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Darwinism, behavioral genetics, and organizational behavior: a review and agenda for future research

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Summary In this article, a case is made for the importance of evolutionary processes and behavioral genetics for organizational behavior. First, we present scientific arguments connecting evolutionary biology and psychology, Darwinian theories, behavioral genetics, and individual differences. Second, we provide a review of behavioral genetics research on constructs relevant to organizational behavior, such as cognitive ability, personality, work attitudes, and leadership. Third, we discuss mechanisms explaining genetic influences on organizational outcomes such as attitudes and leadership. Finally, current issues in behavioral genetics research in general and their implications for organizational behavior are discussed. We also discuss issues specific to conducting research on genetic effects influencing constructs from the organizational realm, and offer suggestions for future research. Copyright © 2006 John Wiley & Sons, Ltd.

Introduction

In the first family study on the inheritance of talent, Sir Francis Galton, the father of behavioral genetics, presented evidence that talent is inherited from parents to offspring: ‘I find that talent is transmitted by inheritance in a very remarkable degree . . . . I justify my conclusions by the statistics I now proceed to adduce, which I believe are amply sufficient to command conviction’ (Galton, 1865, p. 157). ‘Commanding conviction’ with respect to the fact that variation in human behavior is attributable, in part, to genetic variation has been a primary goal of subsequent behavioral genetics research. Research in quantitative genetics, the traditional individual-differences perspective on genetics (vs. molecular genetics which takes a species-universal perspective; Plomin, DeFries, Craig, & McGuffin, 2003) has firmly established that individual differences in virtually all behavioral domains have a genetic component. However, we note that these research findings do not imply that nature is more important than nurture in the development of individuals or in influencing their behavior. As Plomin and Daniels

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(1987, p. 1) indicate, 'behavioral-genetic research seldom finds evidence that more than half of the variance for complex behavioral traits is due to genetic differences among individuals', and therefore such results provide 'the best available evidence' (Plomin & Daniels, 1987, p. 1) for the importance of environmental influences (also see Plomin et al., 2003). More generally, as Sherman et al. (1997) note in the American Society for Human Genetics statement on behavioral genetics:

> The acknowledgement that genetic as well as environmental influences underlie human behavior is consistent with Darwinian natural selection and hence places human behavior within a broad evolutionary framework.

Findings from behavioral genetics research have profound implications for the study of organizational behavior. Heritable constructs such as intelligence, personality, and attitudes are central to the study of behavior in organizations, and calibrating the relative contribution of genotypic and environmental differences to the variation in these constructs across individuals informs research and theory in the areas of selection, work attitudes, and a variety of work outcomes such as voluntary behavior and job performance. Understanding the genetic source of human behavior should lead to a better understanding of the ways in which employees perceive, react to, or feel about their jobs in general or about daily events, how they guide their decisions, and perhaps would aid in designing organizations that would work in harmony with human nature (Nicholson, 1998).

In this article, we have four broad goals. First, we present scientific arguments connecting evolutionary biology and psychology, Darwinian theories, and behavioral genetics and individual differences. Second, we review the extant behavioral genetics research on constructs relevant to work in organizations. Third, we discuss potential explanatory mechanisms for the influence of genetics on work attitudes and behaviors. Specifically, we propose that the genetic effects on work attitudes documented in previous research and the implied genetic effects on behavior in organizations and job performance are mediated by individual differences from domains such as ability and personality. In support of this assertion, we describe recent research on the mediating role of stable traits in explaining the heritability of job satisfaction (Ilies & Judge, 2003) and of leadership emergence (Ilies, Gerhardt, & Le, 2004), as well as on-going research on the different roles played by genetics and personality in determining leadership tendencies and behaviors (Arvey, Rotundo, Johnson, McGue, & Zhang, 2004). Fourth, we discuss future directions for behavioral genetics research in general and for organizational applications of behavioral genetics in particular, and we suggest topics for future research as well as some designs that could be useful in studying these topics.

Darwinism, Evolutionary Psychology, and Behavioral Genetics

When asked whether he would discuss man in the *Origin of the Species*, Darwin replied, 'I think I shall avoid the subject, as so surrounded with prejudice, though I full admit it is the highest and most interesting problem for the naturalist.' (Pearson, 1914–1930, p. 86) Consequently, the only mention of man in the *Origin of the Species* is found on the next to last page where Darwin (1859, p. 488) wrote:

> In the distant future I see open fields for far more important researches. Psychology will be based on a new foundation, that of the necessary acquirement of each mental power and capacity by gradation. Light will be thrown on the origin of man and his history.

Galton, on the other-hand replied to the same question quite differently, asserting that 'I shall treat man and see what the theory of heredity and variations and the principles of natural selection means when applied to man' (Pearson, 1914–1930, p. 86). Galton launched a research program that was to develop into the systematic study of individual difference and the founding of modern statistics (the biometric school) and behavior genetics, among other accomplishments (Gillham, 2001). His early work on individual differences was summarized in *Hereditary Genius* (Galton, 1869/1914) and Darwin incorporated the findings from *Hereditary Genius* into his theorizing. In *The Descent of Man, and Selection in Relation to Sex* Darwin (1871) argued:

> So in regard to mental qualities, their transmission is manifest in our dogs, horses, and other domestic animals. Besides special tastes and habits, general intelligence, courage, bad and good temper, etc., are certainly transmitted. With man we now know through the admirable labors of Mr. Galton that genius, which implies a wonderfully complex combination of high faculties, tends to be inherited; and on the other hand, it is too certain that insanity and deteriorated mental powers likewise run in the same families. With respect to the causes of variability we are in all cases very ignorant . . . (pp. 110–111)

We are no longer in complete ignorance of the causes of variability. Whereas Galton (1869/1914; 1865) was correct that heredity is important neither he nor Darwin knew what was transmitted or how the mechanism of transmission worked. Gregor Mendel provided a major part of the answer (particulate inheritance, dominance, independent segregation and recombination) in 1865, but his ideas had no influence until their rediscovery in 1900. The rediscovery did not, however, result in a unified theory. Evolutionists divided into a number of camps; Mendelians, Biometricians, Naturalists, and it was many years before the evolutionary synthesis brought them together (Mayr & Provine, 1980).

Among other contributions, the evolutionary synthesis helped answer the question of how species originate, a question that has been difficult to answer within the tenets of Darwin's theory of natural selection (by itself, evolution through natural selection as a gradual and continuous process is seemingly at odds with the discontinuity between species). Mayr (1942, 1991) proposed that when populations of organisms become separated, they develop different characteristics, and thus can no longer interbreed. Within species, the evolutionary perspective on individual differences stipulates that dispositions have evolved because they contributed to solving specific adaptation problems (e.g., Buss, 2001). Individual differences in personality traits, for example, represent ranges of viable evolutionary strategies for humans as traits reflect evolved motive dispositions (Buss, 1991; Lusk, MacDonald, & Newman, 1998; MacDonald, 1991, 1995; 1998):

> This perspective proposes that personality variation represents a continuous distribution of phenotypes that matches a continuous distribution of viable strategies. Genetic variation in personality and other valued traits serve to facilitate the production of a wide range of variation (within a delimited range) which facilitate the occupation of a wide range of possible niches in the human and nonhuman environment. (Lusk et al., 1998, p. 686)

Frequency-dependent selection, an evolutionary process where the fitness of a phenotype is dependent on its frequency relative to other phenotypes in the population, offers a potential explanation for the continued existence of genetic variation of traits (e.g., Budaev, 1999).[1] This mechanism thus can also explain variability in phenotypes within a population. However, frequency-dependent selection is not the only mechanism that can explain variations in phenotypical characteristics within a population. Alternatively, such variations can be random, they can be culturally induced (Wilson, 1978), or may be

[1] In positive frequency dependent selection, the fitness of a phenotype increases with its frequency in the population (as it becomes *more* common); in negative frequency dependent selection, the fitness of the phenotype under consideration decreases with its frequency (fitness increases as the phenotype becomes *less* common). For interested readers, Hori (1993) illustrates the link between frequency dependent selection and fitness in fish, and Budaev (1999) presents empirical evidence consistent with a frequency-dependent natural selection mechanism influencing human personality.

the incidental 'by-product' of assortative mating or other processes (Buss, 1991). In an illustrative study, Bailey, Kirk, Zhu, Dunne, and Martin (2000) used a behavioral genetic design to test whether within-gender variations in sociosexuality (willingness to engage in casual sex) results from genetic variation maintained by frequency dependent selection, or whether such variations are culturally influenced (children acquire mating strategies by observing parents' relationship). These authors interpreted their results showing genetic and non-shared environmental influences (induced by factors from the environment that are unique for each individual) on sociosexuality, but no shared environmental effects (influences induced by factors from the environment shared by siblings reared together), as indirectly supportive of the natural selection explanation for the existence of variations in sociosexuality.

We cannot in this article provide either decision rules or theories to support the evolutionary origin of the specific human mental traits considered herein, as this would be a technically complex task (Bock & Cardew, 1997), although the finding that a trait is a human universal provides a strong a-priori case (Brown, 1991; MacDonald, 1998) and a strong indirect case can be made for many traits (Kenrick & Luce, 2004). The fact that a trait has heritable variance certainly tells us that it can be subject to selection, sexual or natural. The specific genetic architecture of a trait may also be revealing regarding the degree to which it has been under selection pressure. As we will show, personality traits in humans are heritable to a significant degree, but it is difficult to study their consequences for fitness, however (see Eaves, Martin, Heath, Hewitt, & Neale, 1990).

The bottom line of this extended discussion is that the behavior genetic study of human traits is a major component of the Darwinian research program, a point clearly recognized by Darwin himself as shown by his citation of Galton's work. Quantitative behavior genetic studies are also being systematically incorporated into naturalistic studies such as those of birds (e.g., Dingemanse, 2003) and other organisms because observational studies and molecular genetic studies alone only provide part of the evolutionary picture (Boake et al., 2002; Stirling, Réal, & Roff, 2002). Even evolutionary psychologists from the 'strong' adaptationist camp have begun to incorporate behavior genetics findings into their theorizing (Pinker, 2002). In addition, the evolutionary perspective on human differences reflected in heritable traits anchors individual differences theories within a much broader and perhaps more meaningful context, as Buss (1991) notes with respect to personality theories:

> Evolutionary theory promises to circumvent the plethora of seemingly arbitrary personality theories by anchoring a theory of human nature in processes known to govern all life. There is no reason to believe that humans are except from the organizing forces of evolution by natural selection. (p. 461)

In sum, from an evolutionary perspective, heritable traits reflect variations in evolved psychological systems that have helped humans solve adaptive problems in their social environment (e.g., Buss, 2001; MacDonald, 1998).[2] Information about one's or others' standing on personality traits, for example, is valuable; in that it helps humans solve social and interpersonal problems (personality factors represent broad dimensions of individual characteristics that must be considered in determining the suitability of certain strategies for navigating the social environment; MacDonald, 1998). Genetic variations underlying individual differences are thought to have maximized fitness across heterogeneous environmental niches, and thus have adaptive value (e.g., MacDonald, 1995). In the remainder of the article we consider the links between genetic differences and phenotypic (measured) differences between individuals that are important for organizational behavior.

[2]An accessible, but comprehensive treatment of evolution, behavior genetic, and evolutionary psychology for social scientists is provided by Carey (2003).

A Primer on Behavioral Genetics

Human behavioral genetics seeks to identify and characterize both the genetic and the environmental influences on individual differences in behavior. An individual's genotype (the biochemical code providing the individual's genetic composition) will impact his or her personal characteristics through biological processes and through development. Even though individual phenotypes are influenced by genetic composition; unlike genotypes, phenotypes include environmental influences.

In short, behavioral geneticists attempt to partition the variance in behavior among individuals (phenotypic variance) into genetic and environmental components. For a behavioral trait, for example, a parameter that is of interest concerns what is called the heritability (h^2) of the trait—this statistic estimates the proportion of phenotypic variance (between individuals) accounted for by genetic differences (Bouchard & McGue, 2003). Here we should point out that heredity and environment may have such an intertwined influence on within-individual human development such that it might be difficult to completely disentangle their effects (Olson, Vernon, Harris, & Jang, 2001). Currently, behavioral genetic designs can only estimate the extent to which between-individual differences in a particular individual attribute or characteristic reflect environmental or genetic variation within particular ranges of environmental and genetic variation, and not in an absolute sense. In this respect, Olson et al. (2001, pp. 845–846), state:

> Asking how much a particular individual's attitudes or traits are due to heredity versus the environment is nonsensical, just like asking whether a leaky basement is caused more by the crack in the foundation or the water outside. In a very real sense, genetic effects are also environmental because they emerge in an environment, and environmental effects are also genetic because they are mediated by biological processes.

Nevertheless the effects of the heredity and environment on a population phenotype (measured characteristic) found within a specific range of genetic and environmental variation can be estimated. Psychologists are typically interested in estimating *broad heritability*, which is composed of *additive genetic effects* (transmissible across generations) and *non-additive genetic effects* (depending on specific configurations of genes, and non-transmissible) because broad heritability represents the genetic source of individual differences.[3] In contrast, *narrow heritability* refers only to the genetic effects on the trait that are transmitted across generations, thus it considers only the additive genetic effects (e.g., Bouchard & McGue, 2003). With respect to influences produced via environmental variation, these differences can be further decomposed into differences caused by common (shared) family environments (shared environmental influences would caused unrelated individuals reared together as siblings to become similar) and differences caused by environmental influences that are unique for each individual (unshared environmental components) and, of course, error. Worth noting here is the need to account for the effects of measurement error in estimating the heritability of a particular trait. With few exceptions (e.g., Ilies & Judge, 2003; Lykken, Bouchard, McGue, & Tellegen, 1993), the heritability estimates available in the literature do not account for the attenuating effects of measurement error. Such estimates actually represent the heritability of scores on the particular measure used in the specific study, and not the heritability of the construct per se (Schmidt & Hunter, 1999). More generally, not accounting for the effects of measurement error in behavioral genetic research can result in substantial overestimation of environmental effects and underestimation of genetic effects on psychological constructs (see Schmidt & Hunter, 1999).

[3]Non-additive genetic effects include *dominance*, depending on gene combinations present at a given chromosomal locus, and *epistasis*, which depend on gene configurations across chromosomal loci.

We do not provide a review of specific methods for estimating the heritability of, and the additive and non-additive genetic effects on, scores on specific behavioral measures in this article; interested readers can find descriptions of basic behavioral genetics methods in Carey (2003), Bouchard and Loehlin, (2001), and Boomsma, Busjahn, and Peltonen (2002). In-depth treatments of model-fitting procedures based on structural equation modeling are provided by Neale and Cardon (1992) and the manual for the widely used Mx statistical modeling program (Neale, Boker, Xie, & Maes, 1999).

Behavioral Genetic Research and Organizational Behavior

A decade ago, in their review of the behavioral genetics findings with respect to measures used in organizational settings, Arvey and Bouchard (1994) made a strong case that, in psychology in general, 'biology is back.' That is, research in most domains of psychology has shown that human behavior is influenced by genetic and biological characteristics of individuals (Bouchard & McGue, 2003; Dick and Rose, 2002; Plomin et al., 2003; Sherman et al., 1997). In the organizational domain, though progress in understanding the role of genetic differences has been rather slow-paced (Arvey & Bouchard, 1994), it has become increasingly accepted that traits, attitudes, and behaviors relevant to the workplace also have a genetic component. In the remainder of this section, we review behavioral genetic research relevant to organizations. We structured this review around five construct classes: traits, attitudes, values and interests, affect, and behaviors. Whereas Arvey and Bouchard (1994) developed a review earlier, we will provide a substantially updated set of material.

Traits

General cognitive ability (GCA)

Whereas estimates of genetic influences on GCA in the reported literature vary considerably, there is little debate on whether such genetic influences exist. In a review that summarizes the entire literature on genetic influence on adult IQ, Bouchard (1998) estimates that the broad heritability of intelligence falls somewhere between 0.60 and 0.80. Other authors estimated the broad heritability of intelligence to be 0.50 (Chipuer, Rovine, & Plomin, 1990) or less (Devlin, Daniels, & Roeder, 1997). Both of these analyses fail to deal with the fact that the heritability of IQ increases with age as shown by both twin studies (Boomsma et al., 2002; Bouchard, 1998) and adoption studies (Plomin, Fulker, Corley, & DeFries, 1997).

Personality

Numerous behavioral genetics studies have been conducted on a variety of personality factors (see Bouchard & Loehlin, 2001) as well as on facet-level traits (e.g., Jang, McCrae, Angleitner, Riemann, & Livesley, 1998). Because of the emergent consensus that a five-factor model of personality (termed the 'Big Five') adequately describes human personality (Goldberg, 1990) and given its utility in explaining organizational outcomes (Barrick & Mount, 1991; Judge, Bono, Ilies, & Gerhardt, 2002; Judge & Ilies, 2002), we will only review research on the Big Five factors. Loehlin (1992) estimated various path models on personality data reported in several behavioral genetics studies of personality conducted in multiple countries (e.g., Britain, U.S., Sweden, and Australia). The broad heritabilities of the constructs, estimated by a path model that fit the data well, were 0.41, 0.49, 0.45, 0.35, and 0.38 for emotional stability, extraversion, openness to experience, agreeableness, and conscientiousness, respectively. As Ilies and Judge (2003) note, Loehlin's estimates can be considered meta-analytic estimates of the broad heritability of the Big Five traits and these estimates have been cited as such in the literature (e.g, Riemann, Angleitner, & Strelau, 1997).[4] In sum, personality traits are substantially heritable. Further, personality stability seems to be strongly influenced by genetics as well (McGue, Bacon, & Lykken, 1993, p. 105):

> It appears that the stable portion of an individual's nature—the behavioral continuity that makes one unique, recognizable, and predictable—owes largely to an enduring influence of genetic factors.

Attitudes

Job satisfaction

Perhaps the most important early study that applied behavioral genetics methods to the examination of an organization construct was presented by Arvey, Bouchard, Segal, and Abraham (1989). In this study, the authors used job satisfaction reports collected from monozygotic twins that were reared apart (in different families) to demonstrate that job satisfaction has a substantial genetic component. More specifically, they estimated that genetic factors explained approximately 30 per cent of the variance in job satisfaction scores (i.e., $h^2 = 0.30$), though this result did not remain unchallenged (Cropanzano & James, 1990, also see Bouchard, Arvey, Keller, & Segal, 1992). Subsequently, Arvey, McCall, Bouchard, Taubman, and Cavanaugh, (1994) replicated this estimate of the genetic component of job satisfaction with data from two additional samples. However, Hershberger, Lichtenstein, and Knox (1994) found no significant genetic effects on job satisfaction in a sample of twins from the Swedish Twin Registry. A possible explanation of this result concerns the job satisfaction measure they used—an ad-hoc 9-item measure composed of two items measuring extrinsic job satisfaction and seven items measuring intrinsic job satisfaction. As Hershberger et al. (1994). indicated, examination of the item-level heritabilities revealed that the two extrinsic items showed no genetic influence, consistent with the findings of Arvey et al. (1989), whereas three items measuring intrinsic satisfaction did, in fact, show significant heritabilities. In addition, Hershberger et al. (1994, p. 31) acknowledge that 'not all our job satisfaction items appeared to measure directly the worker's attitude toward the job.'

Other attitudes

Though not all relevant to the organizational domain, a wide variety of specific attitudes has been studied with behavioral genetics designs (e.g., attitudes toward alcohol, cigarettes, and coffee [Perry, 1973]; religious attitudes [Waller, Kojetin, Bouchard, Lykken, & Tellegen, 1990]; attitudes toward education, open-door immigration, etc. [Olson et al., 2001]). Findings from this varied body of literature generally revealed that a substantial proportion of attitudes (though not all) do have a genetic component, with median heritability around 0.30 (Bouchard et al., 2004; Olson et al., 2001).

Values and interests

Work values

Building upon the finding of Arvey et al. (1989) that job satisfaction has a genetic component, Keller, Bouchard, Arvey, Segal, and Dawis (1992) examined whether genetic factors are associated with work values. These authors' reasoning followed Locke's (1969) value-percept theory of job satisfaction that defines satisfaction as a function of what one wants from a job and what one perceives oneself as receiving, and hypothesized that work values (what one wants from one's job) should be, in part,

[4] Ilies and Judge (2003), after pointing out that Loehlin's (1992) estimates do not take into account measurement error, present heritability values corrected for the unreliability of the scores as well as confidence intervals around the point estimates. The corrected values computed by Ilies and Judge were 0.52, 0.62, 0.61, 0.46, and 0.49 for emotional stability, extraversion, openness to experience, agreeableness, and conscientiousness, respectively; the confidence intervals around these point estimates were (0.510, 0.530), (0.616, 0.632), (0.591, 0.630), (0.446, 0.479) and (0.475, 0.506).

influenced by genetics. Keller, Bouchard, Arvey, Segal, and Dawis (1992) used data based on the *Minnesota Importance Questionnaire* (MIQ; Gay, Weiss, Hendel, Dawis, & Lofquist, 1975) that had been administered to 43 pairs of twins reared apart (23 monozygotic pairs and 20 dizygotic pairs) to measure their preferences for 20 job outcomes. The results from multivariate analyses revealed that the six value constructs from the MIQ (achievement, comfort, status, altruism, safety, and autonomy) had heritabilities ranging from 0.18 to 0.56, with a median of 0.38. Arvey et al. (1994) replicated these results with a much larger sample of twins reared together (1165 pairs of dizygotic twins and 1236 pairs of monozygotic twins) and a different value assessment instrument (asking what factors influenced respondents' decision to enter their actual, at that time, occupational field and including 15 work characteristics such a pay, 'chance for interesting work', 'job security' etc.). These authors also found that genetics influenced the various 15 work values—the average heritability across the values was 0.35.

Perceptions of organizational climate

Though distinct from work values or job satisfaction, employees' perceptions of organizational climate represent evaluative constructs that have a dispositional component (Hershberger et al., 1994). Hershberger et al. found that two of the climate constructs (Supportive Climate and Annoyance) were substantially heritable, and further speculated that individuals' ratings of organizational climate are influenced by their affect/affectivity and, because affectivity is heritable (Finkel & McGue, 1997; Tellegen et al., 1988), individuals have genetic predispositions toward evaluating their environment consistent with their affective disposition (e.g., those who score high on positive affectivity would have a predisposition to positively evaluate their work environment). From an evolutionary standpoint, this speculation implies that heritability of organizational climate percepts is a by-product of the heritable variation in evolved traits that have adaptive value (affectivity). Alternatively, extending MacDonald's (1995) argument that personality distributions match distributions of viable adaptive strategies (see also Lusk et al., 1998), variations in organizational climate perceptions may be adaptive because they facilitate fitness to a wide range of work environments.

Vocational interests

A number of studies have found that genetic factors have a substantial influence on vocational or leisure interests (Lykken, et al., 1993; McGue & Bouchard, 1998; Moloney, Bouchard, & Segal, 1991; Waller, Lykken, & Tellegen, 1995). Lykken et al. (1993), for example, administered the *Minnesota Vocational Interests Test*, the *Minnesota Leisure-Time Interest Test*, and the *Minnesota Talent Test* to 2208 twins from the Minnesota Twin Family Registry and 1871 of their spouses or other family members. Lykken et al. computed heritability values for (a) individual interest items, (b) interest factors (e.g., 'Accountant or Numbers Person,' 'Medical & Dental'), and (c) broad superfactors (11 superfactors were derived form the 39-interest factors by means of factor analysis). As expected, the heritabilities of the factors were higher than the heritabilities of the items (average of 0.48 vs. 0.32), and the heritabilities of the superfactors were even higher (average of 0.53). This study suggests that heritabilities tend to be relatively higher for more abstract and broader constructs and factors compared to variables reflecting measurement at a more molecular level.

Affect

Affect is an inclusive term that refers to both emotions and moods (Ashforth & Humphrey, 1995; Kelly & Barsade, 2001). Affective traits, such as the broad positive affectivity (PA) and negative affectivity (NA) factors from the *Positive and Negative Affect Schedule* (PANAS; Watson, Clark, & Tellegen, 1988), are enduring dispositional characteristics of individuals that predispose them to experience certain emotions, emotional reactions, or moods (Watson, Wiese, Vaidya, & Tellegen, 1999). These dispositional traits represent individual differences in affective temperament and reflect differences among individuals in bio-behavioral systems that regulate sensitivities to rewards and punishments, and thus control appetitive and aversive motivation (the behavioral approach system and the behavioral inhibition system, respectively; Fowles, 1987; Gray, 1981, 1990; Watson, et al., 1999). The behavioral approach and inhibition systems are thought to have evolved through natural selection and thus to have adaptive value (MacDonald, 1995; Nesse, 1991).

Affective traits

Two of the five traits from the five-factor model, Neuroticism and Extraversion, have been traditionally associated with the experience of affect (Watson, 2000) and as we summarized earlier there is evidence for the genetic bases of these two traits. The Positive and Negative Emotionality high-order traits from the *Multidimensional Personality Questionnaire* (MPQ; Tellegen, 1982) are perhaps the most closely associated with the broad PA and NA factors from the PANAS. Finkel and McGue (1997) report broad heritabilities of 0.50 and 0.44 for Positive and Negative emotionality and twin reared apart data have constructively replicated the finding suggesting heritabilities of 0.43 and 0.47 (Bouchard & McGue, 2003, Table 6). Because the experience of affective states is influenced by affective traits and these traits are heritable, one can infer that affective experiences are influenced by genetic factors.

Mood

Individuals' affective experiences fluctuate across time (Watson, 2000), and these experiences fluctuate when people are at work as well (e.g., Ilies & Judge, 2002). Such fluctuations are, at least in part, determined by the actual situation when the affective state is assessed. Thus, if general affective tendencies are determined by affective traits (that, in turn, are influenced by genetics) and the actual affective experience is influenced in part by situations, the change in affective experience across situations represents, in fact, a person-situation interaction (Riemann et al., 1998). Studying the genetic influences on affect consistency and variability is exactly what Riemann et al. (1998) did in their study of positive and negative mood experiences of twin pairs across five situations. These authors found not only that genetic effects on aggregate mood measures were substantial, but also there were genetic influences on the consistency of moods across situations (though environmental effects, both shared and non-shared, were larger than the genetic effects).

Behaviors

Job and occupational switching

Following Dawis and Lofquist's (1984) Theory of Work Adjustment, which posits that person-work environment fit influences—through job satisfaction—individuals propensities to leave their job or occupation, McCall, Cavanaugh, Arvey and Taubman (1997), examined whether job and occupational switching are influenced by individuals' genetic makeup. The results of the study showed that genetic differences between individuals accounted for 36 per cent of the differences in the frequency of changing jobs and 26 per cent of the differences in the frequency of changing occupations, among a sample of 1236 monozygotic and 1165 dizygotic twin pairs.

Leadership

In no other area in organizational behavior has been the nature versus nurture debate more relevant than in the leadership area. Though early leadership researchers conceptualized leadership as residing in the person (see Judge et al., 2002), research on the personological basis of leadership has been marked by inconsistencies. Recently, however, as it has been the case in other areas (e.g., job performance, Barrick & Mount, 1991; task motivation, Judge & Ilies, 2002) meta-analytic techniques have brought clarity to the literature on the dispositional source of leadership. Specifically, in their meta-analytic review of the personality-leadership literature, Judge et al. (2002) present results showing that, as a set, the personality traits comprising the five-factor model had a multiple correlation of 0.48 with leadership. Thus, if leadership is dispositional in nature, the natural follow-up questions are whether there are genetic influences on leadership, and if so, how strong are these effects.

One published study directly investigated whether differences in individuals' genetic makeup are responsible for differences in leadership abilities and behaviors between individuals: Johnson, Vernon, McCarthy, Molson, Harris, and Jang (1998) report that a substantial proportion of variance in the broad factors of transactional and transformational leadership factors from the *Multifactor Leadership Questionnaire* (MLQ; Bass and Avolio, 1991) was associated with genetic factors. Other efforts aimed at estimating the extent to which genetics influence leadership behaviors are currently under way, and the emerging findings suggest that the differences between people in the likelihood of becoming a leader are associated with genetic differences between these individuals (Arvey et al., 2004).

In a study that departs from the typical biometric design for partitioning the variance in the scores on a measured behavioral construct, Arvey, Zhang, Rotundo, and McGue (2004) examined genetic influences on leadership exhibited *in high school* and investigated whether early leadership had a moderating influence on the heritability of emergent leadership at work. High school leadership was substantially heritable, and the variable measuring leadership in high school had a positive moderating effect on the heritability of work leadership—the magnitude of the genetic influence on work leadership increased with the number of leadership roles taken on in high school. These results suggest that early leadership experiences influence the degree to which genetic makeup influences leadership emergence in adulthood. These findings are provocative because they indicate that a characteristic (in this case leadership in work contexts) may be substantially heritable whereas the heritability may differ according to some other moderating variable. That is, the heritability of a construct or variable is not constant across all subjects. This type of interaction or moderating influence has been demonstrated by Turkheimer, Haley, Waldron, D'Onofrio, & Gottesman (2003) and discussed by Van den Oord and Rowe (1998). It is our belief that organizational behavior would benefit from studying how genotype-environment interactions affect a variety of organizational outcomes and we will return to this issue when we make suggestions for future research.

Thus, recent behavioral genetics studies strongly suggests that the *likelihood of emerging as a leader* is in part influenced by genetics. In addition, Olson et al. (2001) have shown that people's *attitudes toward being the leader of a group* were heritable ($h^2 = 0.41$), based on a sample of 672 monozygotic and dizygotic twins. Though leadership behaviors or styles and attitudes toward being a leader are distinct constructs, they are causally related, in that having a positive attitude toward leading others may be essential to successful leadership. In this sense, Nicholson (1998) suggests that the passion to lead is shared by successful leaders, and thus it may represent a stable individual characteristic that predicts leadership.

Performance behaviors

At a more molecular level, there has been some research on the heritability of counterproductive work behaviors. In his dissertation, Jockin (1998) used a twin design with monozygotic and dizygotic male twins to explore whether a scale called 'Censured Job Performance' consisting of items associated with counterproductive work behavior and low job performance (i.e., reprimands, probation, or performance-related dismissal) was heritable. His finding showed that this scale was significantly heritable (0.37) although the genetic mechanisms were not additive in nature, but rather reflected 'dominance' or the tendency for genes to interact with one another. Thus, there is some direct evidence that genetic factors are also partially influential in determining a variety of job performance outcomes.

Explaining Genetic Influences on Organizational Behavior

The research reviewed in the previous section has convincingly shown that personological constructs such as cognitive ability and personality, and attitudinal, affective, or behavioral constructs such as job satisfaction are genetically influenced. With respect to attitudes, Arvey and Bouchard (1994, p. 67) note: 'Exactly why genetics should influence attitudes is neither well developed nor understood. It is possible that the linkage is through personality or other dispositions (even IQ).' Similarly, Hershberger et al. (1994) suggest that the genetic influence on perceptions of organizational climate is mediated by personality, cognitive, and demographic constructs. Such mechanisms, as well as explanations for the genetic effects on temperamental differences between individuals are considered in the discussion that follows.

Currently, we have no evidence for a direct tie between attitudes and behaviors and individuals' genotypes. Attitudes, for example, involve evaluative statements that are formed over the years through personal experience and social information. On this issue, Olson et al. (2001, p. 846) note:

> First, it is extremely unlikely that there are direct, one-to-one connections between genes and attitudes (e.g., a gene that causes attitudes toward capital punishment) or even many-to-one connections (e.g., a set of genes that, together, cause attitudes toward capital punishment). Rather, genes probably establish general predispositions or natural inclinations, which then shape environmental experiences in ways that increase the likelihood of the individual developing specific traits and attitudes.

One likely intervening mechanism linking genotypes to phenotypes concerns the role of biological and neurological basis of phenotypic differences. MacDonald (1995; 1998), conceptualizes the human mind as a set of mechanisms that have evolved through natural selection to solve adaptive problems, and expects these systems to be organized in the brain as discrete neurophysiological systems. Trait distributions on Extraversion, Dominance, and Sensation Seeking, for example, are thought to reflect phenotypic variation in the behavioral approach system, which was designed by natural selection to motivate organisms to approach sources of reward (e.g., sexual gratification; MacDonald, 1998).

In short, genes do not directly cause attitudes or behaviors, but they encode evolved neurophysiological systems that have adaptive value (e.g., the behavioral approach system promotes fitness by facilitating the acquisition of resources related to reproductive success). These systems, in turn, are connected to personality, which influences attitudes and behaviors (e.g., individuals with more active behavioral approach systems tend to be more aggressive and dominant). Indeed, there is evidence linking personality systems to distinct brain regions (Canli, et al., 2001; Ebmeier, et al., 1994; Stenberg, Risberg, Warkentin, & Rosen, 1990; Stenberg, Wendt, & Risberg, 1993), as well as to indicators of neurobiological activity such as dopamine receptor density (Farde, Gustavsson, & Jonsson, 1997). Furthermore, several animal species have been found to vary in traits linked to neurophysiological systems similar to those underlying human personality (e.g., primates [Suomi, 1991], wolves [MacDonald, 1983]), and there is also evidence that variations in chimpanzee personality can be understood within the Big Five personality framework (see King & Figueredo, 1997).

Rothbard, Ahadi, and Evans (2000), argue that understanding individual differences in temperament is crucial for understanding human personality. These authors assert that temperamental differences are directly linked to genetic differences between individuals, and that temperament 'influences and is influenced by the experience of each individual, and one of its outcomes is adult personality' (Rothbard, et al., p. 122). Similarly, Cloninger, Adolfsson, and Svrakic (1996) argue that because individual differences dimensions assessed with instruments designed to measure temperamental domains (e.g., novelty seeking, harm avoidance, reward dependence) have simple genetic architecture (in contrast to the complex architecture of traits derived by factor analysis at the phenotypic level, such as the Big Five factors), such instruments should be useful for 'unraveling the genetics and neurobiology underlying human personality' (p. 3).

As noted, we believe that genetic influences on attitudes and behavior are realized, in part, through personality. With respect to job satisfaction, Judge, Heller, and Mount (2002) suggest that because personality predisposes people toward specific interpretations of life or work events (e.g., extroverts are more likely to interpret their life circumstances more positively than introverts) and also influences their pattern of behavioral activity (e.g., extroverts have more friends, spend more time in social situations and find social interactions more rewarding), personality factors should predict employees' satisfaction with their job. In their meta-analytic review, these authors found that, indeed, personality was related to job satisfaction in that the Big Five personality factors, as a set, showed a multiple correlation of 0.41 with job satisfaction.[5]

In a follow-up investigation, Ilies and Judge (2003) examined whether the Big Five factors of personality are primarily responsible (through mediation) for the genetic influences of job satisfaction, using path analysis of meta-analytic correlations. Unexpectedly, they found that the five factors mediated only 24 per cent of the genetic variance in job satisfaction. An alternative dispositional framework, comprising the affective traits of PA and NA (as measured by the Positive and Negative Emotionality scales from the MPQ), was found to mediate 45 per cent of the genetic effect. To the extent that the Positive and Negative Emotionality constructs represent a broader conceptualization of affective personality than the Big Five factors, the fact that the two emotionality constructs, jointly, are stronger mediators of genetic effects on job satisfaction than the set of Big Five factors, is consistent with our observation that broader and more abstract constructs seem to be more strongly influenced by genetics than narrower and more specific constructs.

Similar to the Ilies and Judge (2003) analysis of mediated genetic effects, Ilies, et al. (2004) conducted an investigation of genetic effects on leadership emergence as mediated by cognitive ability and personality. These authors computed a partial heritability of leadership emergence $h_p{}^2 = 0.17$ (the genetic effects mediated by general cognitive ability and the Big Five personality factors). Whereas the magnitude of this estimate may not seem very large, given that other genetic effects on leadership emergence are likely to exist (e.g., through genetically influenced characteristics such as physical appearance, height, etc.), the fact that 17 per cent of the between-individual differences in the likelihood of emerging as a leader are associated with genetic differences expressed through cognitive ability and personality are, in our view, impressive.

The two genetic mediation studies described above have used an indirect method for computing the partial heritability of job satisfaction and leadership emergence. Whereas the Ilies and Judge method is a valuable tool for investigating mediated genetic effects on organizational outcomes, the method has limits in that as it can be used only if meta-analytic estimates of the correlations of the predictor traits with the various outcomes and the intercorrelations among the predictors traits are available in the literature (Ilies & Judge, 2003). In addition, whereas it may be reasonable to assume that one can capture important mediated effects with path analysis on meta-analytic correlations, it is not reasonable to assume that one can capture all trait-mediated effects with such a design. Finally, unless estimates of

[5]See Heller, Watson, and Ilies (2004) for a review and conceptual analysis of the connection between individuals' personality, their satisfaction with various life domains, and their general life satisfaction.

the trait intercorrelations *at the genetic level* exist, the Ilies and Judge method can only consider traits that can be reasonably thought of as having independent genetic causes (i.e., they are not correlated at the genetic level; see Ilies & Judge, 2003).

The limitations of the Ilies and Judge (2003) method can be avoided by using primary twin or familial data to investigate mediated genetic effects. Though not represented in the organizational literature, designs for investigating mediated genetic effects are not uncommon in behavioral genetics studies. Jockin, McGue, and Lykken (1996), for example, examined whether genetic influences on personality explained the heritability of divorce risk in a sample of 745 pairs of monozygotic and dizygotic twins from the Minnesota Twin Registry. They found that additive genetic effects on personality explained 30 per cent of the heritability of divorce risk for women, and 42 per cent of it for men. Similarly, Olson et al. (2001) found that some of the attitudes examined in their study were significantly correlated with self-reported personality and ability factors at the genetic level.

In sum, there have been direct studies investigating mediated genetic effects through personality (Jockin et al., 1996; Olson et al., 2001), and there have been indirect studies investigating mediated genetic effects on organizational constructs such as job satisfaction (Ilies & Judge, 2003) and leadership (Ilies et al., 2004). The evidence from these studies suggests that genetic effects on attitudes, affect, and behaviors are partially mediated, or explained, by an integrated framework of personal characteristics composed of a set of heritable constructs from the domains of physical characteristics, cognitive ability, and personality. Such mediating mechanisms have been suggested by Arvey and Bouchard (1994) and by Ilies and colleagues. In the model of mediated effects on leadership emergence, for example, Ilies et al. (2004) included personality (the Big Five factors) and intelligence as mediating factors. Ilies et al. mentioned that it is unlikely that the traits they considered mediate all, or even most, of the genetic effects on leadership emergence because other heritable constructs such as height and appearance are likely to have strong effects on leadership emergence.[6]

It is important to note that mediating constructs such as the Big Five personality factors reflect individual differences in affective, cognitive, and behavioral tendencies and are not direct reflections of temperamental differences (Cloninger et al., 1996). The existence of individual differences in a personality trait, does not by itself explain why such differences exist. As Watson (2000, p. 16) notes, 'in contrast, the concept of temperament implies that these observed individual differences at least partly heritable and that are to some extent already present at birth (Buss & Plomin, 1984).' Cloninger et al. define temperament as 'the dynamic organization of the psychobiological systems that regulate automatic responses to emotional stimuli' (p. 3). We suggested that broader and more abstract individual differences constructs such as Positive and Negative Emotionality may be stronger mediators of the genetic effects on attitudes, compared to more specific constructs. Presumably, these differences arise because the broader constructs are more direct reflections of temperamental differences, compared with specific traits reflecting observed differences in behavioral tendencies.

We recognize that the notion of possible mediating constructs between genetic factors and outcomes is not a new one. For example, Herrnstein and Murray (1994) articulated a mediated genetic model for earnings and prestige, where IQ was the mediating construct. As with other socially important outcomes, a criticism that can be leveled against such explanations of between-people differences in indicators of life success concerns the fact that traits and skills important for success are culturally transmitted within a population. At a very broad level, E. O. Wilson's gene-culture co-evolution theory (e.g., Wilson, 1978) offers an elegant explanation for how genetics and culture intertwine to create the complexity of human life. That is, Wilson (1978, p. 78) considers that 'human social evolution proceeds along a dual track of inheritance: cultural and biological. Cultural evolution is Lamarckian and

[6]Olson et al. (2001) mention that physical characteristics such as height (as well as psychological traits such as intelligence and personality) may influence how individuals develop their attitudes.

very fast, whereas biological evolution is Darwinian and usually very slow.' Implicit in the gene-culture co-evolution theory is the argument that the culture reinforces patterns of social behavior that reflect traits that had adaptive value during human evolution, thus genetics and culture are related.

Current Issues, Implications, and Directions for Future Research

General issues

The publication of the working draft of the human genome sequence in February 2001 (The International Human Genome Mapping Consortium, 2001; Venter et al., 2001) marked the beginning of the genomic era. In this new era, great opportunities for increasing our understanding of human evolution and of what makes us different from other species have been created (Caroll, 2003). Besides studying DNA sequences that make humans different from other species, the sequencing of the human genome also makes possible the study of DNA sequences that make us different from one another (Plomin et al., 2003).

As noted, single genes do not have direct influences on human behavior. In general, behavioral tendencies depend on the interplay between the environment and multiple-gene systems called Quantitative Trait Loci (QLT; e.g., Sherman et al., 1997). Although QLT studies have been successful in identifying trait loci associated with complex disorders such as schizophrenia and complex behavioral traits such as neuroticism without using the human genome sequence (Fullerton et al., 2003; see Sherman et al., 1997), the availability of the human genome sequence should greatly facilitate the location of QLTs associated with behavioral traits, which will lead to greater understanding of the biological basis of individual differences. (McGuffin, Riley, & Plomin, 2001).

Besides creating great opportunity, scientific advances in genomics and their applications for understanding behavioral differences between individuals imply new responsibilities. For example, because of the possibly profound social consequences of the newly acquired knowledge, the publicly funded Human Genome Project allocated 3–5 per cent of its budget to study how the rapidly accumulating knowledge about the human genetic makeup may affect society in general (Collins, Morgan, & Patrinos, 2003). Social consequences of scientific advances in genomics are especially relevant to the work and organizations. If genetic structures associated with particular behavioral traits continue to be identified in the future, organizations might use genetic information for screening and selection (Arvey et al., 1994). To prevent unethical use of genetic testing and genetic information, as of early 2003, more than 40 states in the United States have passed genetic non-discrimination bills (Collins et al., 2003), and the Genetic Non-discrimination Bill was moving forward in the United States Senate.

Implications for Organizational Behavior and Suggestions for Future Research

Advances in basic genetic science will have a substantial impact on psychological science. On this issue, McGuffin et al. (2001, p. 1249) argued that:

> Ultimately, the human genome sequence will revolutionize psychology and psychiatry. The most important impact will be on understanding the neurological basis of individual differences and achieving a better grasp of the etiology of disease.

Understanding individual differences in behavioral traits will be of great value to organizational behavior as such knowledge can guide the development of nomological models explaining attitudes and behavior at work.

For the more immediate future, we believe that behavioral genetics research has the potential to add to the understanding of behavior at work in at least four areas. First, biometric studies have the potential to advance our understanding of between-individual differences in organizational behavior outcomes such as leadership, motivation, and job performance. When possible, studies based on twin or familial data should be conducted in these areas. When such data are not available, following Ilies and Judge (2003), researchers can compute lower-bound estimates of the influence of genetic differences on differences in organizational outcomes. As noted, one such possible area of study concerns job performance. By combining the estimate for the heritability of intelligence (Bouchard, 1997), corrected for unreliability, with the meta-analytical correlation between intelligence and job performance (Hunter & Hunter, 1984), the partial heritability of job performance through intelligence alone (and across a wide assortment of jobs) reaches 21 per cent. Given that personality, which is also heritable (e.g., Loehlin, 1992) also predicts job performance (e.g., Barrick & Mount, 1991), the partial heritability of job performance through the combination of intelligence and personality will likely surpass 30 per cent. Future studies should compute more precise estimates of genetic effects on performance by calibrating the heritability of job performance mediated by constructs suggested in our model. In addition, moderator analyses for various types of jobs can further increase the precision of the estimates (e.g., physical characteristics predict performance in job involving manual labor more strongly; intelligence predicts performance more strongly for more complex jobs, Hunter & Hunter, 1984).

Second, specific operational models explaining the mechanisms through which genetics influence certain organizational outcomes can and should be developed and tested. One issue that deserves investigation is the causal flow of effects from the genotype. We suggested that the most proximally influenced individual differences concern temperamental dimensions, followed by more specific individual differences constructs. In turn, genetically influenced person-based constructs influence more specific evaluative reactions (e.g., affect and attitudes), which in turn influence behavior. Such causal flow is suggested by differences in heritability estimates among the mediating constructs (broad temperamental factors are more heritable than narrower, more specific individual differences constructs), but future research should directly test this type of mediated genetic effects.

Third, examining how genetics and environment interact in influencing behavioral constructs is a developing area of research that offers great promise and has fascinating implications. Genotype-environment interactions refer to real effects of specific combinations of genes and environments (vs. genotype-environment correlations, which refer to the finding that specific genotypes are more likely to exist in specific environments; Van den Oord & Rowe, 1998). In a recent study, Turkheimer et al. (2003) examined genetic and environmental effects on IQ in a sample of mothers enrolled in the study during pregnancy and their children who were followed up until age seven. These authors found that an environmental variable, socioeconomic status (SES), had a moderating effect on the heritability of IQ (it influenced the proportion of variance in IQ explained by genetics).[7] More specifically, the results showed that the effect of the shared environment on IQ within impoverished families accounted for about 60 per cent of its variance while the effects of genes on IQ was negligible within this category. In contrast, in affluent families, the results showed that the relative contribution of the environment and genetics influences was essentially reversed. As mentioned, the findings of Arvey et al.

[7]The SES measure was based on a linear combination of parental education, occupational status, and income. Of note is that the SES measure is not a pure environmental marker; differences among children reared in families at the low- and high-end of the SES spectrum can be both environmental and genetic in nature (Meehl, 1970, p. 394; Scarr & Weinberg, 1978).

(2004) indicate that the extent to which work leadership is genetically influenced depends on the opportunity to experience leadership early in life.

The findings mentioned above suggest that examining the role of genotype-environment interactions in producing developmental outcomes relevant to work in organizations (such as IQ and leadership qualities) can lead to understanding how early experiences and environmental conditions and opportunities influence the relative contribution of genes and environment in explaining individual differences in such outcomes. For example, if other interactions are observed between environmental and genetic factors, it may be possible to amplify certain developmental (or environmental) experiences among individuals to help accelerate their leadership potential.

Fourth, biometric studies of attitude change and consistency have the potential to offer new insights into how person-situation interactions influence general attitudinal evaluations (and other relevant work variables). Recently, studies that investigated within- and between-individual components of job attitudes (Ilies & Judge, 2002; Judge & Ilies, 2004) with dynamic designs (e.g., examining and explaining temporal variations in attitudinal evaluations) have shown that people's attitudes vary considerably across time. Following the method of investigating person-situation interactions by using ratings of momentary experiences (mood) presented by Riemann et al. (1998), future research could investigate the connection between genetics and task satisfaction variability and consistency (perhaps more feasibly in the laboratory). Given that some research findings suggest that personality is related to individuals' differences in mood and job satisfaction variability (Ilies & Judge, 2002), it would not be surprising if genetic differences between individuals would be found to be associated to differences in characteristic variability of job satisfaction.

Another area where investigating person-situation interactions can reveal interesting results concerns job performance at different points in time. We mentioned that, on average, job performance is likely to be heritable. Examining influences of person-situation interactions on job performances across time and situations can reveal whether genetic effects on performance are stronger when employees are new on the job (or the task is novel) or are at the beginning of a career, or such effects are stronger when employees are more experienced on the job or with a task. In addition, such examinations have the potential to uncover the source of consistency and variability in behavioral tendencies at work.

Conclusion

In this article, we (a) make a case for the links between evolution, genetics, and individual differences, (b) provide an up-to-date review on behavioral genetics research on constructs and outcomes relevant to organizational behavior, (c) address the mechanisms explaining genetic influences on organizational outcomes, (d) discuss the implications of current advances in genetic science for psychology and organizational behavior, and (e) suggest areas of research where behavioral genetics can shed new light on organizational issues. We believe the paper will be informative to organizational behavior scholars, and we certainly hope it will stimulate new research.

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