self-report questionnaires extend beyond vulnerability to faking and include the tendency of most individuals to overrate their skills.
- Despite general recognition of these limitations and the handicap they present for assessing the importance of personality traits, few novel measurement approaches have been validated for many traits of interest.

- Thus, whereas multi-source, multi-method approaches to personality measurement are superior, they are difficult if not impossible to implement in many research contexts.
- To the extent that IQ is more accurately measured than personality, estimates of the effects of personality on outcomes will be disproportionately attenuated (see Duckworth and Seligman 2005).
- Accounting for measurement error is empirically important in using psychometric measurements in empirical work. Cunha and Heckman (2008) estimate substantial measurement error components in both cognitive and noncognitive test scores.

- A fourth limitation of the estimates in Figure 3 is that they do not capture interaction effects.

- Finally, standard measures of predictive power are effect size and variance explained.
- However, R^2, or goodness of fit measures, are only one way to measure the importance of variables.
- Heckman, Stixrud, and Urzua (2006) develop a different measure of predictive power based not on variance explained, but on the response of outcomes to a change in the variable.
- They examine the effect of moving people from different percentiles in the latent factor distributions of cognitive and personality skills on the following outcomes.

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).

Changing Preference Parameters and Psychological Variables

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

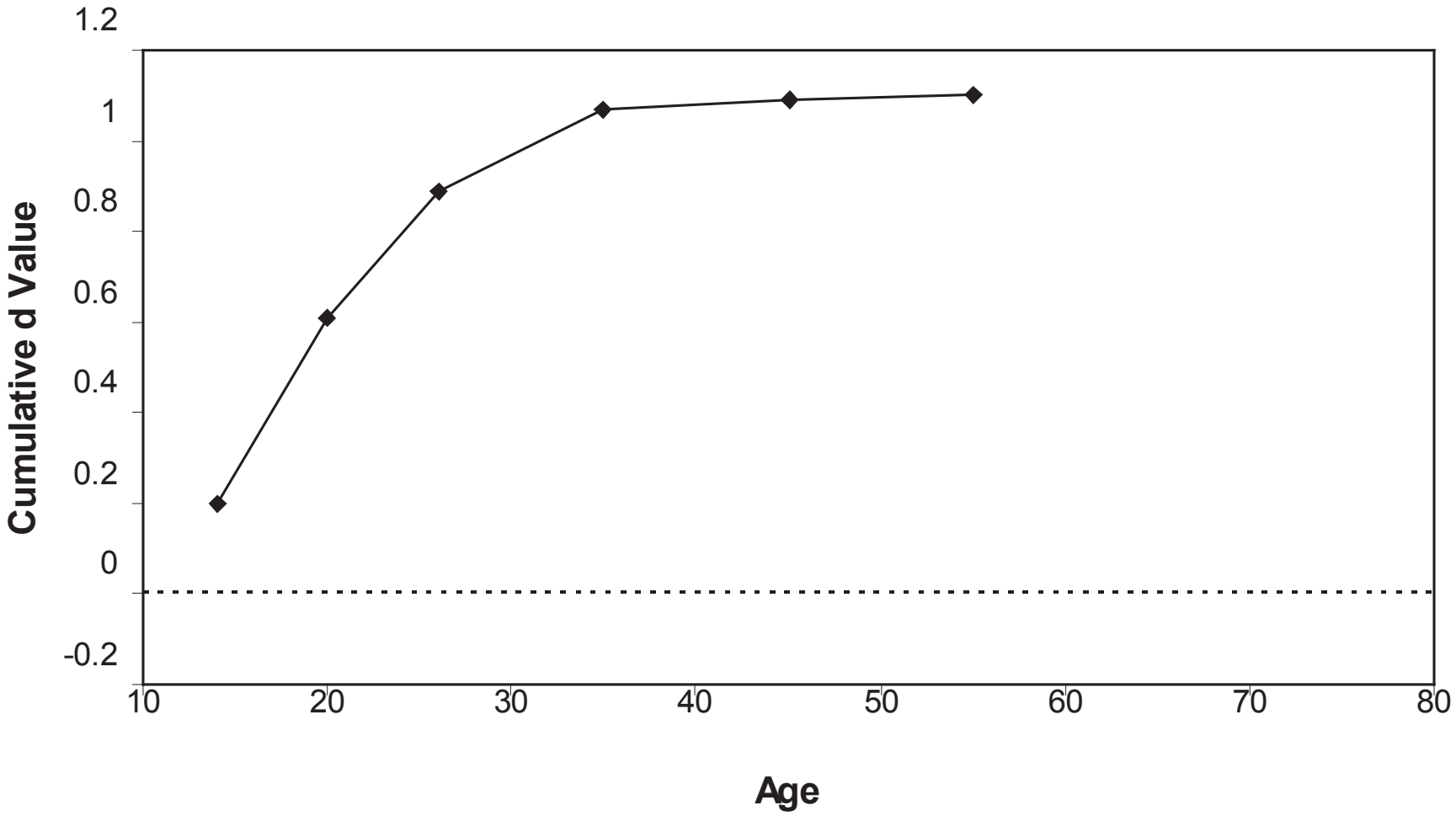
- The malleability of personality can be defined and measured in several ways: Mean-level change refers to change over time in absolute levels of a trait and is measured by changes in scores over time.
- Rank-order change, in contrast, refers to changes in the ordinal ranking of a trait in a population 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).

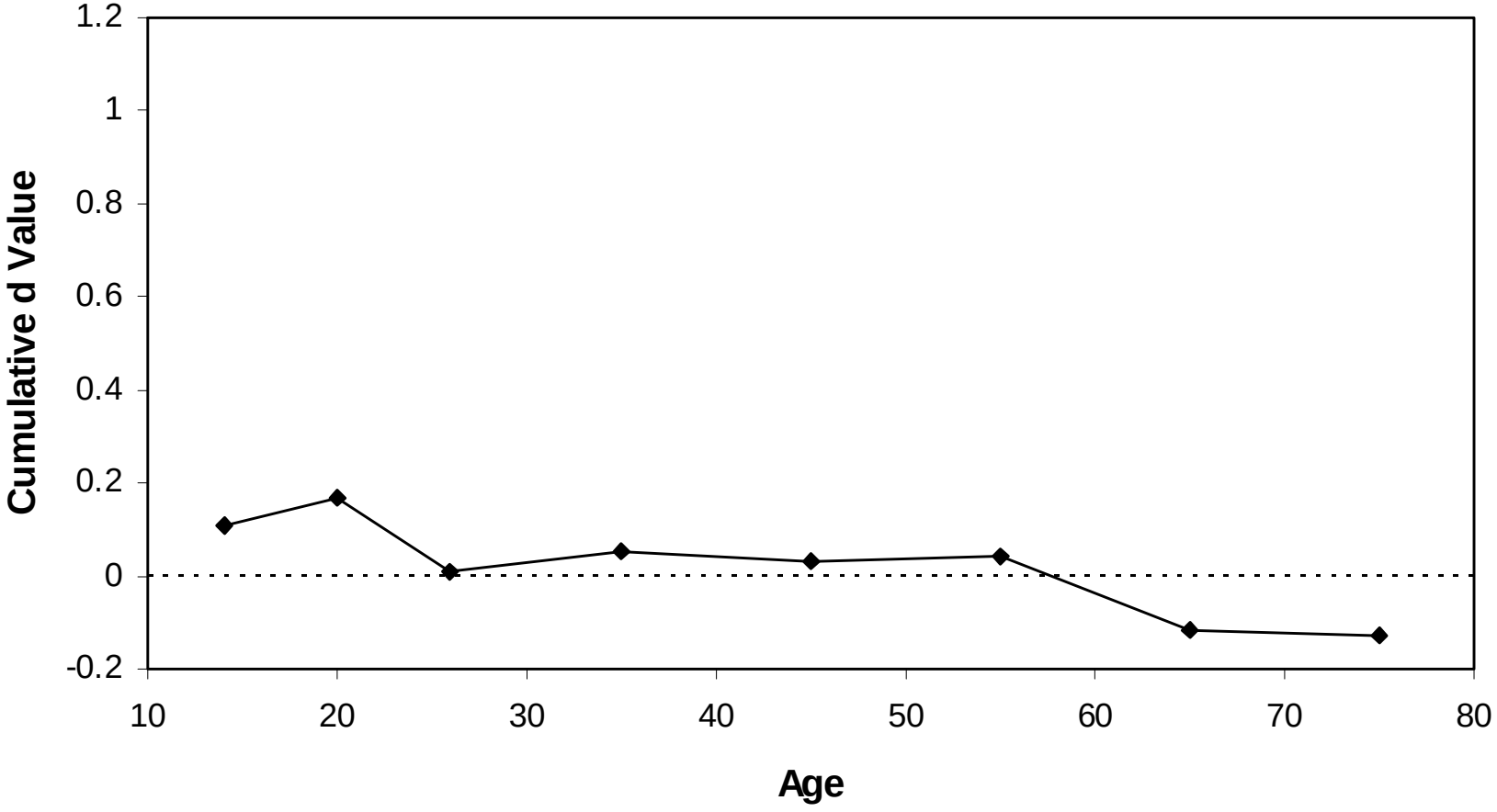
Mean Level Changes

- People typically become more socially dominant

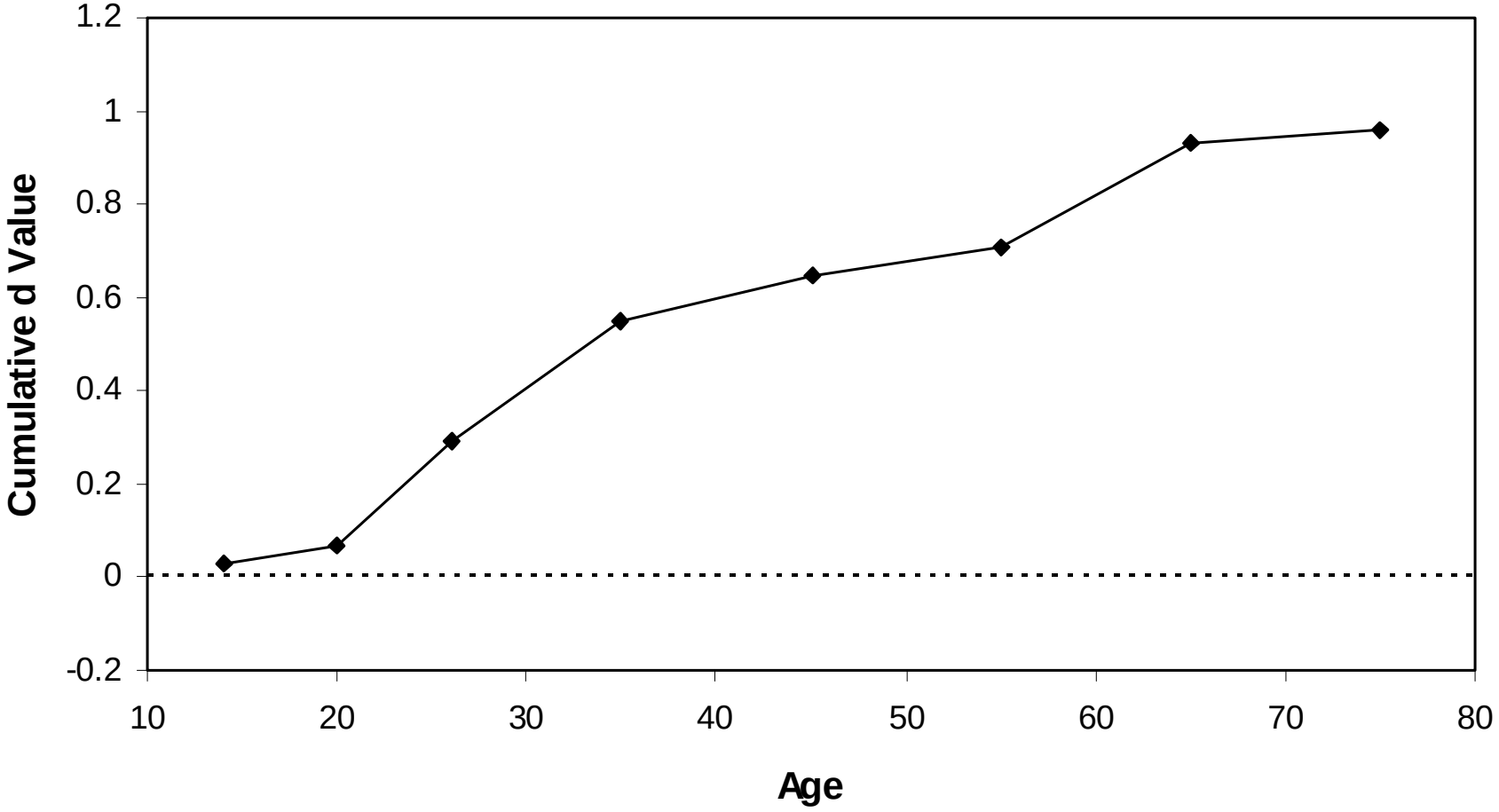
Social Dominance



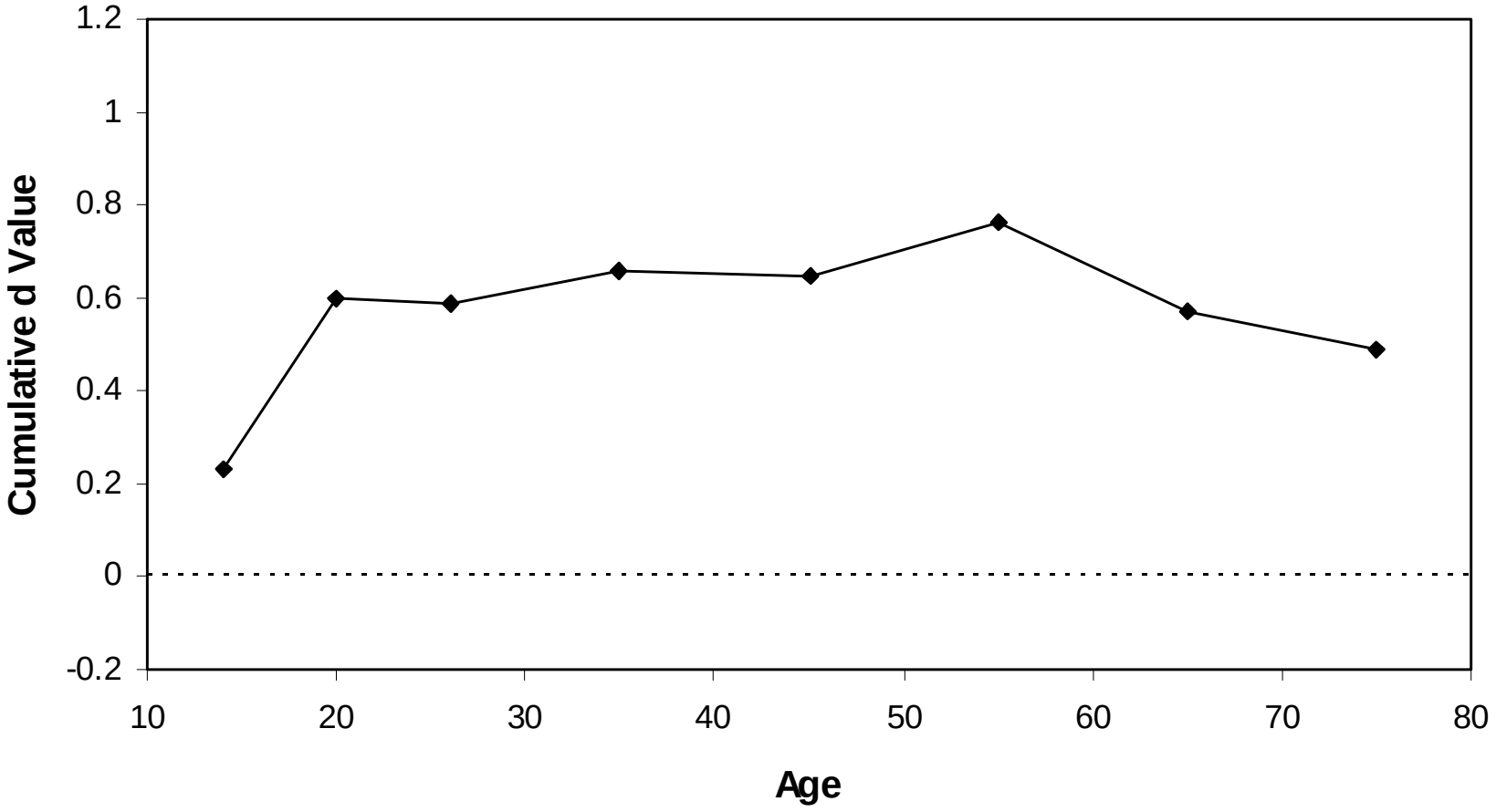
Social Vitality



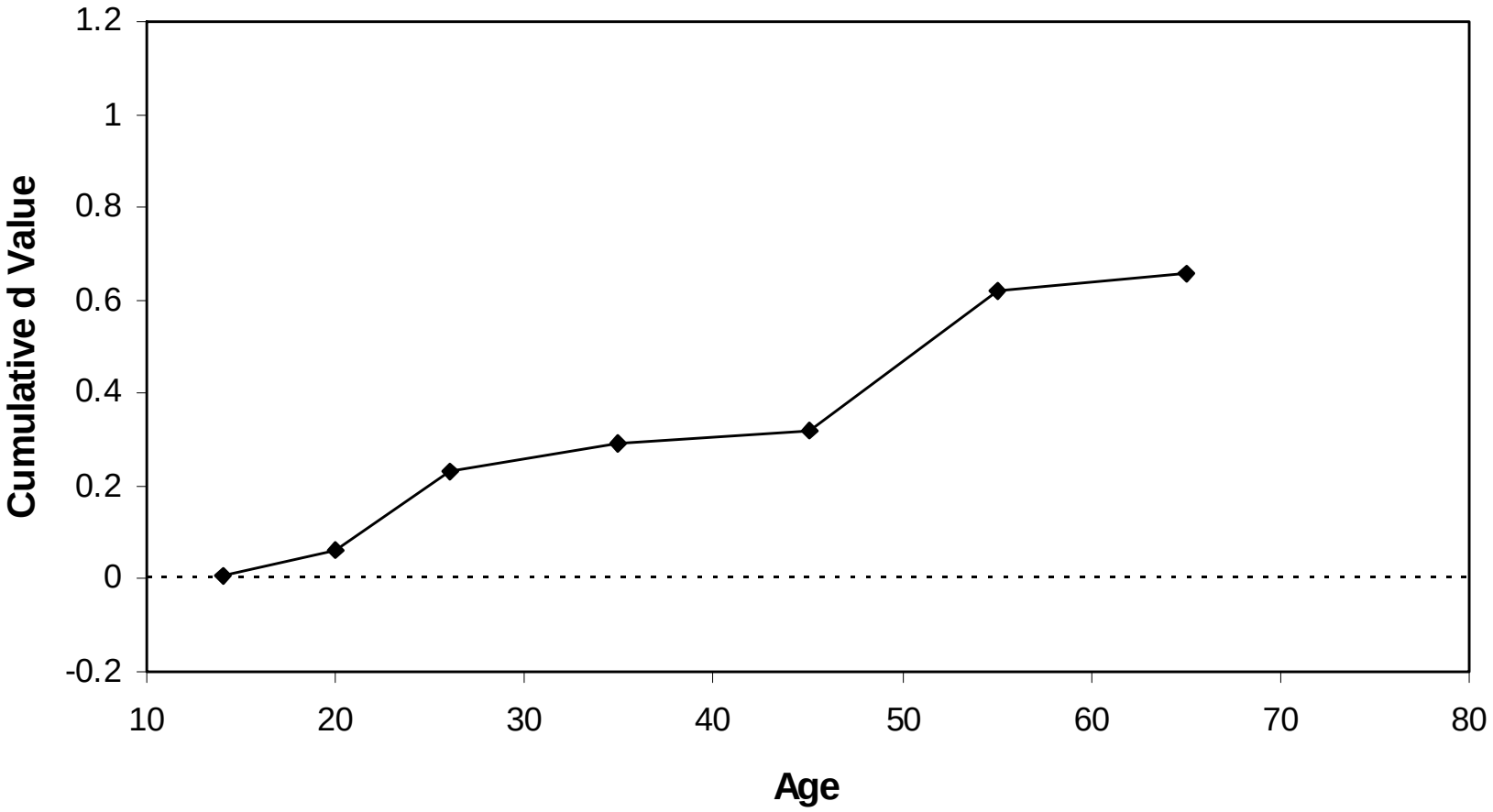
Conscientiousness



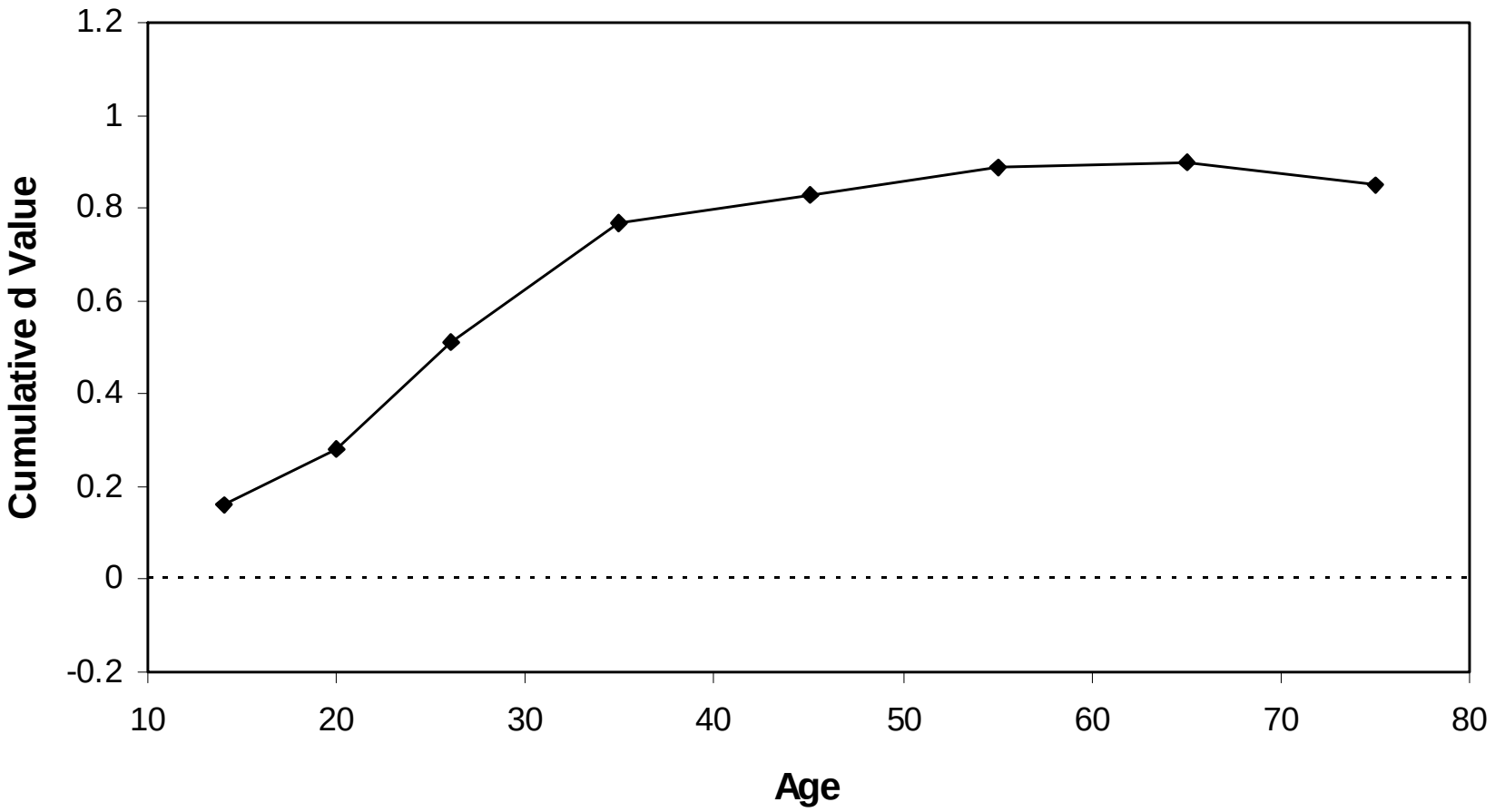
Openness to Experience



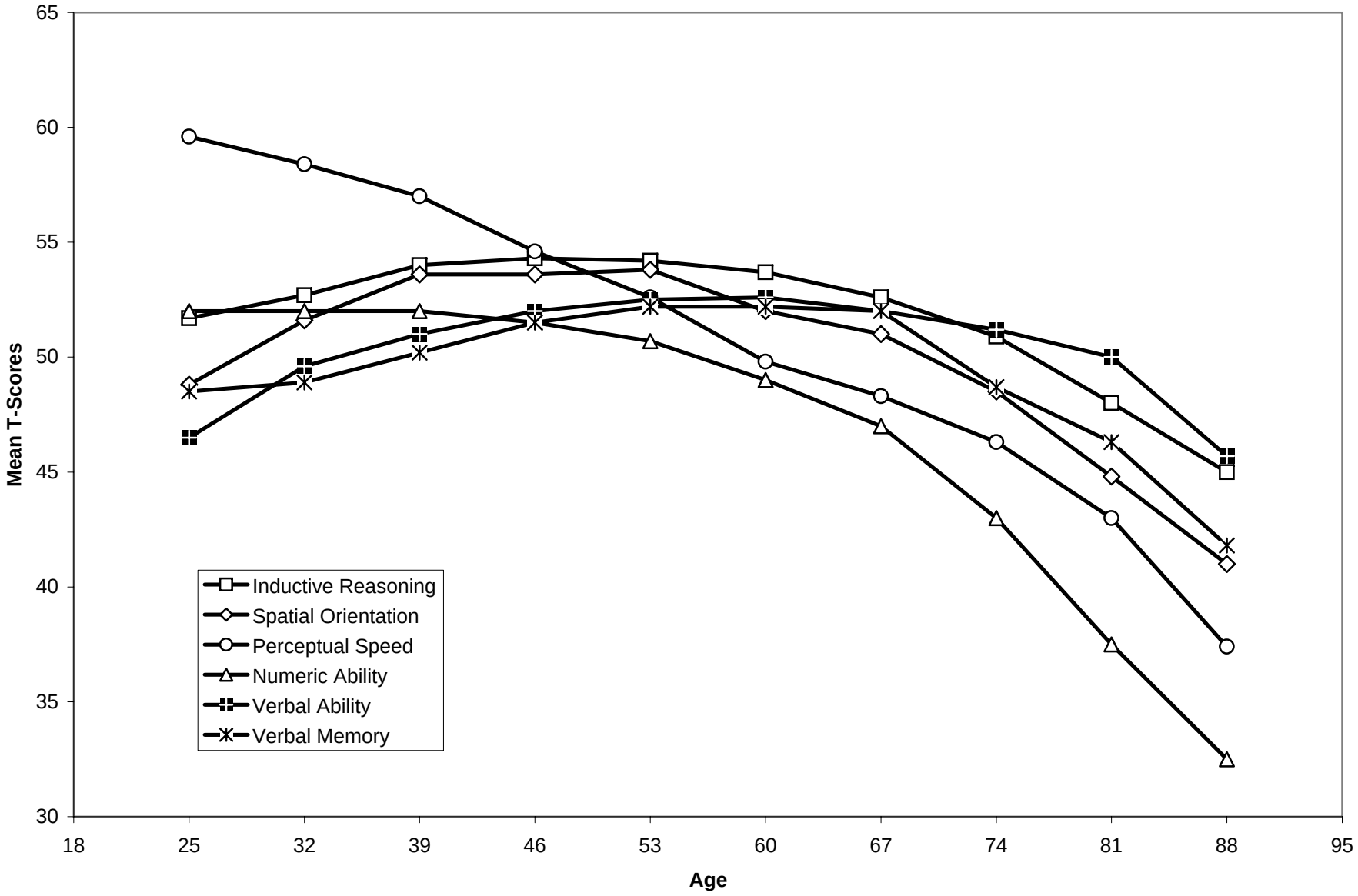
Agreeableness

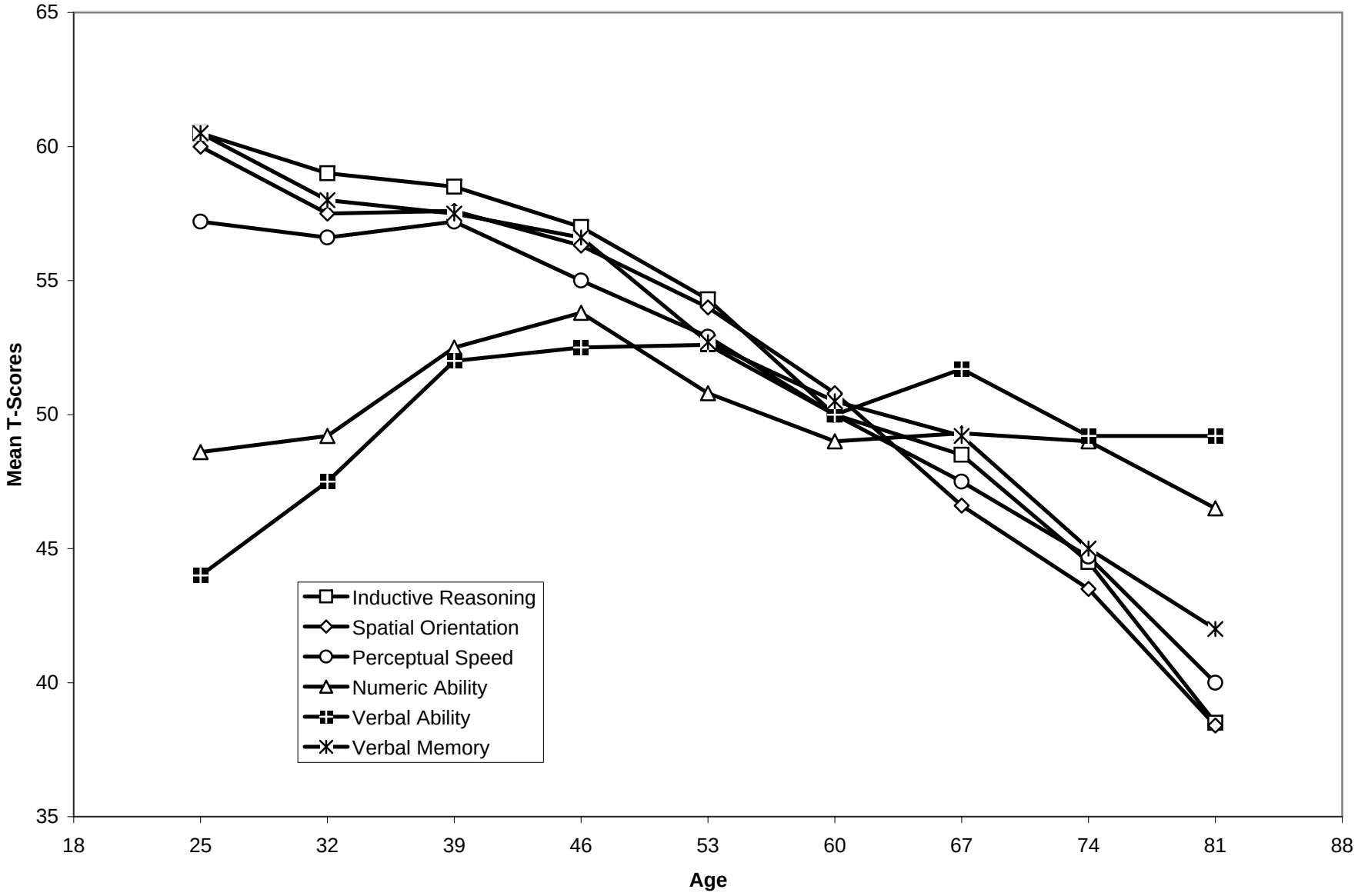


Emotional Stability



- Figure 4b shows mean-level changes in cognitive skills using a longitudinal analysis, and the bottom panel of Figure 4b shows mean-level changes using a cross-sectional analysis.


65
60
55
50
45
40
35
30
Mean T-Scores
18
25
32
39
46
53
60
67
74
81
88
95
Age
Inductive Reasoning
Spatial Orientation
Perceptual Speed
Numeric Ability
Verbal Ability
Verbal Memory


65
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Mean T-Scores
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60
67
74
81
88
Age
Inductive Reasoning
Spatial Orientation
Perceptual Speed
Numeric Ability
Verbal Ability
Verbal Memory

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.

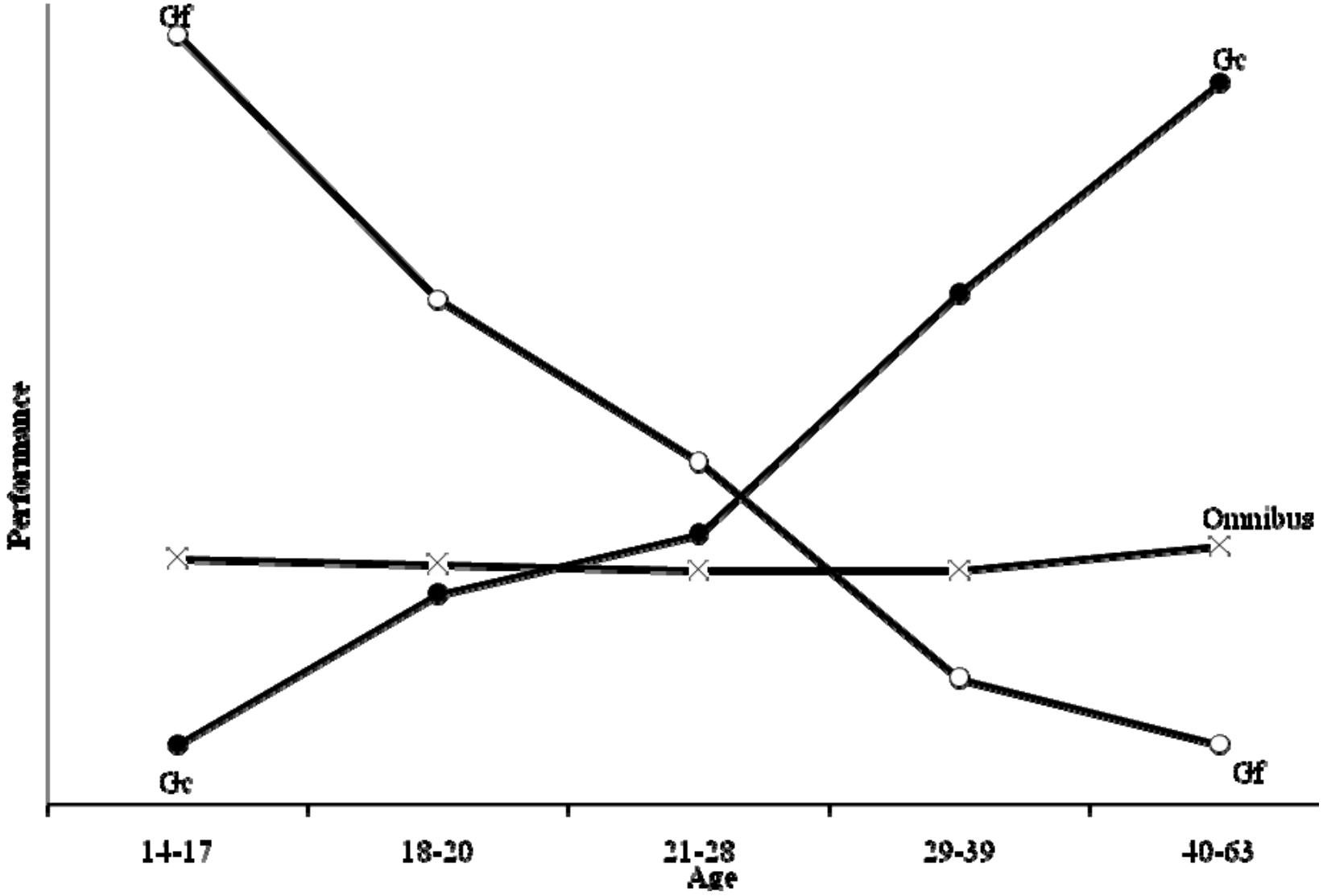
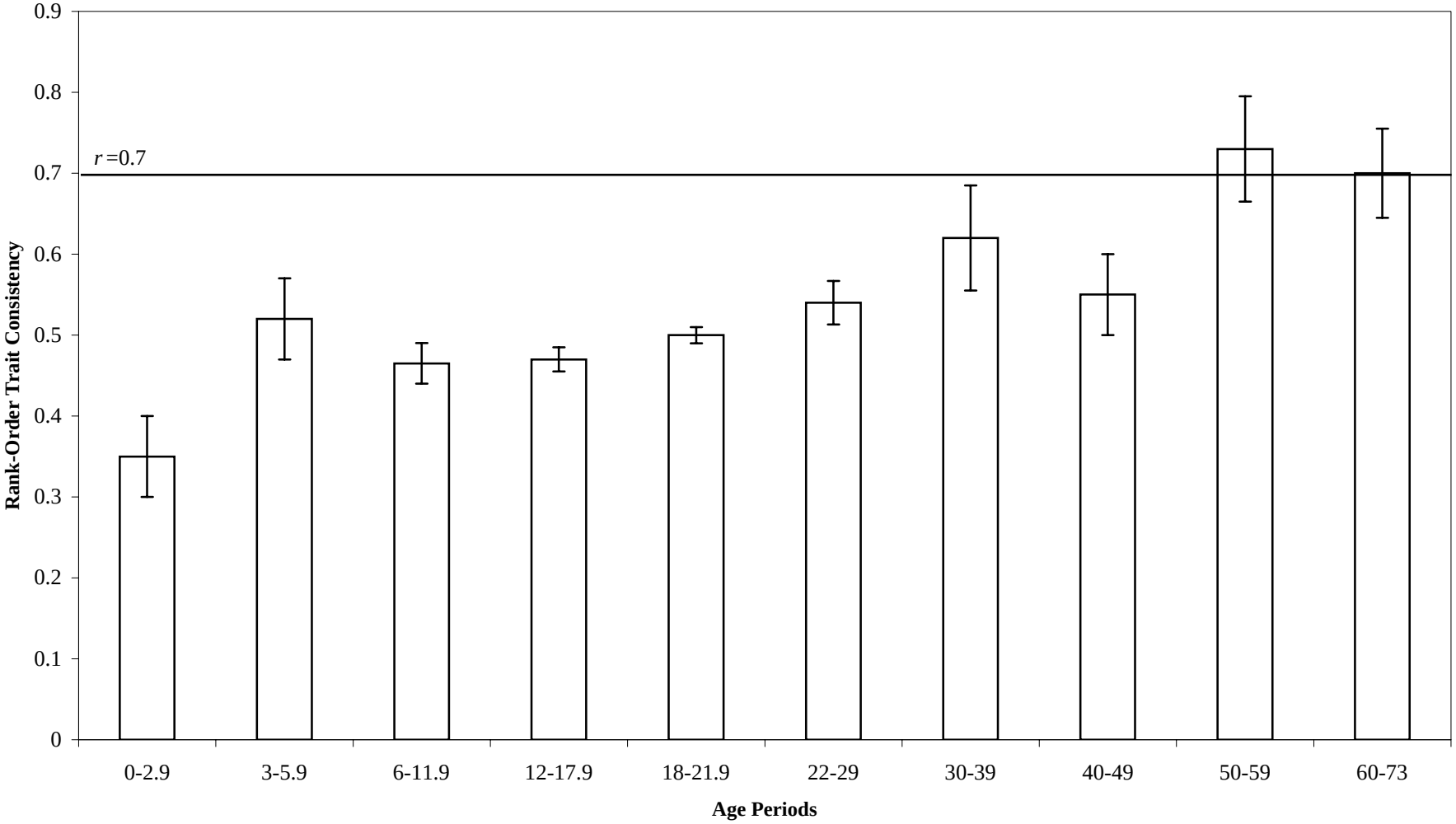
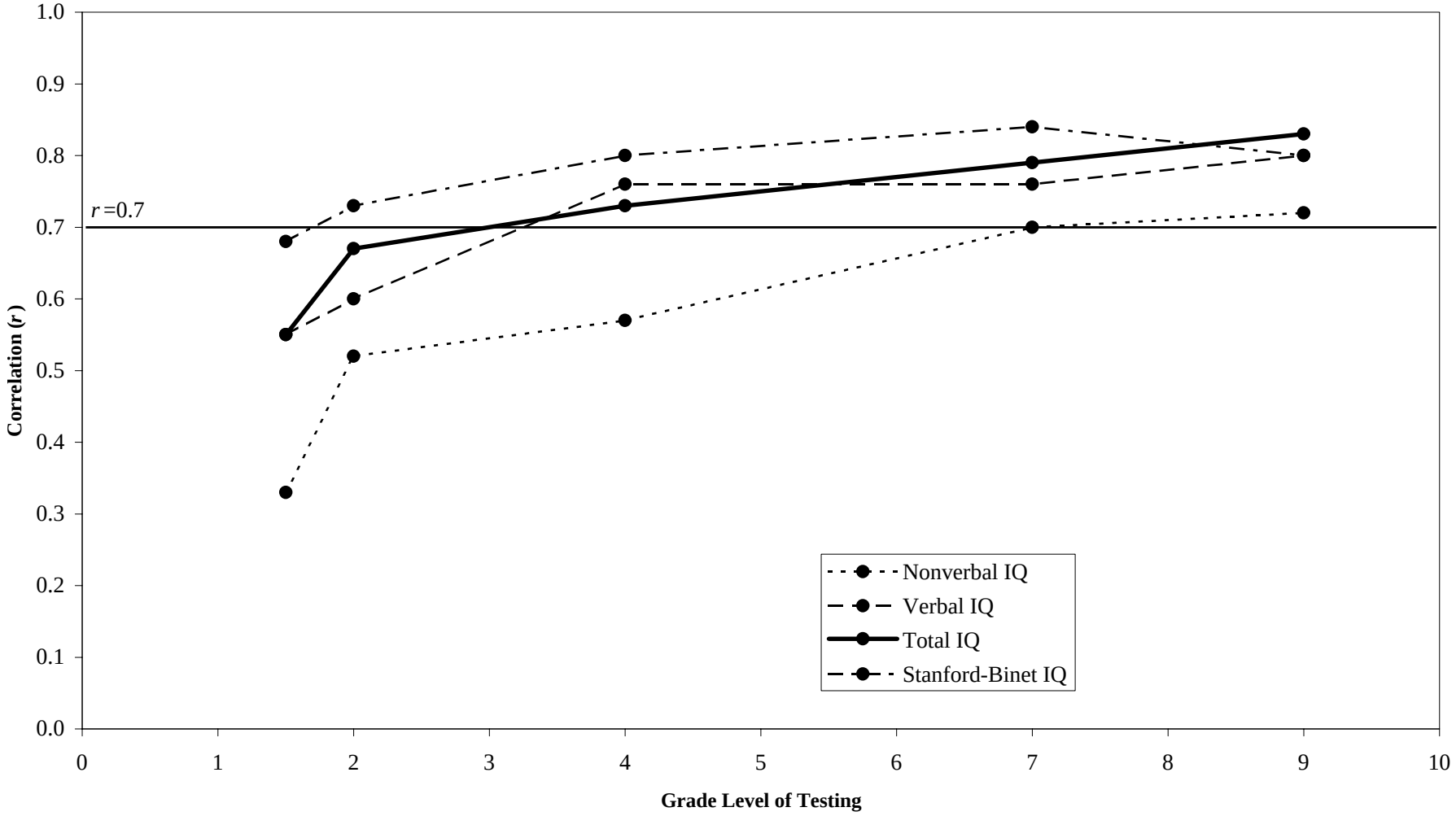


Figure 4c


0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
r =0.7
Rank-Order Trait Consistency
0-2.9
3-5.9
6-11.9
12-17.9
18-21.9
22-29
30-39
40-49
50-59
60-73
Age Periods


1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
r =0.7
Correlation (r)
0
1
2
3
4
5
6
7
8
9
10
Grade Level of Testing
Nonverbal IQ
Verbal IQ
Total IQ
Stanford-Binet IQ

Mechanisms of Change for Cognitive and Personality Traits

- What mechanisms underlie stability and change in personality?
- Behavioral genetics studies typically estimate the effect of parental environments to be near zero, but Turkheimer et al. (2003) find estimates from such studies to be biased downward by the over-representation of middle and upper-class families.

- Genes exert their influence in part through the selection and evocation of environments that are compatible with one's genotype-a phenomenon sometimes referred to as "gene-environment correlation" or "nature via nurture" (see Rutter 2006).

- It is important to note that the family studies of genetic influence measure only the effects of shared environments, which become less similar as children age.

- What other than preprogrammed genetic influences might account for mean-level changes in personality?
- 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.

- One difficulty with many of these studies is the problem of reverse causality discussed in Section III and analyzed in Hansen, Heckman, and Mullen (2004) and Heckman, Stixrud, and Urzua (2006).

- Are the effects of environment on personality change long-lasting? Do changes endure after the environmental cause is removed?
- At the moment, the prevailing view in psychology is relatively pessimistic.

- The enduring effects of environment are greater earlier in life.
- Knudsen et al. (2006) and Cunha and Heckman (2007) summarize this evidence and relate it to models of investment in economics.

Cunha and Heckman (2007)

- latent traits are time (or age) subscripted: $f_{i,t}$.

$$f_{i,t+1} = \psi\left(f_{i,t}, IN_{i,t}\right), \ t = 1, \ldots, T, \tag{7}$$

- $IN_{i,t}$ is a vector of experience related to inputs which can include the parental and school environments, experiences in the workplace, and the like.
- The initial condition reflects genetic material and the in utero environment that determines the initial stock of traits.

- Both cognitive and personality skills can be affected by parental investment and schooling, which are components of $IN_{i,t}$.

- For example, the Perry Preschool Program, an enriched early childhood intervention evaluated by random assignment where treatments and controls are followed to age 40, did not boost IQ but raised achievement test scores, schooling, and social skills.
- It raised personality skills but not cognitive skills, at least as measured by IQ. Effects were not uniform across gender groups (Heckman, 2004; Heckman, Stixrud, and Urzua, 2006).

Stability of Economic Preference Parameters

- Less is known about the stability of economic preferences.
- No longitudinal study has measured the mean-level or rank-order stability of time preference over the life cycle (Frederick, Loewenstein, and O'Donoghue. 2002).
- A handful of cross-sectional studies using relatively small samples have examined mean-level stability, and their findings are mixed.

- In summary, the answer to the question of whether change in personality is possible must be a definitive yes, both in terms of mean-level and rank-order change.
- However, change may be more difficult later in the life cycle,

Frameworks for Integrating Personality Psychology and Economics

Psychological Variables as Constraints

- 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

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

- 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.

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 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.
- 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.

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.

- In addition, 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.
- On the other hand, "energy," e, which can be vector valued, may be used to moderate the manifestation of the trait (for example, energy may be spent controlling anger in a given activity).
- Individuals differ in their endowment vector of the trait $\bar{f}$.
- Thus there may be a time constraint as in Becker (1965) or more generally there may be energy constraints (constraints on effort capacity).

A Simple One-period Model

- Assume that there are J activities with outputs Z_j, $j = 1, \ldots, J + 1$.
- We add one activity to account for market earnings. Z_j is produced by combining tasks, T_j, defined in section II, with purchased market goods, X_j.

- We augment the task functions defined by equation (8) to include levels of energy, and time, in vector e^j

$$T_j = h_j\left(f^j, e^j\right) \text{ for } j = 1, \ldots, J+1 \tag{8}$$

  f^j is to be distinguished from f_j, the jth 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.
- Thus if $e^j = 0$, the trait f^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

$$Z_j = \varphi_j \left(T_j, X_j \right) \text{ for } j = 1, \ldots, J+1 \tag{9}$$

- 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 f as well as other variables which we keep implicit.
- The utility function is

$$U = U\left(Z_1, \ldots, Z_j, e^1, \ldots, e^{J+1}, f\right) \tag{10}$$

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

$$\sum_{j=1}^{J+1} P_j X_j = Y + Z_{J+1} \tag{11}$$

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

- It is possible to distinguish two different cases for f.
- For psychological traits, we can distinguish the case where f is a public good, $f^j = \bar{f}$ for all $j = 1, \ldots, J+1$.
- When it is a private good, $\sum_{j=1}^{J+1} f^j = \bar{f}$
- 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.

		f	
		Public	Private
e	Private	case I	case II

- In case I, the additional constraint operating on the consumer beyond the budget constraint (11) is

$$f^j = \bar{f}, \ \sum_{j=1}^{J+1} e^j = \bar{e}, \text{ for all } j = 1, \ldots, J+1. \tag{12}$$

- In case II, the operative constraints are

$$\sum_{j=1}^{J+1} f^j = \bar{f}, \ \sum_{j=1}^{J+1} e^j = \bar{e} \tag{13}$$

Case I: Traits as Public Goods

- In case I, different bundles of $\bar{f}$ 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, $j = 1, \ldots, J + 1$, display constant returns to scale in non-public inputs.

- In terms of the technologies (16), when f is a public good, we assume constant returns to scale in e^j but that $f^j = \bar{j}$ is a fixed, environmental variable.
- Different levels of $\bar{f}$ produce different productivities in different tasks.
- Feeding $\bar{f}$ into the activity functions (9), 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 $\bar{f}$ except for its effect on Z_{J+1}.
- Holding energy and money resources fixed, changes in $\bar{f}$ 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.

- 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 $(\bar{f}, \bar{e})$ differentially expand the consumption possibility set for activities intensive in (f, 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 summarized in sections IV and V of this lecture would seem to favor case II, since different levels of traits are often found in different activities.
- However, since most of the estimates reviewed in this paper 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.

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; and (c) dynamic constraints connected with asset, skill and trait formation.

- Preferences are central to conventional economic choice models.
- In their most general form, we may write utility for an 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 as

$$U(X_1, \ldots, X_T; f), \tag{14}$$

where it is assumed that U is neoclassical.

- A general non-separable intertemporal preference function is consistent with substantial departures from standard utility theory such as hyperbolic discounting (Phelps and Pollak 1968; Ainslie 1991; Laibson 1998) and a variety of "exotic" or nonstandard preferences as discussed in, for example, Backus, Routledge, and Zin (2005) and Hansen (2005).
- Preference specifications (14) is consistent with different rates of time preference for different goods and across different periods as is found in the literature reviewed in Section IV.

- Few economists would embrace the high level of generality of specification (14).
- Fruitful economic models are more tightly structured. Specification (14) can characterize a one-shot model of lifetime decision making under certainty.
- Agents choose their lifetime consumption bundles at the beginning of life and are fully committed to those choices.

- A basic problem with these specifications is time inconsistency.
- In open markets, persons are not committed to their initial desired choices.

- More generally, agents may look at future decisions differently in period 2 than they did in period 1.
- Let U^t be the utility of the agent at stage t for the remainder of life $U^t = G^t(X_t, \ldots, X_T; f)$.
- Without further restrictions, there is no reason why in period t, the agent is compelled to value the utilities of previous period consumption bundles or account for past consumption behavior in the way done prior to period t in evaluating future consumption streams.
- The problem of preferences changing over time is distinct from the problem of revised information sets although both produce possible departures from initial decisions based on (14).

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

$$U(X_1, \ldots, X_T, f) = \sum_{t=1}^{T} \frac{1}{(1+\rho)^{t-1}} U(X_t, f). \tag{15}$$

- Specification (15) is not required to achieve time consistency of choices.
- This is an important point, because there is a lot of evidence that speaks against (15) as previously noted in section IV.
- Notice that (15) is just a special case of equation (14), which is also a standard model of economic preferences.
- A more general form of discounting than specification (15) that is consistent with (14) is

$$U(X_1, \ldots, X_T, f) = \sum_{t=1}^{T} \prod_{j=2}^{t} \left(\frac{1}{1+\rho_j} \right) U(X_t, f), \tag{16}$$

where discount rates may vary with age.

- Let f_t denote personality and cognitive traits at age t.
- Can use $U_t(X_t, f_t)$ in place of $U(X_t, f)$, allowing for personal traits to evolve over time, and we can allow for utility in period t itself to change, even after controlling for ft and X_t.
- The analysis of Becker and Mulligan (1997) and Mulligan (1997) models the evolution of the discount rate through investment decisions.
- Becker and Murphy (1988) model the evolution of preferences for addiction where f_t is a stock of addictive capital.

- A wide variety of special cases of lifetime preferences are subsumed in specification (14).
- Personality factors like deliberation, future time perspective, and the capacity to inhibit impulses likely determine discount factors or preferences more generally.
- So may aspects of cognitive ability.
- Loewenstein et al. (2001) discuss how decisions are affected by moods and emotions, which are influenced by personality variables.
- There is some evidence that higher IQ persons have lower discount rates (see Frederick 2005 and Dohmen et al. 2007).

- The standard model of social interaction in economics is interaction through markets (See Arrow and Hahn 1971).
- This aspect of human interaction is not captured by specifications (14)-(16) unless the include outcomes, choices or utilities of other persons.
- As noted previously in section IV, a large literature in economics discusses the implications of altruism (see Becker, 1981 and Laferrre and Wolff, 2006, for a survey).
- Fehr and Gachter (2000) discuss the consequences of social preferences for economic decisions.
- Models of social preferences have been developed by Fehr and Schmidt (1999) and Falk and Fischbacher (2006).

- Surveys by Fehr and Schmidt (2006) and Meier (2007).
- One of the major findings of personality psychology noted in section V is that sociability, empathy, and the capacity to get along with others are important predictors of success in many activities.
- These traits are not the same as altruism or social preferences, but they are facets related to Big Five agreeableness and extraversion.

- Sociability and empathy may affect preferences for group activity which may be a source of pleasure (or displeasure) for some and which may also affect productivity in group activities in the workplace or in learning environments.
- Dohmen et al. (2008) present evidence on how trust, positive reciprocity, and negative reciprocity relate to Big Five personality traits.
- These and other personality traits play dual roles.
- They are a source of pleasure and they can also be a source of productivity in certain contexts.
- Agents making choices under any of the standard preference schemes, including those that recognize social interactions, are constrained in their information, the resources required to support consumption and in their ability to accumulate financial assets and skills.

- Uncertainty and risk are essential aspects of life. Economists have devoted much attention to the specification of the preferences of agents and the effect of uncertainty on choice (see Mas-Colell, Whinston, and Green 1995).
- Individuals who are more intelligent or more open to experience (that is, more intellectually curious and motivated to learn) may acquire information more cheaply.
- Other personality traits may affect the basic attribute spaces perceived by agents.

- The conventional model of uncertainty in economics is the expected utility model.
- Break X into values that occur in different states a s and time t, $(X_{11}, \ldots, X_{ts}, \ldots X_{1S_T})$.
- Expected utility represents preferences

$$U(X) = \sum_{t=1}^{T} \sum_{s=1}^{S_t} P_{t,s} U(X_{t,s}) \text{ where } \sum_{s=1}^{S_t} P_{t,s} = 1, t = 1, \ldots, T \tag{17}$$

  $X_{t,s}$ is a state s, time t-specific bundle of traits.
- $P_{t,s}$ is the probability that state s occurs in period t.

- Considerable empirical evidence against this model. Many departures from it have been proposed to rationalize the available evidence.

- Personality factors may affect the arrival and processing of information. People not open to experience fail to learn from it.
- Impulsive people who do not act with deliberation may process information inefficiently (Frederick 2005).

- There are far richer models of decision making under uncertainty in economics than the standard expected utility model or models based on decision making under uncertainty generated from objective distributions.
- These specifications allow for preferences over the temporal resolution of uncertainty about states of the world (Kreps and Porteus 1978; Epstein and Zin 1991), uncertainty about distributions over states of the world (ambiguity) and different types of risk and uncertainty aversion in preferences (see Starmer 2000).

- Personality traits are likely to prove useful in economic models of decision making under ambiguity.
- Individuals may differ in their capacities to deal with poorly defined situations.
- Greater intelligence may help define situations, but person with greater self control, openness to experience, lower levels of anxiety and those who seek excitement may better cope with ambiguity.
- Personality traits may also affect the resources available to agents.
- As emphasized by Bowles, Gintis, and Osborne (2001), certain personality and character traits may be more highly valued than others in the labor market (trustworthiness, perseverance, outgoingness, for example).

- They present evidence for Germany and the United States that the increased importance of people skills has affected the labor-market outcomes of blacks and women.
- They find that the relative employment of women is higher in occupations in which people tasks are more important in Britain, Germany and the United States.
- The reverse is true for racial, ethnic, cultural, and linguistic minorities in the United States.
- Diligent or trustworthy employees require less supervision.
- More generally, different personality and cognitive traits may be more highly valued in some activities than in others.
- In any activity, whether it is learning, information processing or performance of a workplace task, those who exert higher levels of effort will be more productive.

- Comparative advantage in the labor market: Roy (1951), Mandelbrot (1961, 1962), Tinbergen (1956), Rosen (1974), Sattinger (1979, 1993), Willis and Rosen (1979), Heckman and Sedlacek (1985), and Teulings (1995; 2005).

- Borghans, ter Weel, and Weinberg (2007) develop a model in which personality traits are included in an assignment model.
- Productivity of a person in occupation (pursuit) j at time t as $Y_{j,t} = \alpha_{j,t}(f_t^j, e_t^j), j = 1, \ldots, J_t$, where we adjoin t subscripts to the trait and energy levels.
- Different occupations or tasks require (or weight) different traits differently.

- In subsection B, we analyzed specifications of market productivity functions that are used in the efficiency wage literature (see Weiss 1991).
- 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

$$j_t^* \operatorname{argmax}_{j_t} \{ Y_{j,t} \}_{t=1}^{J_t}. \tag{18}$$

- In this case, Y_{i,j_t^*} corresponds to $Z_{J+1,t}$ for the period t as introduced in subsection C.
- This framework captures the notion of comparative advantage in the labor market where agents sort into sectors based on their comparative productivity.
- Hogan (2005) and Hogan and Hogan (2007) show the predictive power of personality traits in different occupations.

- Over time, persons may also accumulate assets and skills, and may change their personality characteristics and cognitive traits.
- Preference parameters affect asset and skill accumulation.

- Section VI presents evidence that cognitive and personality traits can be changed (see Cunha and Heckman 2007 and Fraley and Roberts 2005).
- Both are influenced by experience and current stocks of the characteristics and other determinants.
- To formalize these notions, define C_t as a capacity vector that includes f_t and e_t but encompasses a wider notion of capacities.
- Motivation can be affected by intelligence and other capacities of human beings (see Cunha and Heckman 2008).

- Interventions can affect preferences, information, opportunity sets, and the formation of skills and preferences.
- Personality and cognitive ability evolve over time through investment, through learning by doing or through other life experiences (see Cunha and Heckman 2007; Cunha, Heckman, and Schennach 2007).
- Among the characteristics or capacities C_t can be health, motivation, personality traits and ability (Heckman 2007).

- Using the technology of skill formation capacities evolve via the following recursive technology

$$C_{t+1} = \tau(C_t, IN_t), t = 1, \ldots, T-1, C_0 = c_0 \qquad (19)$$

- c_0 is an initial condition for capacities and is investment at stage t and where is concave in τ, and is assumed to be differentiable in C_t and IN_t.
- In one version, $f_t = C_t$
- Cognitive and personality skills can evolve over time.
- Characteristics may be self-productive $\left(\frac{\partial \tau(C_t, IN_t)}{\partial C_t} > 0\right)$.
- Investment, which can include experience and other inputs, may affect the evolution of abilities and personality, that is, $\left(\frac{\partial \tau(C_t, IN_t)}{\partial IN_t} > 0\right)$.

Do Personality Parameters and Economic Preference Parameters Correspond?

- It is tempting to relate the personality traits to conventional economic preference parameters.
- Omits cognition.

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)

- The Big Five captures traits that seem relevant but 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.

- Economic models of contracting emphasize unobserved effort (a component of e), as an important dimension of economic transactions in the presence of imperfect information (Salanie 1997).

- Individuals may put in more effort in a task (a component of $T_j, j = 1, \ldots, J + 1$) and will be more productive than other individuals at the task whether the task is a job, learning in school or acquiring information.
- Persons for whom the utility cost of effort is low, and hence exert more effort, will be more productive in a variety of activities.
- Behavior is affected by incentives and is not necessarily constant across settings.

- "Warmth" (a facet under extraversion) may be a productive trait in some settings, but it may be unproductive in certain settings (for example, an assembly line, on the battlefield or in a seminar).
- Fantasy (under Openness) can be counterproductive in routine tasks but very productive in creative work, providing that the person is also self-disciplined and open to criticism.
- There is wisdom in considering traits that have domain-specific productivities.

- Do the traits discussed by personality psychology cause us to rethink the standard economic model?
- The 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).

- Is it possible that 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 in Table 1.
- For one thing, it is likely that these parameters are produced both by cognition and personality as we have previously noted.
- However, certain traits associated with Big Five conscientiousness might be rationalized by basic preference parameters.

- 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 of the traits in Table 1 (for example, hostility, warmth, anxiety, trust) are less easily explained by standard economic preferences.

Summary and Suggestions for Future Research

- Whereas the significance of personality traits for success in many aspects of life has long been appreciated at an intuitive level, it was not until recently that a substantial body of empirical analysis has documented this intuition.
- However, recognizing the importance of traits other than intelligence is not enough. It is also essential to identify which traits are important for which outcomes.
- Such an understanding not only leads to better measures and richer models, but ultimately provides direction for policy and intervention.

- Economists are not alone in their interest in the description, prediction, and explanation of human behavior.
- Psychologists, too, have approached these challenges.
- Economists can profitably leverage research from psychology on the measurement, prediction, and malleability of personality traits organized in the widely-accepted Big Five taxonomy.

Answer to Question 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 Question 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 Question 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 Question 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 explicitly model motivation through preferences.
- The evidence suggests that performance on tests can be affected by incentives but only for certain personality types.

- Economists have long emphasized that organizations can succeed by aligning the interests of the workers with those of managers.
- This can be achieved by selecting persons with compatible personality traits (for example, on the basis of trustworthiness, cooperativeness, and the like) or by giving incentives to workers of each personality type or by a mixture of the two strategies.
- However, implementing both types of strategies in the same workplace may be counterproductive because of envy and other social effects.

- 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.

- Both preferences and constraints should be analyzed.
- Implementing the simple models presented would be a good first start.
- An example of how economic theory can be changed in a fundamental way by learning lessons from personality psychology is the recent work on multidimensional screening that adds personality skills to traditional screening and signaling models and produces a fundamental reformulation of signaling theory (Araujo, Gottlieb, and Moreira, 2007).

Answer to Question 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.

- 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.

- 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.