WEBSITE APPENDIX A

Personality, Abilities and Motivations

Table 1. Individual differences widely studied in psychology

Individual Difference	Definition (APA Dictionary definition in quotes)	Example Measures
Personality Traits: How individuals typically act, think, and feel		
Big Five personality model	"A model of the primary dimensions of individual differences in personality. The dimensions are usually labeled extraversion, neuroticism, agreeableness, conscientiousness, and openness to experience, thought he labels vary somewhat among researchers."	NEO-PI-R (Costa & McCrae, 1992); Big Five Inventory (John & Srivastava)
Big Five Openness to Experience	"A dimension of the Big Five personality model that refers to individual differences in the tendency to be open to new aesthetic, cultural, or intellectual experiences." Openness correlates with IQ (*r* about .3). Also called Intellect, this dimension includes facets such as open-mindedness, creativity, appreciation of arts and music.	Typical Intellectual Engagement (TIE, Ackerman); Need for Cognition (Cacioppo); Openness domain of any Big Five questionnaire
Big Five Conscientiousness	"The tendency to be organized, responsible, and hardworking, construed as one end of a dimension of individual differences (conscientiousness vs. lack of direction) in the Big Five personality model." Conscientiousness predicts work and health outcomes and includes facets such as dependability, orderliness, perseverance, and need for achievement.	Conscientiousness domain of any Big Five questionnaire
Big Five Neuroticism/Emotional Stability	"One of the dimensions of the…Big Five personality model characterized by a chronic level of emotional instability and proneness to psychological distress." This dimension is often termed *emotional stability*, which is the opposite of neuroticism, and includes facets such as hostility, depression, and anxiety.	Neuroticism domain of any Big Five questionnaire. Negative affect measures could also be used but the latter often emphasize *temporary* affect rather than dispositional affect.
Big Five Agreeableness	"The tendency to act in a cooperative, unselfish manner, construed as one end of a dimension of individual differences (agreeableness vs. disagreeableness) in the Big Five personality model." This dimension includes facets such as trust and compliance.	Agreeableness domain of any Big Five questionnaire.
Big Five Extraversion	"An orientation of one's interests and energies toward the outer world of people and things rather than the inner world of subjective experience. Extraversion is a broad personality trait and, like introversion, exists	Extraversion domain of any Big Five questionnaire.

	on a continuum of attitudes and behaviors. Extroverts are relatively more outgoing, gregarious, sociable, and openly expressive." Roberts (2006) suggests that there are two aspects of Extraversion: social dominance and social vitality. See below.	
Social vitality	A subdimension of Big Five Extraversion proposed by Roberts (2006) that includes facets such as sociability, positive effect, and gregariousness.	CPI Sociability Scale; NEO-PI-R Gregariousness and Activity Scales
Social dominance	A subdimension of Big Five Extraversion that includes facets such as dominance, independent, and self-confidence, especially in social settings.	NEO-PI-R Assertiveness scale; 16PF Dominance Scale
Need for Achievement/Ambition	"A strong desire to accomplish goals and attain a high standard of performance and personal fulfillment. People with high need for achievement undertake tasks in which there is a reasonable probability of success and avoid tasks that are too easy or too difficult" A facet of Big Five Conscientiousness. Desire to achieve difficult goals or reach high standards.	Projective measures (unreliable), Conscientiousness subscales
Delay of gratification/Impulsivity/Self-Control/Time Preference	"forgoing immediate reward in order to obtain a larger or more desirable reward in the future" A facet of either Neuroticism or Conscientiousness. When faced with a choice between immediate temptation and superior, deferred gratification, the ability to control behavior, attention, and thoughts in order to attain superior, deferred reward.	Marshmallow task (Mischel); UPPS Impulsive Behavior Subscale (Whiteside & Lynam); Self-Control Scale (Baumeister); Time Perspective Inventory (Zimbardo)
Sensation Seeking	"The tendency to search out and engage in thrilling activities as a method of increasing stimulation and arousal. It takes the form of engaging in highly stimulating activities accompanied by a perception of danger." A facet of either Conscientiousness or Extraversion. Attraction to novel, intense experiences and willingness to take risks for them.	Sensation-seeking Scale
Perceived Self-efficacy/locus of control/optimism	Perceived Self Efficacy: "Subjective perception of own capability of performance or ability to attain results". Locus of Control: "perception of how much control individuals have over conditions of their lives". Possibly a facet of Neuroticism. The belief that one has control over outcomes. The opposite of helplessness.	Generalized self-efficacy scales[41], Rotter Locus of Control Scale, Attributional Style Questionnaire

[41] Bandura does not endorse any trait-level scales

Regulatory Focus	Orientation toward either promotion of positive outcomes or prevention of negative outcomes.	Regulatory Focus Questionnaire (Higgins et al., 2001)
Affect, Well-Being	Positive affect is the internal feeling state that occurs when a goal has been attained, a source if threat has been avoided or the individual is satisfied with the present state of affairs" Positive affect includes emotions such as joy, contentment, and pride. Negative effect, which is only moderately inversely correlated with positive effect, includes fear, anxiety, sadness, etc. Life satisfaction is a cognitive, not affective, appraisal of the quality of one's life. Well-being is characterized by the presence of positive effect, the absence of negative effect, and positive life satisfaction.	PANAS (Watson, Clark, & Tellegen) for positive and negative affect; SWLS (Diener) for life satisfaction
Self-esteem	"The degree to which the qualities and characteristics contained in one's self concept are perceived to be positive" One's estimation of one's own self-worth. A construct that enjoyed tremendous popularity in the 1970ss but since has been considered epiphenomenal not causal. A minority of psychologists consider positive and negative evaluations of the self to be the sixth and seventh factors of personality. Possibly grouped with self-efficacy, etc.	Rosenberg Self-Esteem Scale
Temperament (childhood)	"Basic foundation of personality, usually assumed to be biologically determined and present early in life[…] Includes characteristics such as energy level, emotional responsiveness, response tempo and willingness to explore" Precursors to personality traits, temperament variables are patterns in behavior or affect that appear early in life that are assumed to have a neurobiological basis. There are fewer temperament variables than personality traits because these individual differences are less salient and stable in children than in adults.	Children's Behavior Questionnaire
Psychopathology	*"Patterns of behavior or thought processes that are abnormal or maladaptive".* A broad category comprising dysfunctional patterns of thought, feeling, or behavior. Most disorders are included in the DSM-IV manual. Axis I disorders (e.g., depression) are more intense and episodic/discreet, whereas Axis II disorders (i.e., personality disorders) are more tonic and enduring.	Beck Depression Inventory; Beck Anxiety Inventory; MMPI (omnibus measure); Child Behavior Checklist (Achenbach)

Myers-Briggs Type Indicator (MPTI)	"A personality test designed to classify individuals according to their expressed choices between contrasting alternatives in certain categories of traits. The categories, based on Jungian typology, are extraversion-Introversion, Sensing-Intuition, Thinking-Feeling, and Judging-Perceiving…The test has little credibility among research psychologists but is widely used in educational counseling and human resource management…"	MBTI
Type A/Type B personality	Type A personality is "a personality pattern characterized by chronic competitiveness, high levels of achievement motivation, and hostility." Type B personality is "a personality pattern characterized by low levels of competitiveness and frustration and a relaxed, easy going approach."	
Intelligence, General Mental Ability, "g", IQ	Intelligence and general mental ability both refer to "the ability to derive information, learn from experience, adapt to the environment, understand and correctly utilize thought and reason." "*g*" ("general factor") refers to the first factor extracted from a factor analysis of cognitive tasks, which many researchers consider to represent general (vs. specific) intelligence."It represents individuals' abilities to perceive relationships and to derive conclusions from them. It is the basic ability that underlies the performance of different intellectual tasks" " Intelligence quotient (IQ) refers to one's intelligence relative to one's age group (especially for children) but can also be used synonymously with intelligence.	WISC, WAIS, Raven's Progressive Matrices, ASVAB
Specific mental abilities	"Abilities as measured by tests of an individual in areas of spatial visualization, perceptual need, number facility, verbal comprehension, word fluency, memory, inductive reasoning and so forth" An umbrella category for lower-level mental abilities, including math, verbal, and spatial abilities, as well as even more specific mental capacities.[42]	Subtest scores on IQ tests
Creativity	"Ability to produce original work, theories, techniques or thoughts […] Related with imagination, expressiveness, originality." Ability to generate novel ideas and behaviors that solve problems.	Creative Personality Scale (Gough, 1979)

[42] Cattell considered fluid (capacity to learn) and crystallized intelligence (knowledge) to be second-order aspects of intelligence.

Executive Function	"Higher level cognitive processes that organize and order behavior, including logic and reasoning, abstract thinking, problem solving, planning and carrying out and terminating goal directed behavior" Broad set of higher-level cognitive capacities attributed to the prefrontal cortex, often involving the coordination and management of lower-level processes.	Innumerable neuropsychology tasks (e.g., go/no-go, Stroop, Continuous Performance Task)
Cognitive reflection	A specific mental ability. The tendency to reflect before taking an intuitive answer as correct.	Cognitive Reflection Test (Frederick, 2005)
Emotional Intelligence	"Ability to process emotional information and use it in reasoning and other cognitive activities. According to Mayer and Slovey 1997 model it comprises four abilities: to perceive and appraise emotions accurately, to access and evoke emotions when they facilitate cognition, to comprehend emotional language and make use of emotional information, and to regulate one's own and others' emotions to promote growth and well-being" Ability to perceive emotion, to integrate it in thought, to understand it and to manage it (Mayer)	MSCEIT (Mayer & Salovey) but really there are no good measures
Motivation – What individuals *want* to do, feel, or think		
Values	"A moral, social or aesthetic principle accepted by an individual (or society) as a guide to what is good, desirable or important." What individuals feel is important in a moral sense.	Values in Action Inventory of Strengths
Interests	"Attitude characterized by a need to give selective attention to something that is significant to the individual". What spontaneously attracts and holds one's attention, and is considered pleasant.	Self-Directed Search, Strong Interest Inventory
Goals, Needs, Motives	Goal: "The end state toward which a human is striving" Motive:"physiological or psychological state of arousal that directs an organism's energies toward a goal". What individuals aim to achieve or experience. Examples include need for power, need for affiliation, and need for achievement. Note that many consider need for achievement as an aspect of personality.	Thematic Apperception Test (TAT), need for achievement questionnaires

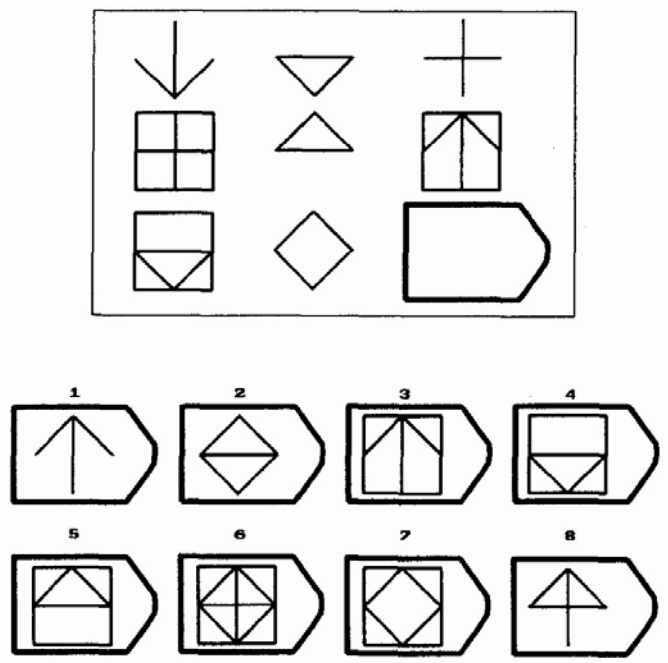

Figure 1

Problem similar to the Raven's Progressive Matrices test items

Note: The bottom right entry of this 3x3 matrix of figures is missing and must be selected from among 8 alternatives. Looking across the rows and down the columns, the test taker attempts to determine the underlying pattern and then pick the appropriate missing piece. The correct answer to this problem is 5. Figure taken from Carpenter, Just, and Shell (1990), used with permission of the publisher, copyright American Psychological Association.

Measurement Error Can Create the Illusion of Multiple Factors when Only One is Operative

If some outcome Y_j is predicted by f_k, and there are multiple mismeasured proxies for f_k, those proxies will be predictive for Y_j even though only one factor generates the outcome. Thus, if the following relationship holds between Y_j and f_k, where U_j is statistically independent of f_k,

$$Y_j = \alpha + \beta f_k + U_j,$$

and we use N Q-adjusted proxies for f_k

$$\widetilde{M}_k^n = M_k^n - \mu_k^n(Q) = \lambda_k^n f_k + \varepsilon_k^n$$

where ε_k^n is independent of f_k, has mean zero and variance $\sigma^2_{\varepsilon_k^n}$, where we allow the means of the measures to depend on Q $(\mu_k^n(Q))$, we obtain an equation

$$Y_j = \widetilde{\alpha} + \sum_{n=1}^{N} \gamma_n \widetilde{M}_k^n + \widetilde{U}_j,$$

where $\widetilde{U}_j = \beta f_k + U_j$ and where the true values of γ_n are all zero, because the test scores do not determine Y_j but instead f_k determines it unless $\beta = 0$. Straightforward calculations show that under general conditions, if one arrays the γ_n in a vector of length N, γ^N, and the Q-adjusted test scores in a vector of length N, denoted $\widetilde{M}$, the OLS estimator

$$\hat{\gamma}^N = \left(\mathrm{Cov}\left(\widetilde{M}, \widetilde{M}\right)\right)^{-1} \mathrm{Cov}\left(\widetilde{M}, Y_n\right)$$

converges in large samples to

$$\text{plim}\ \hat{\gamma}^N = \beta\sigma^2_{f_k}\begin{pmatrix} \sigma^2_{\varepsilon^1_k} + \left(\lambda^1_k\right)^2\sigma^2_{f_k} & \lambda^1_k\lambda^2_k\sigma^2_{f_k} & \cdots & \lambda^1_k\lambda^N_k\sigma^2_{f_k} \\ \lambda^1_k\lambda^2_k\sigma^2_{f_k} & \sigma^2_{\varepsilon^2_k} + \left(\lambda^2_k\right)^2\sigma^2_{f_k} & \cdots & \vdots \\ \vdots & & \ddots & \\ \lambda^1_k\lambda^L_k\sigma^2_{f_k} & \cdots & & \sigma^2_{\varepsilon^N_k} + \left(\lambda^N_k\right)^2\sigma^2_{f_k} \end{pmatrix}^{-1}\begin{pmatrix} \lambda^1_k \\ \vdots \\ \lambda^k_N \end{pmatrix}.$$

Assuming $\sigma^2_{f_k} > 0$, $\beta \neq 0$ and $\sigma^2_{\varepsilon^n_k} > 0$, for all $n = 1, \ldots, N$, *any* error-ridden predictor of f_k will be statistically significant in a large enough sample. Using a purely predictive criterion to determine personality traits produces a proliferation of "significant" predictors for outcome Y_j, as is found in the psychological studies that we survey in the text. Cunha and Heckman (this issue) show that estimated measurement errors in both cognitive and noncognitive tests are important so that the problem of proxy proliferation using a predictive criterion is serious. Under such a criterion, many "significant" predictors of an outcome can be found that are all proxies for a single latent construct.

If, in addition to these considerations, the measures fail discriminant validity, the predictors for one outcome may proxy both f_k and $f_{k'}$ $(k \neq k')$ if f_k and $f_{k'}$ are correlated. We present evidence in the text, Section III, that IQ tests proxy both cognitive and personality factors. A purely predictive criterion fails to distinguish predictors for clusters associated with the f_k from predictors for clusters proxying the $f_{k'}$. Thus, items in one cluster can be predictive of outcomes more properly allocated to another cluster.

Accounting for Reverse Causality

A test score may predict an outcome because the outcome affects the test score. Hansen, Heckman, and Mullen (2004) analyze a model in which, in the previous representation, the outcome being related to cluster (factor) *k*, say Y_j, is an element of *Q*

and determines $\mu_k^n(Q)$ and $\lambda_k^n(Q)$. In addition, they allow (factor) f_k to be a determinant of Y_j. They establish conditions under which it is possible to identify *causal* effects of f_k on Y_j when the proxies for f_k suffer from the problem of reverse causality because the Q in $\lambda_k^n(Q)$ and $\mu_k^n(Q)$ may include Y_j among its components. They establish that tests of cognitive ability (e.g., AFQT) are substantially affected by schooling levels at the date the test is taken.

To understand how their method works at an intuitive level, consider the effect of schooling on measured test scores. Schooling attainment likely depends on true or "latent" ability, f_k. At the same time, the measured test score depends on schooling attained so it affects $\mu_k^n(Q)$ or $\lambda_k^n(Q)$ or both. Hansen, Heckman, and Mullen (2004) assume access to longitudinal data that randomly sample the population. Included in the sample are adolescents. At the time the adolescents are given the test, persons who eventually attain the same schooling level are at different grade levels at the date of the test because the longitudinal sample includes people of different ages and schooling levels. From the longitudinal data we can determine final schooling levels. Final schooling levels are assumed to depend on latent ability f_k. Conditional on the final schooling level attained, schooling levels at the date of the test are random with respect to f_k because the sampling rule is random across ages at a point in time. One can identify the causal effect of schooling on test scores from the effect of variation in the years of education attained at the date of test on test scores for persons who attain the same final schooling level. See Hansen, Heckman, and Mullen (2004) for additional details on this method and alternative identification strategies. The basic idea of their procedure is to

model the dependence between Q and f_k and to solve the problem of reverse causality using this model. Heckman, Stixrud and Urzua (2006) develop this method further. Cunha and Heckman (2007) and Cunha, Heckman and Schennach (2006) extend this procedure to allow f_k to evolve over time through investment and experience.

a) Personality

a1. "BIG FIVE":

The literature on personality psychology widely adopts "the big five" as a taxonomy for describing one's personality traits.
The idea is that there are five big dimensions over which personality can be studied. These dimensions are openness to experience, conscientiousness, neuroticism, agreeableness and extraversion.
Each dimension is then subdivided in lower level traits called "facets". While there is a relatively broad consensus over the big five, there is still a wide disagreement over which facets correspond to each dimension. In the present scheme, we propose one of the possible lower order structure.

Measures for the big five:

- Big Five Inventory, 44 items questionnaire at page 70 of John O., Srivastava S., (1999): "The Big Five Traits Taxonomy: History, Measurement, and Theoretical Perspectives": http://www.uoregon.edu/~sanjay/pubs/bigfive.pdf
- NEO-PI-R (Costa, McCrae, 1992), 240 items. It measures not only the Big Five, but also six "facets" of each of the Big Five. Commercial product not publicly available. See http://www3.parinc.com/products/product.aspx?Productid=NEO-PI-R
- NEO FFI, 60 items only measuring the big five. Also not publicly available. http://www3.parinc.com/products/product.aspx?Productid=NEO-SS_PIR-FFI

For a general introductory literature on the "big five":

- Costa P., McCrae R. (1999), "A five factors model of personality", Handbook of Personality, Theory and research, Guilford Press, New York.
- Digman J., (1990) "Personality Structure: Emergency of the Five factor model", Annual Review of Psychology 41, 417-440
- Goldberg L.R., (1990), "An alternative description of personality: the big five factor structure", Journal of Personality, 59(6), 1216-1229
- John O., Srivastava S., (1999), "The big five trait taxonomy: history, measurement and Theoretical Perspectives", 102-139 in "Handbook of personality: Theory and research", Guilford Press, New York.
- John O., (1989) "Towards a taxonomy of Personality Descriptors", in Buss and Cantor Eds, Personality Psychology: Recent trends and Emerging Directions", 261-271, Springer, NY.
- John O., Goldber L.R., (1991)" Is there a level of personality description?", Journal of Personality and Social Psychology 60, 348-361
- Srivastava, S. (2006). Measuring the Big Five Personality Factors. Retrieved from http://www.uoregon.edu/~sanjay/bigfive.html

For a discussion of facets:

- Costa, McCrae,Dye,(1992). "Facet scales for agreeableness and conscientiousness: A revision of the NEO Personality Inventory". Personality and Individual Differences, 12, 887-898.
- Costa, McCrae (1995): "Domains and facets: Hierarchical Personality Assessment using the revised NEO PI", Journal of Personality Assessment 64, 21-50

For further readings on the links between big five and smoking, crime, scholastic achievement and labor market outcomes.:

1) on smoking and alcohol use:

- T. Trull , C. Waudby, K. Sher K. (2004): " Alcohol, Tobacco and Drug use disorders and personality disorder symptoms" Experimental and Clinical Psychopharmacology 12 (1), 65-75; for a review.

- Zuckermann M., (1993) "Behavioral expression and biosocial bases of sensation seeking" New York, Cambridge University Press

2) on crime

- Gottfredson and Hirschi 1990, " A General Theory of Crime", Stanford, CA: Stanford University Press; on relationship between self control and crime
- Schaeffer C., Petras H., Ialongo N., Poduscka J., Kellman S., (2003), "Modeling Growth in Boys' Aggressive Behavior Across Elementary School: Links to Later Criminal Involvement, Conduct Disorder and Antisocial Personality Disorder" Developmental Psychology 39 (6): 1020-1035; on relationship between aggression and crime

3) on scholastic achievement

- Borghans L., Meijers H. and Ter Weel B., (2006), "The role of non cognitive skills in explaining non cognitive test scores" Maastricht University working paper, Maastricht, the Netherlands.
- Duckworth A., Seligman M.(2005)," Self Discipline outdoes IQ in predicting Academic Performance in Adolescents" Psychological Science 16, 934-944; on self control and scholastic achievement
- Noftle and Robins, in press. I can't find it!
- Wolfe R. and Johnson S., (1995), "Personality as a Prediction of College Performance", Educational and Psychological Measurement, 55 (2), 177-185

4) on labor market performance

- Barrick, Mount, (1991) " The big five personality dimensions and job performance", Personnel Psychology, Blackwell Synergy.
- Roberts B., Wood D., Smith J.(2005) "Evaluating Five Factor Theory and Social Investment Perspectives on Personality Trait Development", Journal of Research on Personality 39: 166-184
- Barrick, Higgins, Murray, Chad, Judge, Thoresen (1999) "The Big Five Personality Traits, General Mental Ability and Career Success across the Life Span", Personnel Psychology, 52
  Roberts, B. W., & Robins, R. W. (2000). Broad dispositions, broad aspirations: The intersection of the Big Five dimensions and major life goals. Personality and Social Psychology Bulletin, 26, 1284-1296.
- Roberts, B. W., & Robins, R. W. (2004). A longitudinal study of person-environment fit and personality development". Journal of Personality, 72, 89-110.

DOMAINS OF THE BIG FIVE:

1. Openness to experience

"A dimension of the Big Five personality model that refers to individual differences in the tendency to be open to new aesthetic, cultural, or intellectual experiences." (APA Dictionary)

It is the Big Five domain that correlates most with IQ (r about .3). It is also called Intellect. Includes facets such as open-mindedness, creativity, appreciation of arts and music.

For its correlation with openness to experience, authors include into this category also J. Cacioppo's **need for cognition** concept: an individual's tendency to engage in and enjoy effortful cognitive endeavours. For a **measure of need for cognition** see the 18 items questionnaire at Cacioppo, Kao, Petty (1984), - http://www.leaonline.com/doi/pdfplus/10.1207/s15327752jpa4803_13.

Another measure related to openness to experience is the **TIE**, Typical Intellectual Engagement (see Ackerloff and Goff, 1992, 1994)

For readings on Openness to Experience:

- Cacioppo, Kao, Petty, (1984), "An efficient assessment for need for cognition", Journal of Personality Assessment, 48 (3) http://www.leaonline.com/doi/pdfplus/10.1207/s15327752jpa4803_13
- Elias, Loomis (2002) : Utilizing Need for Cognition and Perceived Self-Efficacy to Predict Academic Performance, Journal of Applied Social Psychology 32 (8), 1687–1702.
- Goff, Ackerman, (1992), "*Typical Intellectual Engagement* (TIE) measure", Journal of Educational Psychology 84(4), December 1992, 537–552

2. Conscientiousness

"The tendency to be organized, responsible, and hardworking, construed as one end of a dimension of individual differences (conscientiousness vs. lack of direction) in the Big Five personality model." (APA Dictionary)

Conscientiousness is the Big Five domain that best predicts work and health outcomes.

Most of the work on conscientiousness is done by Brent Roberts. His website link below is a good source for further readings.

Two well studied facets empirically related to conscientiousness are **need for achievement** and **delay for gratification.**

- *Need for achievement* is defined as "A strong desire to accomplish goals and attain a high standard of performance and personal fulfillment. People with high need for achievement undertake tasks in which there is a reasonable probability of success and avoid tasks that are too easy or too difficult"
- while *Delay for gratification* is the ability of foregoing immediate reward in order to obtain a larger or more desirable reward in the future" (APA Dictionary)

The "Marshmallow test" (Mischel 1989) was the first study of the relationship between delayed gratifications and outcomes later in life. See literature below. There is no single measure for delay of gratification.

As for need for achievement, it is usually measured by McClelland N-Ach Tematic Apperception Test (TAT), a projective test that however has come under serious critique from mainstream psychology.

For readings on Conscientiousness

- **Brent Roberts** papers on conscientiousness are available at his website,http://www.psych.uiuc.edu/~broberts/Brent%20W%20Roberts%20Research%20Interests.htm
- **Need for Achievement**:
  - McClelland, D.C. (1961) The achieving society. Princeton: Van Nostrand.
  - McClelland, D. C., Atkinson, J. W., Clark, R. A., & Lowell, E. L. (1958). A scoring manual for the achievement motive; in J. W. Atkinson (Ed.), Motives in Fantasy, Action and Society. New York: Van Nostrand.
  - Costa and McCrae, (1992) " NEO PI-R professional manual". Odessa, FL: Psychological Assessment Resources, Inc.
- **Delay of Gratification:**
  - Mischel, Shoda, Rodriguez,. (1989). "Delay of gratification in children". *Science, 244,* 933-938.
  - Funder, Block (1989) "The role of Ego-Control, Ego-Resiliency and IQ Delay of Gratification in Adolescence". Journal of Personality and Social Psychology, 57(6), 1041–1050. A delay gratification experiment with 14 years old adolescent, evidence that delay behaviour is related with IQ.
- **Self Control**:
  - Roy Baumesteir at http://www.psy.fsu.edu/~baumeistertice/

3. Neuroticism

Neuroticism is "characterized by a chronic level of emotional instability and proneness to psychological distress." (APA Dictionary)

It describes the tendency to feel negative emotions, such as anxiety, fear, sadness, and hostility, particularly when under stress.

Facets empirically loading on neuroticism are **self efficacy and locus of control**. Although some literature considers these measures as independent traits of personality, they are much correlated with each other (with a correlation of about r=.6), as they both refer to the belief to have outcomes under control. Perceived *Self Efficacy* (Bandura, A.) is the "Subjective perception of own capability of performance or ability to attain results". Self Efficacy is case dependent (one can have highs elf efficacy in one field but low in another). It is emphasized that self efficacy is different from ability. For example, some studies have documented that, given ability, girls have lower measure of self efficacy than boys (Pajares, 1996, among others). *Locus of Control* is the "perception of how much control individuals have over conditions of their lives".

Locus of Control can be *internal* or *external*. If internal, the individual attributes events to his own control: success or insuccess is a consequence of his or her actions. If external, the individual believes instead that outcomes are a consequence of good or bad luck.

Measures for perceived self efficacy and locus of control:

Perceived Self efficacy:

Bandura does not endorse and trait specific scales, but generalized self efficacy scales can be found into the "Self Efficacy Measures" paragraph of the website on self efficacy:

http://www.des.emory.edu/mfp/self-efficacy.html

Locus of Control:

Rotter has a 29 items questionnaire to measure locus of control, available at http://wilderdom.com/psychology/loc/RotterLOC29.html
For a measure of optimism: Seligman M., Abramson L., Semmel A., von Baeyer C., Peterson C.: "Attributional Style Questionnaire: description and assessment", Cognitive Therapy 6(3), 287-299. http://www.springerlink.com.proxy.uchicago.edu/content/t372377276jp6636/?p=aded4ffddd064fe8be83883d5bb91b78&pi=4

For reading on the facets of self efficacy and locus of control:

- Bandura A., 1977, "Self-efficacy: Toward a unifying theory of behavioral change" Psychological Review, 84 (2), 191-215
- All of Bandura' publications can be found in his website: http://www.des.emory.edu/mfp/banpubs.html
- Website on self efficacy: http://www.des.emory.edu/mfp/self-efficacy.html
- Rotter, J.B. (1966). "Generalized expectancies of internal versus external control of reinforcements".
- Judge, Bono, Thoresen (2002), "Are Measures of Self-Esteem, Neuroticism, Locus of Control, and Generalized Self-Efficacy Indicators of a Common Core Construct?" Journal of Personality and Social Psychology, 83(3)

4. Agreeableness

"The tendency to act in a cooperative, unselfish manner, construed as one end of a dimension of individual differences (agreeableness vs. disagreeableness) in the Big Five personality model." This dimension includes facets such as trust and compliance. (APA Dictionary)

5. Extraversion

"An orientation of one's interests and energies toward the outer world of people and things rather than the inner world of subjective experience. Extraversion is a broad personality trait and, like introversion, exists on a continuum of attitudes and behaviors. Extroverts are relatively more outgoing, gregarious, sociable, and openly expressive." (APA dictionary)
Roberts (2006) suggests that there are two aspects of Extraversion: Social Dominance and Social Vitality.

- **Social Dominance**: describes dominance, independent, and self-confidence, especially in social settings. See NEO PI for a measure.
- **Social Vitality**: describes sociability, positive effect, and gregariousness. See NEO PI and CPI (California Psychological Inventory) sociability scale for a measure.

A third facet is empirically related to both extraversion and conscientiousness:

- **Sensation Seeking**: "the tendency to search out and engage in thrilling activities as a method of increasing stimulation and arousal. It takes the form of engaging in highly stimulating activities accompanied by a perception of danger" (APA Dictionary). Zuckermann is the main author for sensation seeking: he is also the creator of a sensation seeking scale:
- Zuckerman (1979) "Sensation seeking: beyond the optimal level of arousal". Hillsdale, NJ:Erlbaum. The scale is online at http://www.rta.nsw.gov.au/licensing/tests/driverqualificationtest/sensationseekingscale/

Zuckermann has recently published a book on sensation seeking and risky behaviour:

- Zuckermann M. (2006) "Sensation Seeking and Risky Behavior", Washington, DC : American Psychological Association.

a2. POSITIVE AFFECT, WELL BEING AND HAPPINESS

"Positive effect is the internal feeling state that occurs when a goal has been attained, a source if threat has been avoided or the individual is satisfied with the present state of affairs"
Positive affect includes emotions like joy, contentment, and pride. **Negative affect**, which is only moderately inversely correlated with positive emotions, includes fear, anxiety, sadness, etc. **Life satisfaction** (Diener, Seligman) is a cognitive, not affective, appraisal of the quality of one's life. **Well-being** is the presence of positive effect, the absence of negative and positive life satisfaction.

Measures:

- SWLS, "Satisfaction with life scale", (Ed Diener). A 5 questions cognitive, not affective, appraisal of the quality of one's life: http://www.psych.uiuc.edu/~ediener/hottopic/hottopic.html
- PANAS, "Positive and Negative Affect Schedule" (Watson, Clark, & Tellegen) for positive and negative effect. For presentation and for example of PANAS see: http://www.psychology.uiowa.edu/Faculty/Watson/PANAS-X.pdf

Literature:

- Websites, with links to publications:
  http://www.authentichappiness.sas.upenn.edu/
  http://www.centreforconfidence.co.uk/pp/contributors.php
  http://www.enpp.org/
- Snyder, C. R., Lopez, S. J. (Eds.). Handbook of positive psychology. New York: Oxford University Press.
- Feldman Barrett L., Russell J., (1999), "The Structure of Current Affect: Controversies and Emerging Consensus", Current Directions in Psychological Science 8 (1), 10–14.
- Feldman Barrett L., Mesquita B., Ochsner K., Gross J., (2007) "The Experience of Emotion" *Annual Review of Psychology* **58**:1, 373

a3. SELF ESTEEM

"The degree to which the qualities and characteristics contained in one's self concept are perceived to be positive"

Self-esteem is a positive or negative orientation toward oneself: an overall evaluation of one's worth or value

It is a construct that enjoyed tremendous popularity in the 1970ss but since has been considered epiphenomenal not causal. A minority of psychologists consider positive and negative evaluations of the self to be the sixth and seventh factors of personality.

It is measured with Self Esteem Rosemberg Scale. Link at:
http://www.atkinson.yorku.ca/~psyctest/rosenbrg.pdf

Literature:

- Baumeister, Campbell, Krueger, Vohs, (2003). "Does High Self-esteem Cause Better Performance, Interpersonal Success, Happiness, or Healthier Lifestyles?" Psychological Science in the Public Interest, 4, 1-44. http://www.psy.fsu.edu/~baumeistertice/baumeisteretal2003.pdf
- Robins R., Trzesniewski K., Moffit T., Caspi A., Donnellan B., Poulton R., (2006): "Low Self Esteem During Adolescence predicts poor health, criminal behaviour and limited economic prospects during adulthood" Developmental Psychology 42(2); in a different perspective than Bauemeister, Robins and Trzesniewski work show evidence that self esteem does matter.

a4. TEMPERAMENT (childhood)

"Basic foundation of personality, usually assumed to be biologically determined and present early in life. It Includes characteristics such as energy level, emotional responsiveness, response tempo and willingness to explore" (APA Dictionary)

There are fewer temperament variables than personality traits because these individual differences are less salient and stable in children than in adults.

After the pioneering work of Thomas and Chess (1977), different taxonomies have been proposed in the literature. A recent and very comprehensive is the one in Shiner R. And Caspi A. (2003) , which individuates four main domains in child personality:

1)Extraversion/Positive Emotionality, with lower order traits of social inhibition, sociability, dominance and activity level. 2) **Neuroticism/Negative Emotionality** with lower traits of anxious distress (tapping fear and anxiety) and irritable distress (tapping anger and irritability).
3)**Conscientiousness/Constraints**, with lower traits of attention, inhibitory control and achievement motivation. 4)**Agreeableness**

Little is still known about how these early emerging differences evolve into personality traits.

Measures:

There are different typologies of measures for children personality. It should be emphasized that all of them have biases, and that therefore is always good to use more than one.
The typologies are, as indicated in Shiner and Caspi (2003):

1) Naturalistic observations (infants): Naturalistic observations are based on the direct observation of the child's behavior in naturalistic settings, such as the child's home environment. In this procedure, observers typically watch the child for periods of several hours and then use coding procedures for observing a variety of specific behavioral tendencies.
The most used behavioural code is Eaton, Enns and Presse (1987), Journal of Psychoeducational Assessment 3, 273-280. The code is available on the article. Some rate the child's temperament across a variety of dimensions after the observation is completed, using one of the standard temperament questionnaires

2) ***Questionnaires*** completed by parents or teachers (infants and children):
These questionnaires mainly study temperament along the lines of the "big five"

- **IBQ** (Infant Behavior Questionnaire): M. Rothbart
- **CBQ** (Children behaviour Questionnaire): Rothbart M, Ahadi S., Hershey K., Fisher P., (2001) " Child Development 72 (5), 1394-1408. The CBQ detected 15 primary temperament questionnaires, factor analysis individuates **3 main factors**: 1) extraversion/Surgency 2) Negative Affectivity 3) Effortful Control. In appendix A of the paper there are scale definitions and sample items for CBQ. http://www.bowdoin.edu/~sputnam/rothbart-temperament-questionnaires/
- **ICID**: Inventory Child Individual Differences: Halverson C., Havill V., Deal J. (2003):"Personality Structure as derived from parental ratings of free descriptions of children: The Inventory of Child Individual Differences" , Journal of Personality 71 (3). Representative items of ICID are in the "Appendix A" of the article.
- **(HiPIC):** Mervielde I., De Fruyt F. (1999): "Construction of the hierarchical personality inventory for Children" Hierarchical Personality Inventory for Children in Mervielde, Deary, DeFruyt,Ostendorf, Personality Psychology in Europe:Proceedings of the Eight European Conference on Personality, 107-127, Tillburg U Press.Couldn't find the article on line.
Principal component analyses at the item level indicated that, for each age level, the first five principal components tended to group items according to the Big Five. five domains: Conscientiousness, Benevolence, Extraversion, Imagination, and Emotional Stability.
- **Dutch BLIK**: Slotboom, A., & Elphick, E. (1997). Parents' perceptions of child personality: Developmental precursors of the Big Five. Alblasserdam, The Netherlands:
Haveka b. v.
- **Goldberg (2001):**"Analyses of Digman's child-personality data: Derivation of Big Five factor scores from each of six samples. Journal of Personality, 69, 709–744.Working on Digman data on Hawaiian children shows that the big five are derived as dimensions of personality of children.

3) ***Q-Sets*** (children) : an informant (parents, teachers, observers or clinicians) sorts a set of cards into a quasi normal distribution based on how well each item describes the child. Also constructed along the "big five" taxonomy.
The main two Q-Sets are:

- **California Child Q-Set**: Block J., Block JH.(1969/1980): "The California Child Q-Set" Palo Alto, CA: Consulting Psychologists Press. Not publicly available. This Q-set consists of 100 cards; on each was a descriptive statement which parents rank-ordered into nine categories ranging from "most descriptive" to
"least descriptive" of their child.
- **Common Language Q-set**: Caspi A., Block J., Block JH., Klopp B., Lynam D., Moffit T., Stouthamer-Loeber M. (1992): "A 'common language' version of the California Child Q set for personality assessment" Psychological Assessment 4, 512-523. Represents the CCQset in a simpler language and focuses especially on antisocial behavior. An example of the cards can be found at page. 520 of the article.

4) ***Laboratory tasks*** (children):
- Laboratory procedures (LAB-TAB: Goldsmith, Rothbart, 1993): contains measures such as Stranger Approach, Modified Peek-a-Boogame, and Puppet Game. In the lab, 20 episodes or games are used to elicit reactions of frustration (anger), wariness (fear), interest, pleasure, and activity level.

- Preschool Lab-TAB (Goldsmith, Reilly, 1995):
  Information on both at:
  http://psych.wisc.edu/goldsmith/Researchers/GEO/lab_TAB.htm
  The LAB-TAB manual can be downloaded at:
  http://psych.wisc.edu/goldsmith/Researchers/GEO/Lab_TAB_download_info.htm
  Some of the studies using LAB-TAB:
  - Goldsmith, H. H., & Rieser-Danner, L. (1990). Assessing early temperament. In C. R. Reynolds & R. Kamphaus (Eds.), Handbook of psychological and educational assessment of children. (vol. 2) Personality, behavior, and context. (pp. 345-378). New York: Guilford Press.
  - Goldsmith, H., Rieser-Danner, L., & Briggs, S. (1991). Evaluating convergent and discriminant validity of temperament questionnaires for preschoolers, toddlers, and infants. Developmental Psychology, 27, No. 4, 566-579.

5) ***Peer Nominations*** (adolescents): the peer group nominates who is the best described by a particular item.

- Mervielde I., Defruyt F. (2000):"The Big Five Personality Factors as a model for the structure of children's peer nominations" European Journal of Personality 14, 91-106
- Masten A., Morison P., Pellegrini D., (1985): "A revised class method of peer assessment", Developmental Psychology 21, 523-533

6) ***Self Reports*** (adolescents, only recently also children).

- Vance H., Pumariega A. (2001):"Clinical Assessment of children and adolescents behaviour", New York: Wiley.
- Eder R.(1990): "Uncovering young children's psychological selves: Individual and developmental differences" child Development 61, 849-863. New method for understanding children individual differences through self reports with a Puppet interview. The children are 4-8 years old, and the study shows consistency of traits after one month.

Literature:

- Crespi A., Shiner R. (2003) "Personality Differences in childhood and adolescence: measurement, development and consequences", Journal of Psychology and Psychiatry 44(1), 2-32
- Shiner, R. (2006), "Temperament and personality in childhood". In D. K. Mroczek & T. Little (Eds.), Handbook of personality development (pp. 213-230). Mahwah, NJ, Erlbaum.
- Shiner, R. (Personality Differences in Childhood and adolescence: measurement, development and consequences", Journal of Child Psychology and Psychiatry, 44 (1), 2003, p.2-32
- Shiner R., Masten A., Roberts J.(2003). "Childhood personality foreshadows adult personality and life outcomes two decades later". Journal of Personality, 71, 1145-1170. Special issue: Personality development.
- Thomas A., Chess S. (1977): "Temperament and Development" NY: Brunner/Mazel
  Jerry Kagan:
- Kagan J., 1988, "Biological basis of childhood shyness", Science, 240 (4849) , 167 - 171
  Mary Rothbart:
- Rothbart, M. K. (1981). Measurement of temperament in infancy. Child Development, 52, 569-578.
- Rothbart, M, Bates, J (1998)"Temperament", in Handbook of child psychology: Vol 3, Social, emotional and personality development, Damon Eisemberg Eds,

a5. PSYCHOPATHOLOGY

A broad category comprising dysfunctional patterns of thought, feeling, or behavior. Most disorders are included in the DSM-IV manual. Axis I disorders (e.g., depression) are more intense and episodic/discreet, whereas Axis II disorders (i.e., personality disorders) are more tonic and enduring.

Measure:

For depression, the main scale is the Beck one. It indicates the acuteness of depression, but it is only for adults.

- Beck, A., (1961) "An inventory for measuring depression ", Arch Gen Psychiatry, Archives of General Psychiatry 4, 561-571
  A version for kids is Achenbach Child Behavior Checklist:

- http://www.aseba.org/products/forms.html
  Achenbach, T. M. (1991). Manual for the Child Behavior Check List/4–18 and 1991 Profile. Burlington: University of Vermont.
- Another measure of Psychopathology is the Child Depression Index, which can be found in PSID.

Literature:

- Seligman, M.E.P., Walker, E., & Rosenhan, D.L. (2001). Abnormal psychology. (4th ed.) New York: W.W. Norton. Manual in Abnormal Psychology.
- "Diagnostic and Statistical Manual of Mental Disorders", (1995), American Psychiatric Association Pub, Inc

b) Abilities

b1. IQ AND "G" FACTOR

"Ability to reason, solve problems, comprehend abstract associations, learn from experience and think abstractly."

One dominant factor "g" ("general factor") refers to the first factor extracted from a factor analysis of cognitive tasks, which many researchers consider to represent general (vs. specific) intelligence."It represents individuals' abilities to perceive relationships and to derive conclusions from them. It is the basic ability that underlies the performance of different intellectual tasks"

IQ specifically refers to one's intelligence relative to one's age group (especially for children)

Main authors: Arthur Jensen;; Nathan Brody

Measures:

WISC: Wechsler Intelligence Scale for Children

- Wechsler, D. (1974). Wechsler Intelligence Scale for Children-Revised (WISC-R). New York: The Psychological Corporation.

WAIS

Raven's Progressive Matrices

ASVAB

Literature:

- Neisser U., Boodoo G., Bouchard T., Boykin W., Brody N., Ceci S., Halpern D., Loehlin J., Perloff R., Sternberg R., Urbina S., (1996): "Intelligence: Knowns and Unknowns" American Psychologist 51(2), 77-101
- Gottfredson L., (1997) "Why "g" matters: the complexity of everyday life", Intelligence.
- Brody, N., (1992). *Intelligence*. Boston: Academic Press

b2. SPECIFIC MENTAL ABILITIES

"Abilities as measured by tests of an individual in areas of spatial visualization, perceptual need, number facility, verbal comprehension, word fluency, memory, inductive reasoning and so forth"

An umbrella category for lower-level mental abilities, including math, verbal, and spatial abilities, as well as even more specific mental capacities. Measured by subtest scores on IQ tests

- Lubinski D. (2004), "Introduction to the special section on cognitive abilities: 100 years after
- Spearman's (1904) "'General intelligence,' objectively determined and measured." J Personality and Social Psychology 86, 96–111

b3. CREATIVITY

Ability to generate novel ideas and behaviors that solve problems.

Measures:

One **measure** for creativity is Gough 1979 "Creative Personality Scale":

- Gough, H. G. (1979). "A creative personality scale for the Adjective Check List". Journal of Personality and Social Psychology, 37,1398-1405. Link to the scale:
  http://www.indiana.edu/~bobweb/Bob/Gough_Scale.doc

Literature:

- Eysenck, H.J. (1993): Creativity and Personality: Suggestions for a Theory, Psychological Inquiry,
- Eysenck, H.J. (1994), "The measurement of creativity. In Dimensions of Creativity, M.A. Boden.
- Cziksentmihalyi, M. (1996) "Creativity, Flow and the Psychology of Discovery and Invention", London: Harper Collins

- Simonton, D.(1984) , "Genius, Creativity and Leadership: Historiometric inquiries", Harvard U Press.
- Simonton, D. (1997) "Genius and Creativity: selected papers" Ablex Ed.

b4. EXECUTIVE FUNCTION

"Higher level cognitive processes that organize and order behavior, including logic and reasoning, abstract thinking, problem solving, planning and carrying out and terminating goal directed behavior" Broad set of higher-level cognitive capacities attributed to the prefrontal cortex, often involving the coordination and management of lower-level processes" (APA Dictionary)

Executive functions are unrelated to "g", but determine more basic abilities that can vary considerably among the population and that can be important in the process of acquiring cognitive skills: for example, Kim, Whyte, Vaccaro et al. show how executive functions may relate to attention, while Carpenter shows the relationship with working memory.

Executive functions are usually measured by neuropsychology tasks (e.g., go/no-go, Stroop, Continuous Performance Task)

Literature:

- Miller E, Cohen J. (2001) "An integrative theory of prefrontal cortex function". Annual Review of Neuroscience 24, 167-202
- Miller, E.K. (2000) The prefrontal cortex and cognitive control. *Nature Reviews Neuroscience*, 1:59-65
- Miller Lab, with links to publications: http://www.millerlab.org
- Blair C., Razza R.(2007), "Relating Effortful Control, Executive Function, and False Belief Understanding to Emerging Math and Literacy Ability in Kindergarten" Child Development 78 (2), 647–663.
- Carpenter P., (2000): "Working memory and executive function", Current Opinion in Neurobiology**,** 10, 195–19

b6. EMOTIONAL INTELLIGENCE

"Ability to process emotional information and use it in reasoning and other cognitive activities. According to Mayer and Slovey 1997 model It comprises four abilities: to perceive and appraise emotions accurately, to access and evoke emotions when they facilitate cognition, to comprehend emotional language and make use of emotional information, and to regulate one's own and others' emotions to promote growth and well-being" Ability to perceive emotion, to integrate it in thought, to understand it and to manage it (Mayer)" (APA Dictionary)

Emotion is here considered as a feeling state that conveys information about relationships (Mayer), and intelligence refers to the ability of reason validly about this information.

Measures:

The most reliable measure is considered to be the MSCEIT test, but it is not publicly available.

The validity of self reported judgments is still highly debated

Literature:

- John Mayer website for emotional intelligence, with links to all relevant papers: http://www.unh.edu/emotional_intelligence/.

  See also:
- Mayer J., Slovey P., (1997) "What is emotional intelligence? In P. Salovey y D. Sluyter Eds., Emotional development and EI: Educational implications New York: Basic Books
- Mayer, J. Caruso, D., Salovey, P. (1999)."Emotional intelligence meets traditional standards for an intelligence". Intelligence, 27, 267-298.
- Mayer, J. D., Salovey, P., Caruso, D. R. (2000). Models of emotional intelligence. In R. J. Sternberg (Ed.). Handbook of Intelligence (pp. 396-420). Cambridge, England: Cambridge University Press.
- Roberts R., Matthews G., Zeidner M., (2001), "Does Emotional Intelligence meet Traditional Standards for Intelligence? Some New Data and Conclusions" Emotion, 1 (3), 196-231 http://www-users.york.ac.uk/~pjm21/psychometrics/robertsetal2001.pdf
- Roberts R., Matthews G., Zeidner M., (2004) "Emotional Intelligence: Science and Myth", MIT Press, Cambridge, Massachussets.

Goleman D.

Motivation and IQ Summary

Many of these studies used a within-subject design and measured the effect of motivation as the differential between performance with and without incentives. An intriguing possibility for measuring motivation not available at the time of these early studies is offered by Pailing & Segalowitz (2004). A particular error-related ERP (event-related potential) is a metric for the salience or importance of making an error. Subjects who are high in Conscientiousness or low in Neuroticism showed dampened changes in this particular ERP when incentives were given for improved performance.

Table 3. Studies documenting an effect of motivation at the time of test administration and IQ score

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 1 SD 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 .8 SD)	"…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
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	regarded as "at its peak" can significantly alter the level of performance of that behavior." (p. 483)
Clingman & 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 cdtn	Only among low-IQ (<100) subjects was there an effect of the incentive. Contingent reward group scored about .33 SD higher on the Peabody Picture Vocab 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 & 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 cdtns.	Motivation was optimized without giving test-relevant information. Gentle encouragement, easier items after items were missed, etc.	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 standard cdtns. 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 & Zella (1978)	Within and between subjects study of 485 *special education* high school students all took IQ tests, then were randomly assigned to control or incentive groups to retake tests. Subjects were below-average in IQ.	Incentives such as record albums, radios (<$25) given for improvement in test performance	Scores increased by about 17 points. Results were consistent across the Otis-Lennon, WISC-R, and Lorge-Thorndike tests.	"In summary, the promise of individualized incentives on an increase in IQ test performance (as compared with pretest performance) resulted in an approximate 17-point increase in IQ test scores. These increases were equally spread across subtests The incentive condition effects were much less pronounced for students have pretest IQs between 98 and 120 and did not occur for students having pretest IQs between 121 and 140." (p. 225)
Holt & Robbs (1979)	Between and within subjects study of 80 delinquent boys randomly assigned to 3 experimental groups and 1 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 (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 (in preparation)	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

Ayllon, T., & Kelly, K. (1972). Effects of reinforcement on standardized test performance. *Journal of Applied Behavior Analysis. Vol., 5*(4), 477-484.

Breuning, S. E., & Zella, W. F. (1978). Effects of individualized incentives on norm-referenced IQ test performance of high school students in special education classes. *Journal of School Psychology, 16*(3), 220-226.

Clingman, J., & Fowler, R. L. (1976). The effects of primary reward on the I.Q. performance of grade-school children as a function of initial I.Q. level. *Journal of Applied Behavior Analysis, 9*(1), 19-23.

Edlund, C. V. (1972). The effect on the behavior of children, as reflected in the IQ scores, when reinforced after each correct response. *Journal of Applied Behavior Analysis. Vol., 5*(3), 317-319.

Holt, M. M., & Hobbs, T. R. (1979). The effects of token reinforcement, feedback and response cost on standardized test performance. *Behaviour Research and Therapy, 17*(1), 81-83.

Larson, G. E., Saccuzzo, D. P., & Brown, J. (1994). Motivation: Cause or confound in information processing/intelligence correlations? *Acta Psychologica, 85*(1), 25-37.

Pailing, P. E., & Segalowitz, S. J. (2004). The error-related negativity as a state and trait measure: Motivation, personality, and ERPs in response to errors. *Psychophysiology, 41*(1), 84-95.

Zigler, E., & Butterfield, E. C. (1968). Motivational Aspects of Changes in Iq Test Performance of Culturally Deprived Nursery School Children. *Child Development, 39*(1), 1-14.

Ability Bias, Errors in Variables and Sibling Methods

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Econ 312
This draft, May 26, 2006

1 Ability Bias

Consider the model:

$$\log y_{it} = \alpha_0 + \alpha_1 S_i + U_{it}$$

where y_{it} = income, S_i = schooling, and α_0 and α_1 are parameters of interest. What we have omitted from the above specification is unobserved ability, which is captured in the residual term U_{it}. We thus re-write the above as:

$$\log y_{it} = \alpha_0 + \alpha_1 S_i + a_i + \varepsilon_{it}$$

where a_i is ability, $(\varepsilon_{it}, \varepsilon_{i't}) \perp\!\!\!\perp (S_i, S_{i'})$, and we believe that $Cov(a_i, S_i) \neq 0$. Thus, $E(U_{it} \mid S_i) \neq 0$, so that OLS on our original specification gives biased and inconsistent estimates.

1.1 Strategies for Estimation

1. *Use proxies for ability*: Find proxies for ability and include them as regressors. Examples may include: height, weight, etc. The problem with this approach is that proxies may measure ability with error and thus introduce additional bias (see Section 1.3).

2. *Fixed Effect Method*: Find a paired comparison. Examples may include a genetic twin or sibling with similar or identical ability. Consider two individuals i and i':

$$\begin{aligned} \log y_{it} - \log y_{i't} &= (\alpha_0 + \alpha_1 S_i + U_{it}) - (\alpha_0 + \alpha_1 S_{i'} + U_{i't}) \\ &= \alpha_1 (S_i - S_{i'}) + (a_i - a_{i'}) + (\varepsilon_{it} - \varepsilon_{i't}) \end{aligned}$$

Note: if $a_i = a_{i'}$, then *OLS* performed on our fixed effect

estimator is unbiased and consistent. If $a_i \neq a_{i'}$, then we just get a different bias (see Section 1.2). Further, if S_i is measured with error, we may exacerbate the bias in our fixed effect estimator (see Section 1.3).

1.2 OLS vs. Fixed Effect (FE)

In the *OLS* case with ability bias, we have:

$$\text{plim } (\alpha_1^{OLS}) = \alpha_1 + \frac{Cov(a, S)}{Var(S)}$$

(See derivation of Equation (2.2) for more background on the above derivation).

We also impose:

$$\begin{aligned} Var(S) &= Var(S^{'}) \\ Cov(a, S) &= Cov(a', S') \\ Cov(a', S) &= Cov(a, S') \end{aligned}$$

With these assumptions, our fixed effect estimator is given by:

$$\begin{aligned} \text{plim } \alpha_1^{FE} &= \alpha_1 + \frac{Cov\left(S - S', (a - a') + (\varepsilon - \varepsilon')\right)}{Var(S - S')} \\ &= \alpha_1 + \frac{Cov(a, S) - Cov(a', S)}{Var(S) - Cov(S, S')}. \end{aligned}$$

Note that if $Cov(a', S) = 0$, and ability is positively correlated with schooling, then the fixed effect estimator is upward biased.

From the preceding, we see that the fixed effect estimator has more asymptotic bias if:

$$\frac{Cov(a,S) - Cov(a',S)}{Var(S) - Cov(S,S')} > \frac{Cov(a,S)}{Var(S)}$$
$$\Rightarrow \frac{Cov(a,S)}{Var(S)} > \frac{Cov(a',S)}{Cov(S,S')}.$$

1.3 Measurement Error

Say $S^* = S + \nu$, where S^* is observed schooling. Our model now becomes:

$$\log y = \alpha_0 + \alpha_1 S + U = \alpha_0 + \alpha_1 S^* + (a + \varepsilon - \alpha_1 \nu)$$

and the fixed effect estimator gives:

$$\begin{aligned} \log y - \log y' &= (\alpha_0 + \alpha_1 S + U) - (\alpha_0 + \alpha_1 S' + U') \\ &= \alpha_1 (S^* - S^{*'}) + (U - U') + \alpha_1 (\nu' - \nu) \end{aligned}$$

Now we wish to examine which estimator (OLS or fixed effect), has more asymptotic bias given our measurement error problem. For the remaining arguments of this section, we assume:

$$E(\nu \mid S) = E(\nu' \mid S) = E(\nu \mid \nu') = 0$$

so that the OLS estimator gives:

$$
\begin{aligned}
\text{plim } \alpha_1^{OLS} &= \alpha_1 + \frac{Cov(S^*, a + \varepsilon - \alpha_1 \nu)}{Var(S^*)} \\
&= \alpha_1 + \frac{Cov(a, S) - \alpha_1 Var(\nu)}{Var(S) + Var(\nu)}.
\end{aligned}
$$

The fixed effect estimator gives:

$$
\begin{aligned}
\text{plim } \alpha_1^{FE} &= \alpha_1 + \frac{Cov\left(S^* - S^{*'}, (U - U') + \alpha_1(\nu' - \nu)\right)}{Var(S^* - S^{*'})} \\
&= \alpha_1 + \frac{Cov\left((S - S'), (a - a')\right) - \alpha_1 Var(\nu' - \nu)}{Var(S - S') + Var(\nu' - \nu)} \\
&= \alpha_1 + \frac{Cov(a, S) - Cov(a, S') - \alpha_1 Var(\nu)}{Var(S) + Var(\nu) - Cov(S', S)}.
\end{aligned}
$$

Under what conditions will the fixed effect bias be greater? From the above, we know that this will be true if and only if:

$$\frac{Cov(a,S) - Cov(a,S') - \alpha_1 Var(\nu)}{Var(S) + Var(\nu) - Cov(S',S)} > \frac{Cov(a,S) - \alpha_1 Var(\nu)}{Var(S) + Var(\nu)}$$

$$\Rightarrow Cov(a,S')\left(Var(S) + Var(\nu)\right) >$$

$$\left(\alpha_1 Var(\nu) - Cov(a,S)\right) Cov(S',S)$$

$$\Rightarrow \frac{Cov(a,S) - \alpha_1 Var(\nu)}{Var(S) + Var(\nu)} > \frac{Cov(a,S')}{Cov(S',S)}.$$

If this inequality holds, taking differences can actually worsen the fit over *OLS* alone. Intuitively, we see that we have differenced out the true component, S, and compounded our measurement error problem with the fixed effect estimator.

In the special case $a = a'$, the condition is

$$\frac{-\alpha_1 Var(\nu)}{Var(S) + Var(\nu) - Cov(S', S)} > \frac{Cov(a, S) - \alpha_1 Var(\nu)}{Var(S) + Var(\nu)}.$$

2 Errors in Variables

2.1 The Model

Suppose that the equation for earnings is given by:

$$Y_t = X_{1t}\beta_1 + X_{2t}\beta_2 + U_t$$

where $E\left(U_t \mid X_{1t}, X_{2t}\right) = 0 \ \forall \ t, t'$. Also define:

$$X_{1t}^* = X_{1t} + \varepsilon_{1t} \quad \text{and} \quad X_{2t}^* = X_{2t} + \varepsilon_{2t}.$$

Here, X_{1t}^* and X_{2t}^* are observed and measure X_{1t} and X_{2t} with error. We also impose that $X_i \perp\!\!\!\perp \varepsilon_j \; \forall \, i, j$. So, our initial model can be equivalently re-written as:

$$Y_t = X_{1t}^* \beta_1 + X_{2t}^* \beta_2 + (U_t - \varepsilon_{1t}\beta_1 - \varepsilon_{2t}\beta_2).$$

Finally, by assumed independence of X and ε, we write:

$$\Sigma_{x^*} = \Sigma_x + \Sigma_\epsilon.$$

2.2 McCallum's Problem

Question: Is it better for estimation of β_1 to include other variables measured with error? Suppose that X_{1t} is not measured with error, in the sense that $\varepsilon_{1t} = 0$, while X_{2t} is measured with error. In 2.2.1 and 2.2.2 below, we consider both excluding and including X_{2t}, and investigate the asymptotic properties of both cases.

2.2.1 Excluded X_{2t}

The equation for earnings with omitted X_2 is:

$$y = X_1\beta_1 + (U + X_2\beta_2)$$

Therefore, by arguments similar to those in the appendix, we know:

$$\text{plim } \tilde{\beta}_1 = \beta_1 + \frac{\sigma_{12}}{\sigma_{11}}\beta_2. \tag{2.1}$$

Here, σ_{12} is the covariance between the regressors, and σ_{11} is the variance of X_1. Before moving on to a more general model for the inclusion of X_{2t}, let us first consider the classical case for including both variables. Suppose

$$\Sigma_\epsilon = \begin{bmatrix} \sigma_{11}^* & 0 \\ 0 & \sigma_{22}^* \end{bmatrix}, \Sigma_x = \begin{bmatrix} \sigma_{11} & 0 \\ 0 & \sigma_{22} \end{bmatrix}.$$

We know that:

$$\text{plim } \hat{\beta} = \left[I - (\Sigma_{x^*})^{-1} (\Sigma_\epsilon)\right] \beta \tag{2.2}$$

where the coefficient and regressor vectors have been stacked appropriately (see Appendix for derivation). Note that Σ_ϵ represents the variance-covariance matrix of the measurement errors, and Σ_x is the variance-covariance matrix of the regressors. Straightforward computations thus give:

$$\begin{aligned}
&\text{plim } \hat{\beta} \\
&= \left[I - \begin{bmatrix} \sigma_{11} + \sigma_{11}^* & 0 \\ 0 & \sigma_{22} + \sigma_{22}^* \end{bmatrix}^{-1} \begin{bmatrix} \sigma_{11}^* & 0 \\ 0 & \sigma_{22}^* \end{bmatrix} \right] \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} \\
&= \begin{bmatrix} \dfrac{\sigma_{11}}{\sigma_{11} + \sigma_{11}^*} & 0 \\ 0 & \dfrac{\sigma_{22}}{\sigma_{22} + \sigma_{22}^*} \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix}.
\end{aligned}$$

2.2.2 Included X_{2t}

In McCallum's problem we suppose that $\sigma^*_{12} = 0$. Further, as X_{1t} is not measured with error, $\sigma^*_{11} = 0$. Substituting this into equation 2.2 yields:

$$\text{plim } \hat{\beta} = \beta - \begin{bmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{12} & \sigma_{22} + \sigma^*_{22} \end{bmatrix}^{-1} \begin{bmatrix} 0 & 0 \\ 0 & \sigma^*_{22} \end{bmatrix} \beta$$

With a little algebra, the above gives:

$$\begin{aligned} \text{plim } \hat{\beta}_1 &= \beta_1 + \beta_2 \left(\frac{\sigma_{12}}{\sigma_{11}} \right) \left(\frac{\sigma^*_{22}}{\sigma_{22} + \sigma^*_{22} - \dfrac{\sigma^2_{12}}{\sigma_{11}}} \right) \\ &= \beta_1 + \beta_2 \left(\frac{\sigma_{12}}{\sigma_{11}} \right) \left(\frac{\sigma^*_{22}}{\sigma_{22} \left(1 - \rho^2_{12}\right) + \sigma^*_{22}} \right) \end{aligned}$$

where ρ_{12}^2 is simply the correlation coefficient, $\dfrac{\sigma_{12}^2}{\sigma_{11}\sigma_{22}}$. Further, we know that:

$$0 < \rho_{12}^2 < 1$$

so including X_{2t} results in less asymptotic bias (inconsistency). (We get this result by comparing the above with the bias from excluding X_{2t} in section 2.2.1, the result captured in equation (2.1)). So, we have justified the kitchen sink approach. This result generalizes to the multiple regressor case - 1 badly measured variable with k good ones (Econometrica, 1972).

2.3 General Case

In the most general case, we have:

$$\text{plim}\ \hat{\beta} = \beta - (\Sigma_{x^*})^{-1}\,\Sigma_{\varepsilon}\beta$$

$$= \beta - \begin{bmatrix} \sigma_{11} + \sigma_{11}^* & \sigma_{12} + \sigma_{12}^* \\ \sigma_{12} + \sigma_{12}^* & \sigma_{22} + \sigma_{22}^* \end{bmatrix}^{-1} \begin{bmatrix} \sigma_{11}^* & \sigma_{12}^* \\ \sigma_{12}^* & \sigma_{22}^* \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix}.$$

With a little algebra we find:

$$\det(\Sigma_{x^*}) = \sigma_{11}\sigma_{22} + \sigma_{11}\sigma_{22}^* + \sigma_{11}^*\sigma_{22} + \sigma_{11}^*\sigma_{22}^* - \sigma_{12}^{*^2} - 2\sigma_{12}\sigma_{12}^* - \sigma_{12}^2$$

Therefore:

$$\begin{aligned}\operatorname{plim} \hat{\beta} &= \beta - \frac{1}{\det(\Sigma_{x^*})} \begin{bmatrix} \sigma_{22} + \sigma_{22}^* & -(\sigma_{12} + \sigma_{12}^*) \\ -(\sigma_{12} + \sigma_{12}^*) & \sigma_{11} + \sigma_{11}^* \end{bmatrix} \\ &\quad \times \begin{bmatrix} \sigma_{11}^* & \sigma_{12}^* \\ \sigma_{12}^* & \sigma_{22}^* \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix}\end{aligned}$$

Supposing $\sigma_{12}^* = 0$, we get:

$$\det(\tilde{\Sigma}_{x^*}) = \det(\Sigma_{x^*}) \mid_{\sigma_{12}^* = 0}$$
$$= \sigma_{11}\sigma_{22} + \sigma_{11}\sigma_{22}^* + \sigma_{11}^*\sigma_{22} + \sigma_{11}^*\sigma_{22}^* - \sigma_{12}^2$$

and thus:

$$\text{plim } \hat{\beta} = \beta - \begin{bmatrix} \frac{\left(\sigma_{22}+\sigma_{22}^*\right)\sigma_{11}^*}{\det(\tilde{\Sigma}_{x^*})} & \frac{-\sigma_{12}\sigma_{22}^*}{\det(\tilde{\Sigma}_{x^*})} \\ \frac{-\sigma_{11}^*\sigma_{12}}{\det(\tilde{\Sigma}_{x^*})} & \frac{\left(\sigma_{11}+\sigma_{11}^*\right)\sigma_{22}^*}{\det(\tilde{\Sigma}_{x^*})} \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix}$$

Note that if $\beta_2\sigma_{12} < 0$, *OLS* may not be downward biased for β_1. If $\beta_2 = 0$, we get:

$$\text{plim } \hat{\beta}_2 = \frac{\beta_1\sigma_{12}\sigma_{11}^*}{\det(\tilde{\Sigma}_{x^*})}$$

so, if X_2 were a race variable and blacks get lower quality schooling, (where schooling is measured by X_{1t},) then $\sigma_{12} < 0$, and hence $\hat{\beta}_2 < 0$. This would be a finding in support of labor market discrimination.

2.4 The Kitchen Sink Revisited

McCallum's analysis suggests that one should toss in a variable measured with error if there is no measurement error in X_{1t}. But suppose that there is measurement error in X_{1t}. Is it still better to include the additional variable measured with error as a regressor? We proceed by imposing $\beta_2 = 0$.

(i) **Excluded $\boldsymbol{X}_{2t}$.** The equation for earnings with measurement error in X_1 and excluded X_2 is:

$$\begin{aligned} y &= (X_1^* + \varepsilon_1)\,\beta_1 + (U + X_2\beta_2) \\ &= X_1^*\beta_1 + (U + X_2\beta_2 + \beta_1\varepsilon_1) \end{aligned}$$

Therefore:

$$\text{plim}\ \tilde{\beta}_1 = \beta_1 - \beta_1 \left(\frac{\sigma_{11}^*}{\sigma_{11} + \sigma_{11}^*} \right) = \beta_1 \left(\frac{\sigma_{11}}{\sigma_{11} + \sigma_{11}^*} \right) \tag{2.3}$$

$$= \beta_1 \left(\frac{1}{1 + \dfrac{\sigma_{11}^*}{\sigma_{11}}} \right)$$

(ii) **Included $\boldsymbol{X}_{2t}$.** From our analysis in the General Case (Section 2.3), we know that:

$$\text{plim}\ \hat{\beta}_1 = \beta_1 \left(\frac{\left(\sigma_{22} + \sigma_{22}^*\right) \sigma_{11} - \sigma_{12}^2}{\det(\tilde{\Sigma}_{x^*})} \right). \tag{2.4}$$

If $\sigma_{22}^* = 0$, so that X_{2t} is not measured with error:

$$\begin{aligned} \text{plim}\ \hat{\beta}_1 &= \beta_1 \left(\frac{\sigma_{11}\sigma_{22} - \sigma_{12}^2}{\sigma_{11}\sigma_{22} - \sigma_{12}^2 + \sigma_{11}^*\sigma_{22}} \right) \\ &= \beta_1 \left(\frac{1 - \rho_{12}^2}{1 - \rho_{12}^2 + \frac{\sigma_{11}^*}{\sigma_{11}}} \right). \end{aligned} \tag{2.5}$$

Comparing eqn (2.4) and eqn (2.5), we see that adding the variable measured without error always exacerbates the bias.

For, the bias in the excluded case will be smaller if:

$$\beta_1 \left(\frac{1}{1 + \frac{\sigma_{11}^*}{\sigma_{11}}} \right) > \beta_1 \left(\frac{1 - \rho_{12}^2}{1 - \rho_{12}^2 + \frac{\sigma_{11}^*}{\sigma_{11}}} \right)$$

$$\iff \left(1 - \rho_{12}^2 + \frac{\sigma_{11}^*}{\sigma_{11}} \right) > \left(1 + \frac{\sigma_{11}^*}{\sigma_{11}} \right) \left(1 - \rho_{12}^2 \right)$$

$$\iff 0 > -\rho_{12}^2 \frac{\sigma_{11}^*}{\sigma_{11}}.$$

which is always the case, provided $\rho_{12}^2 > 0$. (Note that the coefficients on β_1 for both the excluded and included case are less than one. So, the larger coefficient is the one with less bias, as stated above.)

Now suppose that $\sigma_{22}^* > 0$, so that both variables are measured with error. Then:

$$\begin{aligned}
\operatorname{plim} \hat{\beta}_1 &= \beta_1 \left(\frac{\left(\sigma_{22} + \sigma_{22}^*\right) \sigma_{11} - \sigma_{12}^2}{\det(\tilde{\Sigma}_{x^*})} \right) \\
&= \beta_1 \left(\frac{1 + \dfrac{\sigma_{22}^*}{\sigma_{22}} - \rho_{12}^2}{1 + \dfrac{\sigma_{11}^*}{\sigma_{11}} + \dfrac{\sigma_{11}^*}{\sigma_{11}} \dfrac{\sigma_{22}^*}{\sigma_{22}} + \dfrac{\sigma_{22}^*}{\sigma_{22}} - \rho_{12}^2} \right).
\end{aligned}$$

Intuitively, adding measurement error in X_{2t} can only worsen the bias, and thus exclusion should again be preferred to inclusion. Formally, including X_{2t} gives more bias if and only

if:

$$\beta_1 \left(\frac{1 + \frac{\sigma_{22}^*}{\sigma_{22}} - \rho_{12}^2}{1 + \frac{\sigma_{11}^*}{\sigma_{11}} + \frac{\sigma_{11}^*}{\sigma_{11}} \frac{\sigma_{22}^*}{\sigma_{22}} + \frac{\sigma_{22}^*}{\sigma_{22}} - \rho_{12}^2} \right) < \beta_1 \left(\frac{1}{1 + \frac{\sigma_{11}^*}{\sigma_{11}}} \right)$$

$$\iff \left(1 + \frac{\sigma_{11}^*}{\sigma_{11}}\right) \left(1 + \frac{\sigma_{22}^*}{\sigma_{22}} - \rho_{12}^2\right)$$

$$< \left(1 + \frac{\sigma_{11}^*}{\sigma_{11}} + \frac{\sigma_{11}^*}{\sigma_{11}} \frac{\sigma_{22}^*}{\sigma_{22}} + \frac{\sigma_{22}^*}{\sigma_{22}} - \rho_{12}^2\right)$$

$$\iff -\rho_{12}^2 \frac{\sigma_{11}^*}{\sigma_{11}} < 0.$$

Thus, provided $\rho_{12}^2 > 0$, including X_{2t} results in more bias than excluding it. If $\rho_{12}^2 = 0$, the bias from including X_{2t} is obviously seen to be:

$$\beta_1 \left(\frac{1 + \dfrac{\sigma_{22}^*}{\sigma_{22}}}{1 + \dfrac{\sigma_{11}^*}{\sigma_{11}} + \dfrac{\sigma_{11}^*}{\sigma_{11}} \dfrac{\sigma_{22}^*}{\sigma_{22}} + \dfrac{\sigma_{22}^*}{\sigma_{22}}} \right) = \beta_1 \left(\frac{1 + \dfrac{\sigma_{22}^*}{\sigma_{22}}}{\left(1 + \dfrac{\sigma_{22}^*}{\sigma_{22}}\right)\left(1 + \dfrac{\sigma_{11}^*}{\sigma_{11}}\right)} \right)$$

$$= \beta_1 \left(\frac{1}{1 + \dfrac{\sigma_{11}^*}{\sigma_{11}}} \right)$$

so that including and excluding X_{2t} yields the same result.

Finally, from the General Case section, we have:

$$\text{plim } \hat{\beta}_1 = \frac{\beta_1 \left(\sigma_{22} + \sigma_{22}^*\right) \sigma_{11} - \sigma_{12}^2 + \beta_2 \left(\sigma_{12}\sigma_{22}^*\right)}{\sigma_{11}\sigma_{22} - \sigma_{12}^2 + \sigma_{11}^*\sigma_{22}^* + \sigma_{11}^*\sigma_{22} + \sigma_{11}\sigma_{22}^*}.$$

L'Hôpital's rule on the above shows that:

$$\begin{aligned} \sigma_{11}^* &\longrightarrow \infty \lim \left(\text{plim } \hat{\beta}_1\right) = 0, \text{ and} \\ \lim_{\sigma_{22}^* \to \infty} \left(\text{plim } \hat{\beta}_1\right) &= \frac{\beta_1 \sigma_{11} + \beta_2 \sigma_{12}}{\sigma_{11} + \sigma_{11}^*} \\ &= \frac{\beta_1 \sigma_{11}}{\sigma_{11} + \sigma_{11}^*} + \frac{\beta_2 \sigma_{12}}{\sigma_{11} + \sigma_{11}^*}. \end{aligned}$$

Appendix

Derivation of Equation (2.2)

We can write

$$y_t = x^* \beta + (U_t - \epsilon_{1t}\beta_1 - \epsilon_{2t}\beta_2),$$

where:

$$x^* = \begin{bmatrix} x_1^* & x_2^* \end{bmatrix} \qquad \text{and} \qquad \beta = \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix},$$

and x_1^*, x_2^*, are $T \times 1$.

So:

$$
\begin{aligned}
\hat{\beta}^{OLS} &= \left(x^{*\prime}x^{*}\right)^{-1}\left(x^{*\prime}y\right) \\
&= \beta + \left(x^{*\prime}x^{*}\right)^{-1}\left(x^{*\prime}(U - \epsilon_1\beta_1 - \epsilon_2\beta_2)\right) \\
&= \beta + \left(\frac{\left(x^{*\prime}x^{*}\right)}{T}\right)^{-1} \\
&\qquad \times \left(\left(\frac{x^{*\prime}U}{T}\right) - \left(\frac{x^{*\prime}\epsilon_1\beta_1}{T}\right) - \left(\frac{x^{*\prime}\epsilon_2\beta_2}{T}\right)\right) \\
&\rightarrow \beta + \left(E\left(x^{*\prime}x^{*}\right)\right)^{-1} \\
&\qquad \times \left(E\left(x^{*\prime}U\right) - E\left(x^{*\prime}\epsilon_1\right)\beta_1 - E\left(x^{*\prime}\epsilon_2\right)\beta_2\right)
\end{aligned}
$$

$$
\begin{aligned}
&= \beta - \begin{bmatrix} E\left(x_1^{*\prime} x_1^*\right) & E\left(x_1^{*\prime} x_2^*\right) \\ E\left(x_2^{*\prime} x_1^*\right) & E\left(x_2^{*\prime} x_2^*\right) \end{bmatrix}^{-1} \\
&\qquad \times \left(E \begin{bmatrix} x_1^{*\prime} \epsilon_1 \\ x_2^{*\prime} \epsilon_1 \end{bmatrix} \beta_1 + E \begin{bmatrix} x_1^{*\prime} \epsilon_2 \\ x_2^{*\prime} \epsilon_2 \end{bmatrix} \beta_2 \right) \\
&= \beta - \begin{bmatrix} E\left(x_1^{*\prime} x_1^*\right) & E\left(x_1^{*\prime} x_2^*\right) \\ E\left(x_2^{*\prime} x_1^*\right) & E\left(x_2^{*\prime} x_2^*\right) \end{bmatrix}^{-1} \\
&\qquad \times \begin{bmatrix} E\left(x_1^{*\prime} \epsilon_1\right) & E\left(x_1^{*\prime} \epsilon_2\right) \\ E\left(x_2^{*\prime} \epsilon_1\right) & E\left(x_2^{*\prime} \epsilon_2\right) \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix}
\end{aligned}
$$

$$
\begin{aligned}
&= \left(I - \left(\Sigma_{x^*}\right)^{-1} \begin{bmatrix} E\left(\left(\varepsilon_1' + x_1'\right)\epsilon_1\right) & E\left(\left(\varepsilon_1' + x_1'\right)\epsilon_2\right) \\ E\left(\left(\varepsilon_2' + x_2'\right)\epsilon_1\right) & E\left(\left(\varepsilon_2' + x_2'\right)\epsilon_2\right) \end{bmatrix} \right) \\
&\qquad \times \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} \\
&= \left(I - \left(\Sigma_{x^*}\right)^{-1} \left(\Sigma_\varepsilon\right) \right) \beta,
\end{aligned}
$$

where the second-to-last step follows from the independence of x and ε. This type of argument is also used to derive the probability limit of the β's in section 1.

3 Sibling Models: Components of Variance Scheme

Suppose that data on two brothers, say α and β, is at our disposal. Without loss of generality, we will consider how to estimate parameters of interest for person α in what follows. We will begin by introducing a general model and then focus on the two-person case mentioned above. Consider the following triangular system:

$$\begin{aligned} y_{1ij} &= \varepsilon_{1ij} \\ y_{2ij} &= \nu_{12} y_{1ij} + \varepsilon_{2ij} \\ y_{3ij} &= \nu_{13} y_{1ij} + \nu_{23} y_{2ij} + \varepsilon_{3ij} \end{aligned}$$

Here,i j indexes the jth person in the ith group. We assume that ε_{lij} and $\varepsilon_{li'j}$ are uncorrelated (i.e., uncorrelated across groups). Further, we suppose:

$$\begin{aligned} \varepsilon_{kij} &= \lambda_k h_{ij} + \mu_{kij} \\ h_{ij} &= F_i + g_{ij}, \end{aligned}$$

for $k = 1, 2, 3$. We assume μ_{kij} is uncorrelated across equations and across j within the group, F_i is i.i.d. across groups, and g_{ij} is i.i.d. within groups and uncorrelated with F_i.

3.1 Estimation

We specialize the above model into a two person framework and propose a similar three equation system. Let y_1 = early (pre-school) test score, y_2 = schooling (years), and y_3 = earnings. It seems plausible to write the equation system

$$\begin{aligned} y_1 &= h + U_1 \\ y_2 &= \lambda_2 h + U_2. \\ y_3 &= \nu_{23} y_2 + \lambda_3 h + U_3, \end{aligned}$$

where h = ability. Regressing y_3 on y_2 clearly gives biased estimates of ν_{23} as $E(h \mid y_2) \neq 0$. If $\lambda_3 > 0$, then *OLS* estimates of ν_{23} are upward biased. One estimation approach is to use y_1 as a proxy for ability:

$$y_3 = \nu_{23} y_2 + \lambda_3 (y_1 - U_1) + U_3.$$

However, this results in a similar problem — regressing y_3 on y_1 and y_2 will give biased estimates as y_1 is correlated with our residual. (*i.e.*, y_1 is an imperfect proxy).

Solutions:

One solution is to use $y_{1\beta}$ *as an instrument for* $y_{1\alpha}$. Why is this a valid IV? From our construction of the model, we know that the U_i are uncorrelated across equations and groups. Further, test scores are correlated across siblings. That is, $Cov(y_{1\alpha}, y_{1\beta}) \neq 0$ by our group structure.

Another solution is possible if there exists an *additional early reading* on the same person:

$$y_0 = \lambda_0 h + U_0.$$

Then if $\lambda_0 \neq 0$, y_0 is a valid proxy for y_1, and we can perform $2SLS$.

3.2 Griliches and Chamberlain model

Here we have a modified triangular system as follows:

$$\begin{aligned} y_1 &= \lambda_1 h + U_1 \\ y_2 &= \nu_{12} y_1 + \lambda_2 h + U_2 \\ y_3 &= \nu_{13} y_1 + \nu_{23} y_2 + \lambda_3 h + U_3 \end{aligned}$$

where y_1 = years schooling, y_2 = late test score (SAT), and y_3 = earnings. Note that there are alternative models with other dependent variables. For example, $\{y_1 = \text{schooling}, y_2 = \text{early earnings, and } y_3 = \text{late earnings}\}$, and $\{y_1 = \text{schooling}, y_2 = \text{consumption, and } y_3 = \text{earnings}\}$. Getting the equation system into reduced form and expressing as matrix notation, we write

$$y_k = d_k h + \rho_k,$$

where:

$$d_k = \begin{bmatrix} d_1 \\ d_2 \\ d_3 \end{bmatrix} = \begin{bmatrix} \lambda_1 \\ \lambda_2 + \nu_{12}\lambda_1 \\ \lambda_3 + \nu_{13}\lambda_1 + \nu_{23}(\lambda_2 + \nu_{12}\lambda_1) \end{bmatrix}$$

and:

$$\rho_k = \begin{bmatrix} \rho_1 \\ \rho_2 \\ \rho_3 \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 + \nu_{12}\mu_1 \\ \mu_3 + \nu_{13}\mu_1 + \nu_{23}(\mu_2 + \nu_{12}\mu_1) \end{bmatrix}$$

Estimation. For estimation, we impose that $\nu_{23} = 0$. In our second example of section 3.2, this would be equivalent to stating that there is no correlation between transient income and consumption (permanent income hypothesis). In general, with one factor, we need one more exclusion than that implied by triangularity.

(i) y_1 proxies h.

$$h = \frac{y_1 - \rho_1}{d_1}$$

so that

$$y_2 = \frac{d_2}{d_1} y_1 - \frac{d_2}{d_1} \rho_1 + \rho_2.$$

We can then estimate $\frac{d_2}{d_1}$ consistently by using $y_{1\beta}$ as an instrument for $y_{1\alpha}$ in the equation above.

(ii) Get residuals from (i): $z = \rho_2 - \frac{d_2}{d_1} \rho_1$.

(iii). Use the residuals as an instrument for y_1 in the y_3 equation. Z is valid since it is both uncorrelated with h and U_3, and it is correlated with y_1:

$$Cov(y_1, z) = Cov\left(y_1, \rho_2 - \frac{d_2}{d_1}\rho_1\right)$$
$$= Cov\left(\lambda_1 h + U_1, U_2 + \nu_{12}U_1 - \frac{\lambda_2 + \nu_{12}\lambda_1}{\lambda_1}U_1\right)$$
$$= Cov\left(\lambda_1 h + U_1, U_2 - \frac{\lambda_2}{\lambda_1}U_1\right) \neq 0$$

if $U_1 \neq 0$, and, $\lambda_2 \neq 0$. Thus we can estimate ν_{13}.

(iv). Interchange the role of y_2 and y_3 to estimate ν_{12}.

(v). Form the residual (and recall that ν_{13} is known and $\nu_{23} = 0$)

$$w = y_3 - \nu_{13}y_1 = \lambda_3 h + U_3.$$

(vi) Use y_1 as a proxy for ability. Substituting this into V gives:

$$w = \frac{\lambda_3}{\lambda_1} y_1 + \frac{\lambda_3}{\lambda_1} U_3 - \frac{\lambda_3}{\lambda_1} U_1.$$

(vii) Now use $y_{1\beta}$ as an instrument for $y_{1\alpha}$ in the above to get an estimate of $\frac{\lambda_3}{\lambda_1}$.

(viii) Interchange the role of y_2 and y_3 to estimate $\frac{\lambda_2}{\lambda_1}$.

3.3 Triangular systems more generally

Without loss of generality, suppose that y_2 is excluded from the tth equation of our system. (We are supposing the existence of an extra exclusion than that implied by triangularity). We seek to estimate the parameters of the system in equation t as well as equations before and after t.

Equation t.

i. Use y_1 as a proxy for ability. Solving for h and substituting into the equation:

$$y_k = d_k h + \rho_k$$

We get:

$$y_k = \frac{d_k}{d_1} y_1 - \frac{d_k}{d_1} \rho_1 + \rho_k$$

and we are considering $k = 2, \ldots, t-1$. The ratio $\frac{d_k}{d_1}$ can then be identified using $y_{1\beta}$ as an instrument for $y_{1\alpha}$.

ii. Form the residuals:

$$z_k = \rho_k - \frac{d_k}{d_1} \rho_1 \qquad\qquad k = 2, \ldots t-1$$

Now we have $t-2$ IV's ($z_2, z_3, \ldots, z_{t-1}$) for the $t-2$ independent variables in the t^{th}equation ($y_1, y_3, \ldots, y_{t-1}$), so we can consistently estimate the coefficients in the tth equation.

Equations before t.

iii. Form:

$$y_t^* = y_t - \nu_{1t} y_1 - \cdots - v_{t-1t} y_{t-1}$$

We can use $y_1, \cdots, y_{k-1}, y_t^*$ to form $k-1$ purged IV's and $y_{t\beta}^*$ is used as a proxy for unobserved ability, h. In this way, we can estimate all of the parameters in equations $k < t$. (Note the sequential order implicit in this triangular system. We must first estimate t before this step can be made.)

Example. Suppose $t > 3$ and

$$y_3 = \nu_{13} y_1 + \nu_{23} y_2 + \lambda_3 h + U_3.$$

Use $y_t^* = \lambda_t h + U_t$ as a proxy for h. Substituting this into our y_3 equation yields:

$$y_3 = \nu_{13} y_1 + \nu_{23} y_2 + \frac{\lambda_3}{\lambda_t} y_t^* + \left(U_3 - \frac{\lambda_3}{\lambda_t} U_t \right).$$

Observe that y_1, and y_2, are independent of our residual, but y_t^* is not. We can use $y_{t\beta}^*$ as an instrument for $y_{t\alpha}^*$ to estimate the parameters above. This obviously generalizes for all equations less than t.

Equations after t.

iv. Assume identification for all equations through t via an exclusion restriction in equation t.

Example. As an example, consider the following:

$$y_4 = \nu_{14} y_1 + \nu_{24} y_2 + \nu_{34} y_3 + \lambda_4 h + U_4$$

Define:

$$y_2^* \equiv y_2 - \nu_{12} y_1, y_3^* \equiv y_3 - \nu_{13} y_1 - \nu_{23} y_2$$

Solving for y_1 and y_2 and substituting into the equation for y_4, we find:

$$
\begin{aligned}
y_4 &= \nu_{14} y_1 + \nu_{24} y_2 + \nu_{34} \left(y_3^* + \nu_{13} y_1 + \nu_{23} y_2 \right) + \lambda_4 h + U_4 \\
&= \left(\nu_{14} + \nu_{34} \nu_{13} \right) y_1 + \left(\nu_{24} + \nu_{34} \nu_{23} \right) y_2 + \nu_{34} y_3^* + \lambda_4 h + U_4 \\
&= \left(\nu_{14} + \nu_{34} \nu_{13} \right) y_1 + \left(\nu_{24} + \nu_{34} \nu_{23} \right) \left(y_2^* + \nu_{12} y_1 \right) \\
&\quad + \nu_{34} y_3^* + \lambda_4 h + U_4 \\
&= \nu_{14}^* y_1 + \nu_{24}^* y_2^* + \nu_{34} y_3^* + \lambda_4 h + U_4
\end{aligned}
$$

where:

$$
\begin{aligned}
\nu_{14}^* &= \nu_{14} + \nu_{24}^* \nu_{12} + \nu_{34} \nu_{13} \\
\nu_{24}^* &= \nu_{24} + \nu_{23} \nu_{34}
\end{aligned}
$$

Using $y_1$as a proxy for h and substituting we get:

$$
y_4 = \pi_1 y_1 + \nu_{24}^* y_2^* + \nu_{34} y_3^* + \left(U_4 - \frac{\lambda_4}{\lambda_1} U_1 \right)
$$

where $\pi_1 = \nu_{14}^* + \dfrac{\lambda_4}{\lambda_1}$. We can then use $y_{1\beta}, y_{2\alpha}^*$, and $y_{3\alpha}^*$ as instruments to get an estimate of ν_{34}. Define:

$$\tilde{y}_4 = y_4 - \nu_{34} y_3 = \nu_{14} y_1 + \nu_{24} y_2 + \lambda_4 h + U_4$$

(Excluding y_3 allows us to estimate the remaining parameters). Using y_3^* as a proxy for h yields:

$$y_4 = \nu_{14} y_1 + \nu_{24} y_2 + \frac{\lambda_4}{\lambda_3} y_3^* + \left(U_4 - \frac{\lambda_4}{\lambda_3} U_3 \right).$$

We can then estimate ν_{14}, and ν_{24} by using $y_{1\alpha}, y_{2\alpha}$, and $y_{3\beta}^*$ as an IV. We can continue estimating. For example, consider the 5th equation:

(i) Rewrite in terms of y_1, y_2^*, y_3^*, and y_4^*.

(ii) Use y_1 to proxy h.

(iii) Use a cross-member IV for y_1 in addition to $y_j^*, j = 2, 3, 4$ which gives our estimate of ν_{45}.

(iv) Now form $\tilde{y}_5 = y_5 - \nu_{45} y_4$.

(v) With y_4 excluded, we can use purged IV's on $\tilde{y}_5$, as before.

3.4 Comments

1. One needs to check the rank order conditions for identification (requires imposing an exclusion restriction).

2. Griliches and Chamberlain (IER, 1976) find a small ability bias - 3rd decimal point difference in schooling coefficient.

4 Twin Methods

Basic Principle: Monozygotic or MZ (identical) twins are more similar than Dizygotic or DZ (fraternal) twins. The key assumption is that if environmental factors are the same for both types of twins, then we can estimate genetic components to outcomes.

4.1 Univariate Twin Model

Let y = observed phenotypic variable, x = unobserved genotype, and u = environment. Further, suppose that we can write our model additively:

$$y = x + u$$

and assume independence of x and u so that $\sigma_y^2 = \sigma_x^2 + \sigma_u^2$. Now suppose that we have data on another individual:

$$y^* = x^* + u^*$$

Then our phenotypic covariance is:

$$Cov\left(y, y^*\right) = Cov\left(x, x^*\right) + Cov\left(u, u^*\right)$$

where we are imposing the assumption:

$$Cov\,(x, u^*) = Cov(x^*, u) = 0.$$

Defining standardized forms and some simplifying notation, let

$$\tilde{y} \equiv \frac{y}{\sigma_y}, \quad \tilde{x} \equiv \frac{x}{\sigma_x}, \quad \tilde{u} \equiv \frac{u}{\sigma_u}, h^2 \equiv \frac{\sigma_x^2}{\sigma_y^2}, \quad \rho^2 \equiv \frac{\sigma_u^2}{\sigma_y^2}$$

Thus, $\tilde{y}\sigma_y = \tilde{x}\sigma_x + \tilde{u}\sigma_u$ which implies $\tilde{y} = h\tilde{x} + \rho\tilde{u}$. We can also derive the identity:

$$h^2 + \rho^2 = \frac{\sigma_x^2}{\sigma_y^2}. + \frac{\sigma_u^2}{\sigma_y^2} = 1$$

where the last step follows from our assumption of independence. Now we wish to consider the correlation between ob-

served phenotypes of our two individuals:

$$\begin{aligned} C &= Corr(y, y^*) \\ &= Corr(h\tilde{x} + p\tilde{u}, h\tilde{x}^* + \rho\tilde{u}^*) \\ &= h^2 \frac{Cov(\tilde{x}, \tilde{x}^*)}{Var(\tilde{x})} + \rho^2 \frac{Cov(\tilde{u}, \tilde{u}^*)}{Var(\tilde{u})} \\ &= h^2 g + \rho^2 \nu \end{aligned}$$

say, with g and ν defined as above. We assume that $g_{MZ} = 1$ and that $g_{DZ} < 1$. That is, the genotypic variable is perfectly correlated among identical twins, but less than perfectly correlated among fraternal twins. Replacing this result into the above produces:

$$\begin{aligned} C_{MZ} &= h^2 + \nu_{MZ}\rho^2 \\ C_{DZ} &= h^2 g_{DZ} + \nu_{DZ}\rho^2 \end{aligned}$$

Therefore:

$$\begin{aligned} C_{MZ} - C_{DZ} &= (1 - g_{DZ})h^2 + (\nu_{MZ} - \nu_{DZ})\rho^2 \\ &= (1 - g_{DZ})h^2 + (\nu_{MZ} - \nu_{DZ})(1 - h^2) \end{aligned}$$

where the last equality follows from our established identity. Solving for h^2, we find:

$$h^2 = \frac{(C_{MZ} - C_{DZ}) - (\nu_{MZ} - \nu_{DZ})}{(1 - g_{DZ}) - (\nu_{MZ} - \nu_{DZ})}.$$

The only known in the right hand side of the above equality is the expression $(C_{MZ} - C_{DZ})$, which is simply the correlation coefficient of the observed phenotypic variable. The remaining two expressions, $(1 - g_{DZ})$ and $(\nu_{MZ} - \nu_{DZ})$ can not be computed as they represent statistics on variables we don't observe.

One could impose $\nu_{MZ} = \nu_{DZ}$ so that:

$$h^2 = \frac{C_{MZ} - C_{DZ}}{1 - g_{DZ}}.$$

The expression g_{DZ} is a measure of how closely the genetic variable is correlated across our two observations. One could then guess or estimate a value for this parameter to derive corresponding estimates of h^2, the ratio of how much variance in the phenotypic variable is explained by variance in the genetic component. Other studies have attempted to include $Cov(x, u) \neq 0$ but this presents an identification problem. A typical value of the estimable portion of the above, $C_{MZ} - C_{DZ}$, is commonly reported in the literature to be 0.2.

Web Appendix D

Notes on Figure 2, Predictive Validities of IQ and Big Five Dimensions

Leadership

Associations between personality and IQ and leadership were taken from two meta-analyses conducted by the same research group (Judge, Bono, Ilies, and Gerhardt, 2002; Judge, Colbert, and Ilies, 2004). Leadership was defined jointly as "leader emergence," the degree to which the individual is viewed as a leader by others, and "leader effectiveness," performance in influencing and guiding the activities of a group. Typically, these assessments were made by subordinates, supervisors, peers, or observers. Studies relying on self-report assessments of leadership were not included.

Estimated true score correlations between IQ and leadership were corrected for unreliability in the predictor and criterion, as well as for range restriction. Estimated true score correlations between personality and leadership were corrected for reliability in the predictor and criterion, but not for range restriction.

Job Performance

Associations between personality and job performance were taken from a meta-analysis (Barrick and Mount, 1991). Job performance was defined by three criteria: job proficiency (primarily assessed by performance ratings), training proficiency (primarily assessed by training performance ratings), and personnel data (including salary level, turnover, status change, and tenure).

The association between IQ and job performance was taken from (Hogan, 2005). This article did not state whether this correlation is observed or corrected. The much higher estimate of corrected validity is offered by Schmidt and Hunter (2004). Concerns about over-correction with respect to restriction on range and reliability have been raised by Hartigan and Wigdor (1984) with specific reference to estimating the effect of IQ on job performance.

Longevity

Associations between personality and longevity were taken from a review of 34 studies that were prospective in design and which controlled for demographic factors (Roberts, Kuncel, Shiner, Caspi, and Goldberg, in press). Estimated true score correlations were not provided.

Years of Education

Cross-sectional associations between personality and years of schooling were taken from a study (Goldberg, Sweeney, Merenda, and Hughes, 1998) using a large (N = 3629) sample of individuals representative of working adults in the U.S. in the year 2000. Estimated true score correlations were not provided.

The association between IQ and years of schooling was taken from a review by an American Psychological Association (APA) taskforce (Neisser et al., 1996). This article did not state whether this correlation was observed or corrected.

College Grades

Associations between personality and college academic performance were taken from a meta-analysis of 23 studies (collective *N* = 5878) by O'Connor and Paunonen (in press). Most of the reviewed studies used as measures of academic performance GPA, but several also used course exam grades.

The association between IQ and college GPA is from a review (Jensen, 1998). This article did not state whether this correlation is observed or corrected. A similar estimate (*r* = .5) is offered by Neisser et al. (1996) for the association between IQ and general academic performance.

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