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Cognitive epidemiology: With emphasis on untangling cognitive ability and socioeconomic status

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ABSTRACT

This commentary touches on practical, public policy, and social science domains informed by cognitive epidemiology while pulling together common themes running through this important special issue. As is made clear in the contributions assembled here, and others (Deary, Whalley, & Starr, 2009; Gottfredson, 2004; Lubinski & Humphreys, 1992, 1997), social scientists and practitioners cannot afford to neglect cognitive ability when modeling epidemiological and health care phenomena. However, given the dominant concern about the confounding of general cognitive ability (GCA) and socioeconomic status (SES), and the extent to which SES is frequently seen as the primary cause of health disparities (while GCA is neglected as a possible influence in epidemiology and health psychology), some methodological applications for untangling the relative influences of GCA and SES are reviewed. In addition, cognitive epidemiology is placed in a broader context: Just as cognitive epidemiology facilitates an understanding of *pathology* ("at risk" populations, and ways to attenuate undesirable personal and social conditions), it may also enrich our understanding of *optimal functioning* ("at promise" populations, and ways to identify and nurture the human and social capital needed to develop innovations for saving lives, economies, and perhaps even our planet). Finally, while GCA is likely the most important dimension in the study of individual differences for modeling healthy behaviors and outcomes, other relatively independent dimensions of psychological diversity do add value (Krueger, Caspi, & Moffitt, 2000). For example, *compliance* has at least two psychological components: a "can do" competency component (ability) and a "will do" motivational component (conscientiousness). Ultimately, developing and modeling healthy behaviors, interpersonal environments, and medical maladies are best accomplished by teaming multiple dimensions of human individuality.

This special issue is impressive. Before it appeared, the importance of general cognitive ability (GCA) for modeling epidemiological phenomena had been clearly established (Deary et al., 2009; Gottfredson, 2004; Gottfredson & Deary, 2004; Lubinski & Humphreys, 1992, 1997). In this series of articles, that idea is reinforced and advanced. The topics covered include *behaviors that attenuate cognitive decline* (Anstey et al.), *depression and general health* (Der et al.), *heart disease* (Roberts et al.; Shipley et al.; Singh-Manoux et al.), *metabolic syndrome* (Richards et al.), *mortality risk* (Batterman et al.; Gallacher et al.; Leon et al; Wilson et al.), *persistence with medication* (Deary et al.), *psychological distress* (Gale et al.), *substance use and abuse* (Johnson et al.), and, finally, a theoretical contribution on the extent to which a more general "fitness factor," from an evolutionary point of view, might possibly contribute to the association between cognitive ability and health outcomes (Arden et al.). There are firmly established and substantively significant relationships between these outcomes and GCA, as well as others (Batty, Deary, & Gottfredson, 2007; Deary et al., 2009; DeWalt et al., 2004; Gottfredson, 2004; Lubinski & Humphreys, 1992, 1997; O'Tool, 1990; O'Tool & Stankov, 1992; Seligman et al., 2007).

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This commentary consists of 4 sections: the two dominant currents of research within cognitive epidemiology, untangling the confounding of GCA and SES, extending the spectrum of cognitive epidemiology from pathology to promise (plus augmenting it with other dimensions of human individuality) and, finally, a concluding statement about the importance of normal science.

1. Two dominant currents of research in cognitive epidemiology

Cognitive epidemiology research has two dominant themes: first, the indirect effect of cognitive ability on health through decision-making, and second, health and cognitive ability as two indicators of an individual's system integrity. The first theme addresses the judgment and decision-making required for developing a healthy lifestyle, avoiding health risks, and exercising preventive medicine. All of these tasks require cognitive competencies for acquiring and effectively using new information, which are of critical importance in modern societies, where people have the complex task of managing their own health care. Best practices and life circumstances are forever changing, and there are huge individual differences in coping with change effectively.

Health psychologists have been stressing for years that many ailments are the results of unhealthy behaviors. "Compliance" is the term that surfaces most frequently, and justifiably so, but it is typically conceptualized exclusively in volitional terms. Yet, there are at least two distinct components to compliance: a "can do" aspect and a "will do" aspect. These two components are related to two domains in the study of human individual differences that industrial and vocational psychologists have studied for decades (Dawis, 1992; Lubinski, 2000a; Schmidt & Hunter, 1998): namely, competences and motivational attributes, respectively. That both are critical for effective functioning underscores why Gottfredson's (2004) idea of approaching health behaviors from the perspective of a job description is so compelling. Both competence (ability) and motivation–volition (conscientiousness) are needed for navigating the complex web of information and for executing preventive measures to attenuate personal health risks and risks for those around us.

As they realize the importance of individual differences in GCA, some doctors and hospitals implement procedures designed to simplify the process of staying healthy. For example, while many emergency rooms allow only patients and health care professionals to be behind the curtain, allowing more able loved ones to accompany an injured family member can facilitate adherence to take-home medical instructions, which the more able family member can more readily understand and remember. Other mechanisms for reducing the cognitive load for healthy behaviors, like developing more user-friendly directions for taking prescriptions, have also been discussed (DeWalt et al., 2004; Seligman et al., 2007).[1]

The other aspect of cognitive epidemiology is not unrelated to the first: organismic or system integrity. This concept denotes physiological and physical aspects of human health, which also covary with GCA. A large portion of this special issue deals with this component of cognitive epidemiology (heart disease, neurological phenomena). In this context, an earlier contribution to the medical/physiological correlates of GCA is worth reviewing (Lubinski & Humphreys, 1992): Not only are the substantive findings highly germane to the issues surrounding cognitive epidemiology, but this contribution also highlights a familiar confound mentioned throughout this special issue. The confounding of ability and SES has been a methodological knot that has vexed social scientists for decades (Humphreys & Parsons, 1977; Meehl, 1970, 1986). Because ability (GCA) and economic advantage (SES) covary around .40, it is difficult to assign causal status to one or the other with respect to the longitudinal outcomes they predict (Kahneman, 1965; Meehl, 1971). But there are ways to get a purchase on their relative influences. Because of the importance of this topic, the preponderance of this commentary will be devoted to ways of doing so.

2. Untangling cognitive ability and socioeconomic status

In one of the earliest studies of cognitive epidemiology, Terman (1925) studied the health and medical histories of 1528 participants in the top 1% in GCA (or IQ). In arguably the most famous longitudinal study in psychology, Terman (1925) examined the relationship between intellectual talent and psychological and physical health. At the time, speculation held that the intellectually able were physically weak and sickly relative to their normative peers. A common saying back then was "early to ripe, early to rot." Terman falsified this myth by showing empirically that it was quite the opposite: Intellectually gifted individuals tend to be healthier than their normative peers. They also tend to be better adjusted socially. Yet, because Terman's intellectually talented participants also resided in homes approximately 1 standard deviation above the norm in SES, causal attributions were equivocal: Was their physical and psychological well-being a function of their ability or their economic advantage? Seventy years after Terman's study was launched, the following study appears to have shed some light on this query.

2.1. Extreme GCA and SES groupings

The GCA/SES confound may be reasonably addressed in the following way. Using a large stratified random sample of the U.S. 10th grade student population secured by Project Talent (Flanagan et al., 1962), $N=95{,}650$ participants, Lubinski and Humphreys (1992) selected the top 1% on a measure of cognitive ability, for each sex, as well as the top 1% on a measure of SES. The four resulting groups, gifted boys $n=497$, gifted girls $n=508$, environmentally privileged boys $n=647$, environmentally privileged girls $n=485$, had minimum overlap. Only 41 boys and 46 girls were members of both the privileged and gifted groups. For analytic purposes, these gifted and privileged participants were simply left in each group; then, their medical and physical well-being profiles were compared by sex, and relative to the full sample of Project Talent participants, on 43 indices of medical and physical health and well-being.

[1] A number of these examples utilize health literacy measures rather than GCA measures. In many contexts, however, such measures generate results that are functionally equivalent with the results that GCA assessments would generate (Gottfredson, 2002; see also, Carroll, 1997).

To underscore the gifted/privileged comparisons being made, the two intellectually gifted groups were 2.7 standard deviations above the norm on cognitive ability and 1.1 standard deviations above the norm on SES; whereas the environmentally privileged participants were 2.3 (boys) and 2.5 (girls) standard deviations above the norm on SES, and 1.0 standard deviations above the norm in cognitive ability. Intellectually, the highly privileged participants were closer to the norm than they were to the gifted participants; and, with respect to SES, the gifted participants were closer to the norm than they were to the privileged participants. Lubinski and Humphreys (1992) found in essence that higher levels of health are found in both gifted and privileged groups relative to the norm. However, medical and physical well-being appears to be more highly associated with extreme levels of intellectual giftedness than extreme levels of SES privilege. The intellectually gifted participants were medically and physically healthier than the privileged participants, even though the gifted were raised in homes more than 1 standard deviation *below* the privileged groups in SES.

These findings have been available for over 15 years, yet one still finds a dominant tendency to attribute causal significance to SES relative to cognitive ability in conceptualizing these and other positive (epidemiological-health) outcomes (Adler, 2003; Adler et al., 1994). Indeed, cognitive ability is frequently not considered when modeling healthy behaviors and outcomes. Gottfredson's (2004) more recent treatment of untangling cognitive ability and SES might also have success in forestalling this hazardous practice. While the influence of SES on key outcomes cannot at all be dismissed, these findings do highlight the need to take cognitive ability into account when theorizing about the role SES plays in health outcomes (as well as other outcomes; see below). Moreover, a cleaner ability/SES uncoupling procedure exists that may be of particular interest to epidemiologists and health psychologists. It consists of a "sibling control" (Jensen, 1980; Lubinski, 2004; Murray, 1998), which untangles ability/SES causal paths in an even more compelling way. Because the elimination of this confound is central to many articles in this special issue of *Intelligence*, and because the application of the sibling control design affords great potential to advance cognitive epidemiology, I will describe in detail the sibling control design with empirical examples from a data set that was employed elsewhere in this special issue (viz., the National Longitudinal Survey of Youth; NLSY).

2.2. A sibling control

As many of the contributing authors of this special issue astutely point out, the overlap between GCA and SES ($r \approx .40$) complicates efforts to attribute a causal role to GCA in health outcomes. Clearly, of all the variables thought to compromise causal inferences based on general intelligence, SES is by far the most conspicuous competitor. Indeed, SES is frequently presupposed to be a causal determinant by investigators who fail to take cognitive ability into account. Is there a way to cleanly untangle the ability/SES confound to estimate the relative contributions of these two purported causal sources to outcomes of interest to epidemiologists and health psychologists? In the Lubinski and Humphreys (1992) study, there was overlap in the highly gifted and highly privileged groups (albeit <5%), and to the extent that overlap is operating in extreme group designs, causal inferences are compromised.

Murray (1998) reveals a compelling way to isolate the relative influences of ability and childhood SES on a variety of medical and social science outcomes, and it is readily employable in a large number of data sets utilized by epidemiologists and health psychologists. The design actually requires something that would enhance research protocols throughout developmental psychology and the social sciences: it requires that more than one sibling participate in the study (Jensen, 1980). In addition, the current illustration will involve a longitudinal follow-up, which is not required for utilizing the power of a sibling control design, but is required for cognitive epidemiology. The sibling control is deceptively simple but conceptually powerful (and may be readily implemented in a large number of pre-existing longitudinal data sets): Pairs of biologically related siblings are chosen for longitudinal tracking if they meet two selection criteria: 1. one sibling must fall within an arbitrarily selected normal GCA or IQ range (say, "normal" = 25–74%), whereas the other sibling falls outside of this range, and is placed in however many arbitrary classes that the database affords for reliable comparisons (e.g., "very dull" <10%, "dull" = 10–24%, "bright" = 75–89%, or "very bright" ≥90%). This controls for SES in a way that forestalls methodological concerns attendant with the "partialing fallacy" (Jensen, 1980; Kahneman, 1965; Meehl, 1970), because the SES of the normal control participants are essentially "perfectly matched" by being raised together in the same household by the same parents for several years. Tracking differential outcomes along these GCA gradations reflects the influence of general intelligence while simultaneously implementing a powerful quasi-experimental control for SES.

Tables 1 and 2 illustrate some results gleaned by using this design on 1074 of such sibling pairs taken from the NLSY. They were assessed as young adults on the Armed Forces Qualifying Test (AFQT), and scores were converted to general intelligence equivalents corresponding to the aforementioned arbitrary categories. Outcome data were collected 15 years later.

Table 1 contains only some of the outcomes examined by Murray (1998): years of education, occupational prestige, and earned income. Across these cognitive groups, social class outcomes mirror those seen in the general population across corresponding general ability gradients. The powerful influence of GCA is apparent. Moreover, this design may be further refined. For example, Table 2 presents in two panels those participants in the norm reference group who did not earn a four-year college degree (top panel) and those who did (bottom panel). On adjacent sides, percentages are given for their siblings in the other four classes. The advantages of more cognitive ability are revealed again by this analysis. Another way to look at these data is as follows: 228 sibling pairs were discordant for a four-year college degree; and of these, 88% of college degrees went to the higher ability sibling (i.e., only 12% of lower ability siblings earned college degrees). There is an old saying in applied psychology: for a difference to be a difference it must make a difference. Cognitive differences make real differences in life (Waller, 1971).

In a recent *APS Observer* (Wargo, 2009) story, Nisbett (2009, p. 17) was quoted as saying, "If we want the poor to be

Table 1
Paired sibling sample comparisons.

Cognitive class	Very dull siblings (< 10th percentile)	Dull siblings (10th–24th)	Normal reference group (25th–74th)	Bright siblings (75th–89th)	Very bright siblings (≥ 90th percentile)
IQ characteristics					
$\bar{X}$ IQ (SD)	74.5 (5.4)	85.9 (2.5)	99.1 (5.9)	114.0 (2.7)	125.1 (5.6)
$\bar{X}$ difference	−21.1	−11.2	–	+11.8	+21.8
N	199	421	1074	326	128
Years of education					
$\bar{X}$ difference	−1.6	−0.8	$\bar{X}$ = 13.5 SD = 2.0	+1.3	+1.9
N	149	326	850	266	109
Occupational prestige					
$\bar{X}$ difference	−18.0	−10.4	$\bar{X}$ = 42.7 SD = 21.5	+4.1	+10.9
N	102	261	691	234	94
Earned income					
$\bar{X}$ difference	−9462	−5792	$\bar{X}$ = 23,703 SD = 18,606	+4407	+17,786
Mdn difference	−9750	−5000	Mdn = 22,000	+4000	+11,500
N	128	295	779	257	99

Murray (1998).

Table 2
Paired sibling sample comparison.

Cognitive class	Very dull siblings (< 10th percentile)	Dull siblings (10th–24th)	Normal reference group (25th–74th)	Bright siblings (75th–89th)	Very bright siblings (≥ 90th percentile)
Bachelor's degrees					
For reference siblings without a B.A.					
Comparison siblings with a B.A.	1%	1%	(0%)	42%	59%
n	177	339	811	220	75
For reference siblings with a B.A.					
Comparison siblings with a B.A.	0%	18%	(100%)	76%	91%
n	19	55	198	78	46

Murray (1998).

Table 3
Utopian sample comparisons.

Cognitive class	Very dull (< 10th percentile)		Dull (10th–24th)		Normal (25th–74th)		Bright (75th–89th)		Very bright (≥ 90th percentile)	
Sample	Utopian	Full NLSY	Utopian	Full NLSY	Utopian	Full NLSY	Utopian	Full NLSY	Utopian	Full NLSY
Educational attainment										
$\bar{X}$ years of education	11.4	10.9	12.3	11.9	13.4	13.2	15.2	15.0	16.5	16.5
% obtaining B.A.	1	1	4	3	19	16	57	50	80	77
Employment and earned income										
$\bar{X}$ number of weeks worked	36	31	39	37	43	42	45	45	46	45
Mdn earned income	11,000	7500	16,000	13,000	23,000	21,000	27,000	27,000	38,000	36,000
% w/ spouse w/ earned income	30	27	38	39	53	54	61	59	58	58
Mdn earned family income	17,000	12,000	25,000	23,400	37,750	37,000	47,000	45,000	53,700	53,000
Childbearing characteristics										
Fertility to date	2.1	2.3	1.7	1.9	1.4	1.6	1.3	1.4	1.0	1.0
Mother's $\bar{X}$ age at birth	24.4	22.8	24.5	23.7	26.0	25.2	27.4	27.1	29.0	28.5
% Children born out of wedlock	49	50	33	32	14	14	6	6	3	5

Murray (1998).

smarter,… we should make them richer." Data found in Table 3 might inform this point of view. The design implemented in Table 3 does not utilize a sibling control; it utilizes a different kind of control, a "utopian" control. This method allows evaluation of likely outcomes of social policies designed to achieve explicit goals. Here, a variety of outcomes are examined for the Full NLSY sample ($N=12{,}686$) across the same five general ability gradations. These benchmarks are then compared to the outcomes of a "utopian" sub-sample of the NLSY. Removed from this utopian sub-sample were all NLSY participants who were raised in a single-parent home *or* in homes located within the bottom quartile of earned income. This analysis reveals how social outcomes might change as a function of eliminating single-parent homes and poverty. There are differences, to be sure, across educational attainment, employment and earned income, and childbearing characteristics, but the outcomes are strikingly similar between the full NLSY sample and the "utopian" sub-sample over the five ability gradients.

Finally, as informative as the sibling control and utopian sub-sample designs are, there is a way to complement both by reversing the sibling control analytic procedure and implementing an ability-control analytic procedure: It would be informative, for example, to select biologically unrelated individuals at comparable ability levels, who are raised in homes that systematically vary in SES. Studying these participants longitudinally would complement the power of the sibling control, which controls for SES, by controlling for ability analogously while SES systematically varies. Used in conjunction, these designs would result in a precise estimate of the relative influence of childhood SES and ability on various outcomes. They would also collectively illuminate the hazards of living in especially disadvantaged (lower) SES environments. While this idea of complementing the sibling control design with an ability-control for differential SES gradients has been available for a decade (Lubinski, 2000b, p. 22), I am unaware of an attempt to fully exploit this design. Yet, the potential yield could be tremendous. (For a nice illustration of the extent to which high levels of intellectual talent reside in low SES households, and the inverse, see Humphreys, 1985, Table 1, p. 352.).

3. An epidemiology of differential psychology: a quantitative and qualitative expansion of cognitive epidemiology

Two topics will be touched upon in this section. First, cognitive epidemiology may be expanded to include an epidemiology of promise, and second, a qualitative expansion of cognitive epidemiology to other non-cognitive dimensions of human psychological diversity is possible as well. While this special issue is justifiably focused on negative health outcomes as a function of GCA, there is a flip side to cognitive epidemiology: the examination of the relationships between positive human outcomes and GCA. Furthermore, our understanding of the development of both positive and negative outcomes can be enriched by including non-cognitive dimensions of human individuality (personality) in cognitive epidemiology frameworks. With respect to incorporating positive outcomes in cognitive epidemiology, consider the following.

3.1. Range of ability

Just as insight into the development of medical and social maladies can be gained by considering individual differences in cognitive functioning, the same is true for positive development. However, human populations are frequently placed in crude categories for epidemiological and social science inquiry based on sex, race, age, educational level or degree, developmentally delayed, gifted, etc., without consideration of the huge range of psychological diversity found within these categories (Achter et al., 1996; Dawis, 1992; Gottfredson, 1997; Lubinski, 2000a). Too often individual differences at the extremes are not measured with precision; when they are, important outcomes are seen in a clearer light. The purpose of this section is to highlight what measures of individual differences can uncover when they are not constrained by ceiling and floor effects. Rather than the examining the pathology associated with low levels of cognitive functioning, this will be done through an illustration at the other end of the bell curve, by examining the promise associated with extraordinary high levels of cognitive functioning: namely, *within* the top 1% of cognitive ability. In another context, Malcolm Gladwell (2008, p. 79) recently provided motivation for doing so: "The relationship between success and IQ works only up to a point. Once someone has an IQ of somewhere around 120, having additional IQ points doesn't seem to translate into any measurable real-world advantage." Yet, the top 1% comprises over one-third of the IQ range. The cutting score for IQs in the top 1% is around 137, but IQs can go beyond 200. The question is, do individual differences in IQs within this range make a difference?

Fig. 1 contains data from 2329 participants taken from the first three cohorts of the Study of Mathematically Precocious Youth (SMPY; Lubinski & Benbow, 2006). Because these young adolescents all scored in the top 3% on routine achievement tests administered in their schools, they were given the opportunity to take a college entrance exam before age 13, namely, the SAT (an intellectual assessment designed for college-bound high school seniors). All of these participants met the cutting score for the top 1% on either the SAT-M or SAT-V for their age group (and only a small percentage did not meet both). Frey and Detterman (2004) have shown how the SAT-Math plus SAT-Verbal composite constitutes an excellent measure of general intelligence; so here, an age 12 SAT composite was formed and parsed into quartiles to array these participants on general intelligence. Subsequently, a variety of longitudinal criteria secured 20 to 25 years later, which reflect extraordinary accomplishments in education, the world of work, and creative expression (securing a patent, publishing a novel or major literary work, or publishing a refereed scientific article) were regressed onto four quartiles of GCA based on their age 12 assessments. Odds ratios ("ORs") reflect the comparison between the top and the bottom quartiles, and all are statistically significant at the .05 level.

What is important to assess here is the overall general trend. Moving along the gradient of individual differences within the top 1% of GCA, even when GCA is assessed at age 12, ultimately results in a family of achievement functions indicating that more ability enhances the likelihood of a host of impressive accomplishments decades later. For example,

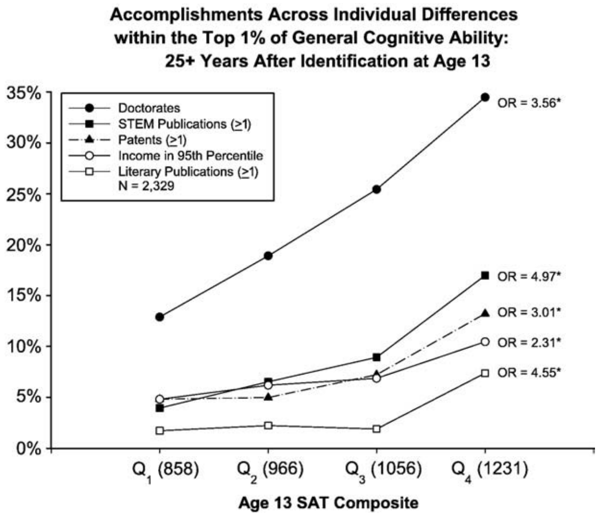

Fig. 1. Participants are separated into quartiles based on their age 13 SAT-M + SAT-V Composite. The mean age 13 SAT Composite score for each quartile is displayed in parentheses along the *x*-axis. An odds ratio comparing the likelihood of each outcome in the top (Q_4) and bottom (Q_1) SAT quartiles is displayed at the end of every respective criterion line. An asterisk indicates that the 95% confidence interval for the odds ratio did not include 1.0, meaning that the likelihood of the outcome in Q_4 was significantly greater than in Q_1. These age 13 SAT assessments were conducted before the re-centering of the SAT in the mid-1990s (i.e., during the 1970s and early 1980s); at that time, cutting scores for the top 1 in 200 were SAT-M ≥500, SAT-V ≥430; for the top 1 in 10,000, cutting scores were SAT-M ≥700, SAT-V ≥630 by age 13. [Taken from Lubinski (2009).]

approximately 1% of the U. S. general population obtains at least one patent. In each quartile, the percentage of people with at least one patent is around five times this rate, but there is a statistically significant difference between the top and bottom quartiles, 13.2% versus 4.8%, respectively. There is also a significant difference between the top and bottom quartiles in the odds of having incomes in the top 95th percentile, 10.5% versus 4.8%, respectively, and these participants are in their mid-30s; typically such incomes are earned much later in life. Overall, there does not seem to be an ability threshold within the top 1%. While other personal attributes such as energy and commitment certainly matter, and opportunity clearly always matters—more ability still imparts an advantage. It is also important to state explicitly the design features that are needed to uncover relationships such as those illustrated in Fig. 1, because studies that do not meet these methodological requirements are unlikely to reveal the functional forms of these relationships.

Empirical studies must meet the following methodological conditions in order to evaluate the significance of individual differences in ability within the top 1%. They must employ ability measures with high ceilings (capable of differentiating the able from the exceptionally able), rare accomplishment criteria (with high ceilings and low base rates), and longitudinal time frames over protracted intervals (to allow sufficient time for expertise to develop). By definition, exceptional intellectual talent is rare, and so are exceptional accomplishments, so assessments that reliably index each are needed to ascertain the extent to which these two rare events covary. In addition, because there are so many ways for exceptional abilities to operate, multiple criteria and large samples are needed. Unlike with negative health outcomes, the co-occurrence of rare positive outcomes is the exception, not the rule. Multiple criteria are needed because investing in one rare accomplishment often precludes others, and large samples are needed to establish that robust statistical trends have been uncovered for all of the criteria under analysis. Finally, as epidemiologists have long known, odds ratios are a more sensitive approach than conventional correlational analyses are for illustrating "relative risk" relationships between a variable and low base rate outcomes. And the odds ratios utilized here are based on individual differences within the top 1% of GCA!

All of these critical design features are met in Fig. 1. But many other criteria could be added to flesh out the multifaceted construct of exceptional human accomplishment and the extent to which general intellectually ability is related to such functional arrays. The modest number of outcomes displayed in Fig. 1 nevertheless makes the point. Recent findings have shown that these relationships hold even within advanced educational degrees earned at institutions of comparable quality (Park et al., 2008); and specific ability measures add refinement to predicting the nature of distinctive accomplishments (Park et al., 2007). These data show how an epidemiology of promise can be achieved with existing databases [see Gottfredson (2002), Seligman (1992, pp. 136–138), and Wai et al. (2009), for other particularly nice examples].[2] In addition, if organismic or system integrity variables were measured and related to individual differences within truly exceptional ranges of cognitive ability, a cognitive epidemiology of resilience, which is likely to be related to cognitive functioning in general, could develop. A whole new area of the physical and physiological features of exceptional cognitive abilities is waiting to be exploited.

3.2. Other dimensions of individual differences

Space limitations preclude an extensive description of how non-cognitive personal attributes would complement traditional applications of cognitive epidemiology, but pre-existing literature can serve that purpose (see Krueger, Caspi & Moffitt, 2000). Cognitive epidemiological research is likely to profit from taking traditional dimensions of personality into account (like conscientiousness, mentioned earlier), and a series of nice illustrations is found in Krueger et al. (2000). Just as industrial and vocational psychologists have found that cognitive ("can do") and non-cognitive ("will do") dimensions from the study of individual differences add incremental validity relative to each other in the prediction of performance in the world of work, the same is likely to be true for outcomes in epidemiology and health care. For example, Gottesman (1991) has argued that, for individuals with schizophrenic potentialities, among the personal assets and liabilities for attenuating-enhancing psychotic manifestations (Batty, Mortensen and Osler, 2005; Seidman, Buka, Goldstein,

[2] Gottfredson (2002) includes a nice discussion of how multiple measures have been developed that all appear to measure the same systematic source of individual differences, namely, GCA (see also, Lubinski, 2004). There are many pre-existing data bases rich for cognitive epidemiological inquiries that have good measures of GCA, if by different names, exemplifying the familiar 'jangle fallacy" (cf. Lubinski, 2004).

& Tsuang, 2006; Walker, et al., 2002; Zammit et al., 2004), GCA is a salient asset or a "cognitive reserve" (cf., Koenen et al., 2008). The same is true for better understanding other nosological psychiatry categories based on GCA and other systematic sources of individual differences in personality Krueger et al. (2000).

4. Cognitive epidemiology and normal science

A major portion of this commentary has been devoted to the importance of untangling GCA and SES. There are multiple reasons for this, and they extend beyond cognitive epidemiology and broadly cover the bio-behavioral sciences. In the neurosciences, for example, a neuroscience of poverty is emerging and multiple studies in this arena neglect the possibility that ability is a more important determinant of the neurological phenomena under analysis than SES is (Hackman & Farah, 2008; Lipina & Colombo, 2009). Just as Sackett et al. (2009) have recently shown that the longstanding purported relationship between SES and academic achievement pales in comparison to the relationship between cognitive ability and academic achievement, the same needs to be kept in mind for the neurosciences. A neuroscience of poverty sounds nice, but neglecting other aspects of human individuality does not mean that these unexamined determinants fail to operate. What is needed is an empirically based form of competitive support (Lubinski, 2000a; Lubinski & Humphreys, 1997); both GCA and SES need to be measured with precision and incorporated in modeling applications. It has now been four decades since the term "sociologist's fallacy" was coined; this phrase refers to the common scenario in sociology in which SES is prejudged as the operative cause of a variety of human outcomes, while other possible determinants like GCA are neglected (Jensen, 1973). Almost all complex human behaviors and outcomes are multiply determined, so seeking multiple determinants will almost always be the most scientifically compelling way to proceed. And as in examining interventions for learning in educational settings (Corno et al., 2002; Snow, 1991), there is reason to assess general ability differences before venturing claims about the causal role of SES. When a determinant has accrued a compelling empirical base in a particular context, as GCA has for a variety of educational-occupational settings (Sackett et al., 2009; Schmidt & Hunter, 1998) as well as for epidemiological and health care outcomes (Deary et al., 2009; Gottfredson, 2004; Lubinski & Humphreys, 1992, 1997), neglecting its possible role (and presupposing causal status to one of its covariates, SES) violates Carnap's (1950) Total Evidence Rule, and results in an error of induction known as the "fallacy of the neglected aspect" (Castell, 1935, pp. 32–33). All of these ideas follow from informed scientific reasoning, but also, they are firmly grounded rules of inductive logic (Lubinski & Humphreys, 1997, pp. 188–192; Lubinski, 2000a, pp. 432–433).

The advances that cognitive epidemiology has contributed over the past 15 years by applying powerful measures of human individuality to epidemiology and health care phenomena, and methods for untangling the relative influences of purported causal determinants of health and medical outcomes, has been scientifically compelling. But what is also impressive is how this has happened. Cognitive epidemiology developed by applying well-established scientifically significant psychological concepts, measures, and methods to a new domain of human phenomena. This has happened in other contexts with similar results.

For example, when powerful concepts, measures, and methods derived from the experimental analysis of behavior where applied to pharmacology (viz., reinforcement/punishment contingencies, schedule effects that temporally structure kinetic patterns and motivation operations, etc.), an elegant science of behavioral pharmacology was spawned (Thompson & Schuster, 1968). A new class of discriminative, eliciting, and reinforcing interoceptive stimuli emerged on the scene: pharmacological agents were shown to be capable of structuring extended behavioral patterns in highly predictable ways and with the same precision as familiar exteroceptive stimuli. In characterizing this important development, MacCorquodale (1971) made the following remarks. But I have taken the liberty of replacing "discriminative, eliciting, and reinforcing stimuli" with "[medical, physical, and social support outcomes]" to underscore the generalizability of MacCorquodale's observations (about behavioral–pharmacology) to the present context (cognitive epidemiology).

> … [T]hese results seem most remarkable to me for their congruence with the effects of other stimulus manipulations. Let me hasten to say that this general orderliness and consistency pleases me, because it reassures me about the sensitivity and generality of our laboratory procedures, and the validity of the generalizations we have made so far about behavior in general. I suppose, however, that research workers in any specialized area would really prefer to get very durable, highly reproducible, but wholly innovative and hopefully disconfirming outcomes. When this happens, one can get lots of extra mileage out of his results by brandishing a new paradigm at everyone else, or at least hinting at one, and proclaiming a scientific revolution. I have heard none of that sort here. We are still in business so far as I can see, but we have a lot of new information about a new class of [medical, physical, and social support outcomes]. That is news; it is useful and it is constructive. But it is not revolutionary, and I am delighted (Kenneth MacCorquodale, 1971, p. 217).

Today, thanks to the exquisite application of behavioral pharmacological techniques, no drugs are sold over the counter that rats or monkeys bar press for because of their abuse liability in humans. Indeed, the abuse liability of drugs is arguably the most powerful animal model of human behavior in all of psychology; yet, even here, within species individual differences are routinely encountered (Lubinski & Thompson, 1993). Perhaps someday, procedures based on cognitive epidemiology will be in place to forestall iatrogenic effects of drugs due to inappropriate usage. Just as behavioral economists have stressed that there are more behavioral determinants operating in marketing than considerations about maximizing profit, cognitive epidemiologists have stressed that compliance is multiply determined. For interventions to be optimally effective, insights from cognitive epidemiology should be utilized for designing preventative measures for populations challenged by limited processing capabilities and temporal horizons.

Cognitive epidemiology is not a fad; on the contrary, it is here to stay. There is much work yet to be done, and this special issue of *Intelligence* takes an important step in the right direction. Cognitive epidemiology is an enterprise that will add precision to conceptual frameworks in epidemiology and health psychology, but it is unlikely to be paradigm-shifting or revolutionary—practicing scientists and health care professionals will have to be satisfied with the more modest ambitions of enhancing the human condition and saving lives.

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