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On the Heritability of Job Satisfaction: The Mediating Role of Personality

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In this article the authors investigate the extent to which traits reflecting individual differences in personality and affectivity explain or mediate genetic influences on job satisfaction. Using estimates of the dispositional source of job satisfaction according to 2 dispositional frameworks—the five-factor model and positive affectivity–negative affectivity (PA–NA)—and behavioral–genetic estimates of the heritabilities of job satisfaction and the dispositional factors, the authors computed the proportion of genetic variance in job satisfaction that is explained by these trait frameworks. Results indicate that the affectivity model is a stronger mediator of genetic effects on job satisfaction than the five-factor model. PA and NA mediate about 45% of the genetic influences on job satisfaction, whereas the five-factor model mediates approximately 24% of these genetic effects.

Though the existence of individual differences in job satisfaction has been recognized for as long as job satisfaction has been formally studied (e.g., Hoppock, 1935; Weitz, 1952), the dispositional approach to job satisfaction has been the focus of major research efforts only since the mid 1980s (House, Shane, & Herold, 1996). Staw and Ross (1985) found that measures of job satisfaction displayed significant temporal and cross-situational consistency. Staw, Bell, and Clausen (1986) found that affective disposition, assessed at childhood, influenced ratings of job satisfaction that were reported more than 40 years later. In perhaps the most provocative study, Arvey, Bouchard, Segal, and Abraham (1989) presented evidence that job satisfaction has a substantial genetic component. Arvey et al. (1989) found significant similarity in general job satisfaction ratings of 34 pairs of monozygotic (MZ) twins reared apart from early childhood (MZA; the intraclass correlation between the twins' ratings was .31, $p < .05$). Subsequently, Arvey and colleagues documented the genetic component of job satisfaction with data from two additional samples (Arvey, McCall, Bouchard, Taubman, & Cavanaugh, 1994).

The studies reviewed above offer only indirect evidence for the dispositional source of job satisfaction in that they did not document any direct relationship between job satisfaction and dispositional characteristics of individuals (Judge, 1992). These studies are to be credited for establishing interest in the dispositional perspective, and the Staw et al. (1986) and Arvey et al. (1989) studies are particularly noteworthy for their potential to stimulate research on the "genetic pathway" (Arvey et al., 1989, p. 191) that may explain the heritability of job satisfaction. More specifically, both Arvey et al. (1989) and Staw and Ross (1985) suggested that research was needed to study the influence of specific traits on job satisfaction. What ensued was a large number of direct studies examining the relationship between job satisfaction and various personality traits.

Consistent with the classic definition of job satisfaction as an emotional state (Locke, 1976), researchers have used a large variety of personality measures in attempts to capture the affective dispositions underlying job satisfaction. Judge and Hulin (1993) and Judge and Locke (1993) found that affective disposition, measured as the response to a series of neutral objects common to everyday life (e.g., the way people drive, 8.5-in. × 11-in. paper), was related to job satisfaction. The premise of this measure is that individuals predisposed to be dissatisfied with neutral items are likely to be unhappy with most aspects of their lives including their job.

A personological framework that has often been studied in relating affective disposition to job satisfaction comprises the traits of positive affectivity (PA) and negative affectivity (NA; Watson & Clark, 1994; Watson, Clark, & Tellegen, 1988). NA reflects individual tendencies to experience aversive emotional states, such as fear, hostility, and anger, whereas PA reflects the propensity to experience positive states, such as enthusiasm, confidence, and cheerfulness (Watson, Wiese, Vaidya, & Tellegen, 1999). Several studies have related PA and NA to job satisfaction. These studies have consistently shown moderate relationships of PA and NA and job satisfaction (see Brief, 1998; Spector, 1997; Watson, 2000). A recent meta-analysis of these relationships found true-score correlations (corrected for unreliability) between PA and NA and job satisfaction of .49 and −.33, respectively (Connolly & Viswesvaran, 2000).

Though traditionally less studied in research on the dispositional source of job satisfaction, the Big Five (Goldberg, 1990) framework, alternatively referred to as the five-factor model of personality, provides a comprehensive taxonomy to organize traits relevant to job satisfaction (Judge, Heller, & Mount, 2002). The five-factor model comprises the dimensions of Neuroticism (often labeled by its polar opposite, Emotional Stability), Extraversion, Openness to Experience, Agreeableness, and Conscientiousness. Judge, Heller, et al. (2002) used the five-factor model to cumulate the results of previous studies that investigated relationships be-

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tween personality traits and job satisfaction by means of meta-analysis. Judge et al. found that four of the Big Five traits were related to job satisfaction. After classifying 335 correlations between personality traits and job satisfaction reported in 135 research projects into categories corresponding to the Big Five traits, Judge, Heller, et al. (2002) computed true-score correlations between each of the Big Five traits and job satisfaction. The true-score correlations were −.29, .25, .02, .17, and .26 for Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness, respectively. Though the Big Five traits vary in their relevance to job satisfaction (with Openness being the least relevant), Judge et al. concluded that organizing personality traits according to the five-factor model leads to substantial support for the dispositional source of job satisfaction.

As noted, there have appeared studies that demonstrate significant stability in job satisfaction (indirectly suggesting a dispositional source of job satisfaction) as well as direct studies showing job satisfaction to be related to various personality traits, and there are the two studies showing that job satisfaction is a heritable construct (Arvey et al., 1989, 1994). Our study attempts to integrate these diverse studies by using the literature on genetic effects on personality. Arvey et al. (1989), like Judge (1992), speculated that heritability in job satisfaction is likely explained by personality dispositions. Logically, because the Big Five personality factors are heritable (Loehlin, 1992; Loehlin, McCrae, Costa, & John, 1998) and because four of the five traits predict job satisfaction (Judge, Heller, et al., 2002), the Big Five factors should mediate the genetic source of job satisfaction. Similarly, PA and NA are heritable (Tellegen et al., 1988), and they are related to job satisfaction (Connolly & Viswesvaran, 2000), so they likewise should mediate genetic influences on job satisfaction. After suggesting that additional research efforts on the influence of specific traits on job satisfaction are needed, Arvey et al. (1989) concluded, "These efforts could aid us in disentangling the various sources of variance that contribute to job satisfaction and other organizationally based phenomena" (p. 191). In this article, we sought to "disentangle" genetic and nongenetic influences that are present in the relationships between personality traits and job satisfaction by integrating meta-analytic results summarizing the relationship between personality and job satisfaction with behavioral–genetic estimates of the genetic nature of personality and of job satisfaction.

Accordingly, the purpose of the present study is to evaluate the extent to which personality, as operationalized through two personological frameworks—the five-factor model and the affectivity model (the PA–NA model)—mediate the genetic effects on job satisfaction. Toward that end, we first introduce several behavioral–genetics concepts that are relevant to our evaluation of the mediation effect of personality. Then we present a method for estimating the mediation process, and finally we offer quantitative estimates of the extent to which the five-factor and the PA–NA models explain job-satisfaction heritability.

Behavioral Genetics and Personality

The human genotype is the biochemical code characteristic to an individual, and the code provides an individual's genetic composition. An individual's genotype will impact his or her personality through biological processes directly and through development (environmental influences) indirectly. A closely related description of an individual is the phenotype, which represents the sum of one's individual characteristics. Even though individual phenotypes are largely determined by genetic composition, unlike genotypes, phenotypes include environmental influences; thus, an individual's phenotype can change over time.

To explain how one's genetic makeup is associated with possible phenotypic manifestations, behavioral geneticists have developed the concept of *reaction range.* Reaction range theory illustrates the phenotypic range associated with a particular genotype (Turkheimer & Gottesman, 1991; Weinberg, 1989). The theory specifies that each genotype will be associated with a specific range of phenotypes across a specific range of environments. Thus, the range of possible phenotypic manifestations, established by the minimum and maximum phenotypic values associated with a specific genotype, will determine the limits between which the environment can influence the development of an individual in terms of his or her personal characteristics. For a specific trait, the correlation between genotype and the measured trait (phenotypic manifestation) is called the *genetic correlation,* and it estimates the degree of association between individuals' genotypes and their standing on the measured trait. The squared value of this correlation is called *heritability* (h^2)—this statistic estimates the proportion of phenotypic variance (between individuals) accounted for by genetic differences (McGue & Bouchard, 1998; Riemann & de Raad, 1998).

Human behavioral genetics seeks to identify and characterize both the genetic and the environmental influences on individual differences in behavior. More specifically, behavioral geneticists attempt to partition the variance in behavior among individuals (phenotypic variance) into genetic and environmental components. To be more precise, the definition of *heritability* presented previously (i.e., an estimate of the proportion of phenotypic variance explained by genetic differences) refers to *broad heritability* (e.g., Loehlin, 1992). The broad heritability of a trait is composed of both *additive genetic effects* (the effects of individual genes on a trait add together in determining the total additive genetic effect; these effects are transmissible across generations) and *nonadditive genetic effects,* which depend on specific configurations of multiple genes, and are not transmitted from parents to offspring. (Nonadditive genetic effects can be further decomposed into *dominance*—depending on gene combinations present at a given chromosomal locus—and *epistasis,* which depend on gene configurations across chromosomal loci.) *Narrow heritability* of a trait refers only to the genetic effects on that specific trait that are transmitted across generations; thus, it considers only the additive genetic effects on the trait (Loehlin, 1992; McGue & Bouchard, 1998).

Loehlin (1992), in explaining the distinction between broad and narrow heritability, noted that broad and narrow heritability estimates are useful for different purposes:

> An animal breeder trying to change some characteristics in a breed by selection of mating pairs would be most interested in heritability in the narrow sense. A psychologist trying to understand the sources of individual differences would most often be interested in heritability in the broad sense, the total effect of the genes on the trait. (p. 6)

The broad heritability of a particular trait can be computed directly in studies of MZA and indirectly by estimating more complex structural models on twin data, biological and adopted

Table 1
Correlation Input Table for the Five-Factor Model Regression Analysis

Variable	1	2	3	4	5	6
1. Emotional Stability	(.78)					
2. Extraversion	.19	(.78)				
3. Openness	.16	.17	(.73)			
4. Agreeableness	.25	.17	.11	(.75)		
5. Conscientiousness	.26	.00	−.06	.27	(.78)	
6. Job satisfaction	.29	.25	.02	.17	.26	(.90)

Note. $N = 46{,}035$ (the harmonic mean of the meta-analytic sample sizes used to estimate each correlation in the table; Viswesvaran & Ones, 1995). All coefficients are true-score correlations (corrected for internal consistency). Values in parentheses along the diagonal are internal consistency (alpha) estimates. The intercorrelations among the Big Five dimensions were estimated by Ones (1993; Ones et al., 1996). On the basis of sample sizes ranging from 135,539 for the correlation between Extraversion and Openness to 683,001 for the correlation between Extraversion and Conscientiousness. The correlations between the Big Five traits and job satisfaction were taken from Judge, Heller, et al. (2002) and are based on sample sizes ranging from 11,856 for Agreeableness to 24,527 for Neuroticism.

family data, and twin-family data (see Loehlin, 1992). Arvey et al. (1989), for example, estimated the broad heritability of job satisfaction with the intraclass correlation between the ratings of MZA pairs.[1] Loehlin (1992) estimated various path models on personality data reported in several behavioral genetics studies of personality conducted in multiple countries (e.g., Britain, United States, Sweden, and Australia). A model including additive and epistasis genetic variance, and assuming that trait-relevant environments are equally similar for MZ and dizygotic (DZ) twin pairs, was found to fit the combined data from the studies reviewed by Loehlin across the Big Five personality traits. The broad heritabilities of the traits, estimated by this model (i.e., the sum of additive and epistasis genetic effects), were .41, .49, .45, .35, and .38 for Emotional Stability, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness, respectively.[2] Loehlin's estimates can be viewed as representing, in fact, meta-analytic estimates of the broad heritability of the Big Five traits, and indeed these results have been cited as "Loehlin's (1992) meta-analysis" in subsequent studies (Riemann, Angleitner, & Strelau, 1997, p. 452).[3] With respect to the PA–NA model, Tellegen et al. (1988) compared the fit of various structural models to data from four twin samples (MZ twins reared together and apart and DZ twins reared together and apart; combined $N = 402$ pairs). They found that a model that included additive and nonadditive genetic effects as well as shared (family) and unshared environmental effects fit the data best. On the basis of this model, they reported heritability values of .40 and .55 for Positive and Negative Emotionality, respectively.

Method

First, we present a general method for estimating the extent to which each taxonomy mediates genetic effects on job satisfaction (or other attitudinal or behavioral constructs). The data required for this method include (a) correlations between the traits and job satisfaction, (b) intercorrelations among the traits, (c) heritabilities of the traits and of job satisfaction, and (d) reliabilities of all measures. Application of this method will answer the substantive question of this article: To what extent do the five-factor and the PA–NA models explain genetic influences on job satisfaction? Following this methodology, three distinct sets of analyses were conducted: (a) estimating the multivariate relationships between the combinations of traits from each dispositional model and job satisfaction and computing the standardized regression coefficients for the individual predictors, (b) computing the partial heritability of job satisfaction using path analysis, and (c) computing the proportion of genetic variance in job satisfaction explained by traits composing the five-factor and PA–NA models.

Predicting Job Satisfaction With the Traits

The five-factor model. We first sought to determine the multivariate relationship between the set of the predictor traits from the five-factor model and job satisfaction and to estimate the regression weights for each trait. To form the correlation matrix that served as input for our computations, we used the meta-analytic estimates of the relationship between the Big Five traits and job satisfaction given by Judge, Heller, et al. (2002) and Ones, Viswesvaran, and Reiss's (1996) meta-analytic estimates of the intercorrelations among the Big Five traits. True score correlations were used in this analysis. The input correlation matrix is given in Table 1. Using Hunter's (1992) regression program, we regressed job satisfaction on the Big Five personality traits. The regression results are shown in Table 2. Though correlations among the Big Five traits are relatively weak (Ones et al., 1996), the regression equation takes into account these trait intercorrelations in predicting job satisfaction.

The PA–NA model. To regress job satisfaction on PA and NA, we used as input a correlation matrix formed by the meta-analytic estimates for the relationships between PA–NA traits and job satisfaction reported by Connolly and Viswesvaran (2000) and the sample-weighted mean correlation among trait measures of PA and NA reported in the Positive and Negative

[1] Because MZA twins share 100% of their genetic material and because they were raised in different environments—thus sharing little if any environmental characteristics—the intraclass correlation of their scores on a measure of a specific trait approximates the total effect of genes on that trait.

[2] An alternative model that assumed null epistasis effects and unequal MZ and DZ environments also fit the data reasonably well; the implications of considering this model are explored in the Discussion section.

[3] The average heritability values for Openness, Agreeableness, and Conscientiousness presented by Loehlin (1992) were not sample size-weighted averages, thus, technically, these estimates cannot be considered meta-analytic heritabilities.

Affect Schedule manual (PANAS-X; Watson & Clark, 1994). The input values are shown in the notes to Table 3.

Partial Heritability of Job Satisfaction

We first estimated a path analytic model that included genetic effects through each of the five-factor model predictor traits (see Figure 1). To estimate the genetic influences on job satisfaction through each trait, we used the regression coefficients computed at the previous step and the heritability estimates for the Big Five reported by Loehlin (1992). We computed the proportion of variance in job satisfaction explained by genetic effects mediated through each of the five traits, and then we summed the individual trait effects to derive the partial heritability of job satisfaction mediated by the five-factor model. Second, to compute the partial heritability of job satisfaction mediated by the PA–NA model, we used the regression coefficients for predicting job satisfaction with PA and NA (computed at the previous step) and the heritability values for Positive and Negative Emotionality reported by Tellegen et al. (1988).

Use of path models based on meta-analytic data has been specifically advocated by Viswesvaran and Ones (1995) as a method of theory testing. A concern that might be raised about the path model is that the meta-analytic estimates were obtained from different sources (i.e., different meta-analytic reviews). One might question the degree to which estimates can be taken from one population and applied to another. Conceptually, such a procedure is appropriate because meta-analytic estimates, though they are estimates, are population values or the single best estimate of validity across samples and settings (Hunter & Schmidt, 1990). This is particularly true when the estimates generalize across studies, as is the case when credibility intervals exclude zero. Indeed, multivariate analyses (path and regression analyses) have been estimated on the basis of diverse combinations of meta-analytic estimates in the areas of justice (Colquitt, Conlon, Wesson, Porter, & Ng, 2001), training (Colquitt, LePine, & Noe, 2000), leadership (Judge, Bono, Ilies, & Gerhardt, 2002), turnover (Tett & Meyer, 1993), and stress (Viswesvaran et al., 1999), among others. In addition to testing structural models and computing point estimates, in analyses based on path models estimated with meta-analytic data, one can and should estimate the variability around the point estimate. Viswesvaran and Ones (1995) recommended the use of the harmonic mean of the sample sizes across the different cells to compute the standard errors of the estimated parameters, and indeed this seems to be the method of choice among researchers who use meta-analytic path analysis (e.g., Colquitt et al., 2001).[4]

In path analysis, to remove error variance, the path model parameters need to be estimated by using true-score correlations as input (i.e., correlations corrected for imperfect measurement; Billings & Wroten, 1978). The correlations between the Big Five and job satisfaction (Judge, Bono, et al., 2002) and between PA–NA and job satisfaction (Connolly & Viswesvaran, 2000) and the Big Five intercorrelations (Ones et al., 1996) were corrected for the attenuation caused by measurement error in the original studies, but the genetic correlation data represent observed (uncorrected) correlations. To correct the genetic correlations for unreliability in the measures, we used meta-analytic estimates of the reliability of the Big Five personality traits (see Table 1) reported by Viswesvaran and Ones (2000), the sample-weighted average of the internal consistency estimates reported in the PANAS-X manual (Watson & Clark, 1994; $\alpha = .86$ for both PA and NA on the basis of 5,091 respondents), and the internal consistency of the Minnesota Satisfaction Questionnaire job-satisfaction measure reported in the test manual (D. J. Weiss, Dawis, England, & Lofquist, 1967). In addition, we corrected the PA–NA correlation (Watson & Clark, 1994) for unreliability in both measures by using the internal consistency estimates for PA and NA presented previously. All reliability data refer to internal consistency reliability (coefficient alpha). Meta-analytic estimates of reliabilities are the single best estimates of the reliability of psychological constructs and therefore are recommended (Viswesvaran & Ones, 1995).[5] The genetic correlations and heritabilities, corrected for unreliability, are presented in Tables 3 and 4.

Table 2
Regression of Job Satisfaction on the Five-Factor Traits

Trait	β	95% confidence interval: Lower limit	95% confidence interval: Upper limit
Emotional Stability	.20	.184	.208
Extraversion	.21	.203	.223
Openness	−.04	−.052	−.028
Agreeableness	.04	.024	.048
Conscientiousness	.20	.185	.209

Note. Following Viswesvaran and Ones (1995) and Colquitt et al. (2001) to compute the confidence intervals, we computed the standard errors of the regression coefficients using the harmonic mean of the meta-analytic sample sizes used to estimate each correlation from the regression input matrix. The correlation between the set of predictors and the dependent variable (R) equals .41.

Table 3
Regression of Job Satisfaction on the Positive Affectivity–Negative Affectivity (PA–NA) Traits

Trait	β	95% confidence interval: Lower limit	95% confidence interval: Upper limit
Positive affectivity	.44	.421	.465
Negative affectivity	−.25	−.222	−.270

Note. As input, we used the meta-analytic correlations between PA–NA and job satisfaction provided by Connolly and Viswesvaran (2000; corrected $r = .49$, on the basis of 3,326 respondents, and corrected $r = -.33$, on the basis of 6,233 respondents, for PA and NA, respectively) and the corrected sample-weighted mean correlation among trait measures of PA and NA reported in the PANAS-X manual (Watson & Clark, 1994; corrected $r = -.19$, on the basis of 5,091 respondents). The standard errors of the regression coefficients were computed using the harmonic mean of the sample sizes used to estimate each input correlation. The correlation between the set of predictors and the dependent variable (R) equals .55.

[4] The heritability values for PA and NA that were used in our analyses were not meta-analytically derived, and these estimates contain a larger amount of sampling error (as compared with the heritiabilities of the Big Five model) because of the smaller sample size on which they were computed. Given that they come from a single study, the PA–NA estimates may also be, to some extent, sample or measure specific.

[5] Because internal consistency reliability (coefficient alpha) takes into account random response and specific-item measurement errors but not other forms of measurement error such as transient errors (Becker, 2000; Schmidt & Hunter, 1999), it is considered an upper-bound estimate for the reliability scores on the measures considered in this study. Thus, using coefficient alpha to correct the observed correlations for measurement error is a conservative approach (i.e., it results in a lower-bound estimate of the true-score correlations). In addition, the corrected heritability values estimated in this article are consistent with estimates obtained by means of confirmatory factor analysis by Loehlin, McCrae, Costa, and John (1998; average true-score heritability of .54 and .55 for our study and Loehlin et al.'s [1998] study, respectively), which suggests that our corrections were appropriate.

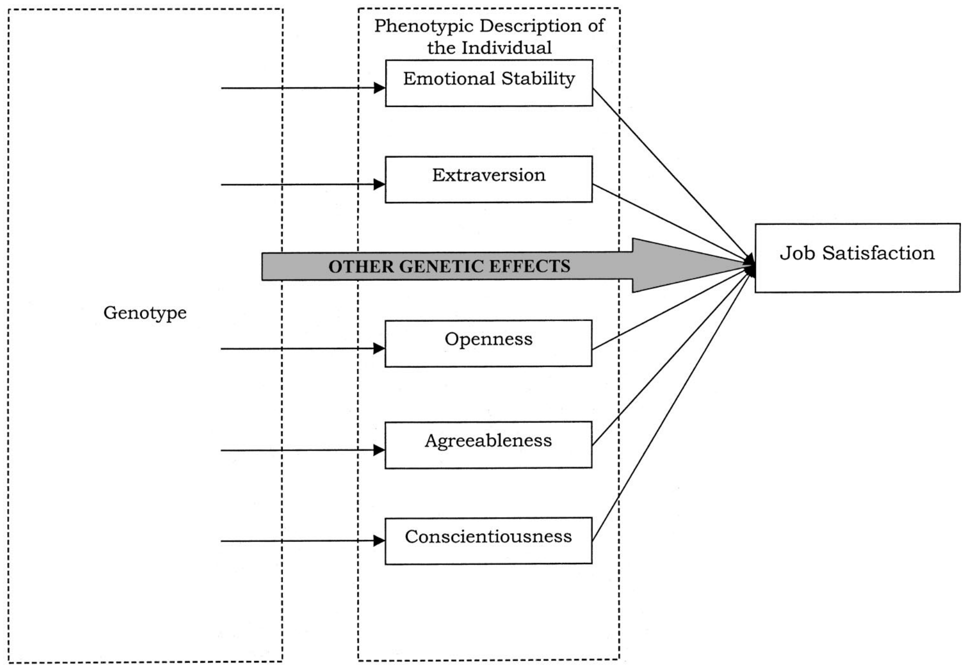

Figure 1. Illustration of genetic influences on job satisfaction through the five-factor model.

Estimating the Extent to Which the Trait Models Mediate Genetic Effects on Job Satisfaction

We estimated the overall heritability of job satisfaction by means of meta-analysis to cumulate the heritabilities of job satisfaction reported in the literature (Arvey et al., 1989, 1994). This small-scale meta-analysis is presented in Appendix A. By dividing the partial heritability of job satisfaction (estimated at the previous step of the analyses) by the overall heritability, we obtained the proportion of genetic variance in job satisfaction that is mediated by the personality traits that form each of the dispositional models considered in this study.

Variability and Confidence in the Point Estimates

As noted, in addition to presenting point estimates for the parameters used or estimated in this study, it is important to describe the variability in these point estimates. Accordingly, we computed 95% confidence intervals

Table 4
Genetic Correlations for Predictor Traits and Job Satisfaction

			h		h^2	
Construct	k	N	PE	95% CI	PE	95% CI
Emotional Stability	58	22,534	.72	.714, .723	.52	.510, .530
Extraversion	58	22,534	.79	.785, .795	.62	.616, .632
Openness	23	4,758	.78	.769, .791	.61	.591, .630
Agreeableness	30	7,454	.68	.668, .692	.46	.446, .479
Conscientiousness	35	8,658	.70	.689, .711	.49	.475, .506
Positive affectivity	4	402	.68	.627, .733	.46	.394, .537
Negative affectivity	4	402	.80	.765, .835	.64	.585, .698
Job satisfaction	3	2,610	.54	.512, .568	.29	.256, .328

Note. Genetic correlations were computed as the square root of the broad heritability estimates taken from Loehlin's (1992) meta-analysis (the sum of additive and epistasis effects presented in Table 3.20, p. 67) and from Tellegen et al. (1988) and were then corrected for unreliability. The heritability of job satisfaction was computed in the meta-analysis presented in Appendix A. Confidence intervals around the genetic correlations for the predictor traits were computed with the standard formula for the sampling variance of a correlation coefficient (e.g., Hunter & Schmidt, 1990, p. 28) and by using the sample sizes involved in estimating each genetic correlation. Confidence intervals around the heritability values of the traits were obtained by squaring the confidence-interval limits for the genetic correlations (Loehlin et al., 1998). The confidence intervals around genetic correlation for job satisfaction and around the heritability of job satisfaction were computed in the meta-analysis presented in Appendix A. k = number of samples; h = genetic correlation; h^2 = heritability; PE = point estimate; CI = confidence interval.

for the standardized regression coefficients, the genetic correlations, and the heritability estimates (see Tables 2–4).

Results

Relationship Between Traits and Job Satisfaction

The regression results are provided in Table 2 (for the five-factor model) and Table 3 (for the PA–NA model). The multiple correlation between the set comprising the Big Five personality traits and job satisfaction was .41. The multiple correlation between the PA–NA combination and job satisfaction was .55. These values show that both models are moderately strongly related to job satisfaction, with the PA–NA model more strongly so.

Partial Heritability of Job Satisfaction and the Magnitude of the Mediation Effects

Standardized regression coefficients, estimated by regressing job satisfaction on the Big Five traits and on PA and NA (see Tables 2 and 3), and genetic correlations for the predictors (see Table 4) were used to estimate the mediating effect of predictor traits.

The five-factor model. Using basic path analysis rules for reconstituting correlations, we arrived at the equation for the partial heritability of job satisfaction (comprising only those genetic effects mediated by the Big Five traits): $h_p^2 = \Sigma(h_i\beta_i)^2$, where the subscript i varies from 1 to 5 for the Big Five personality factors. Substituting the values presented in Table 2 (β values) and Table 4 (h values) in the previous formula gives $h_p^2 = 6.9\%$. We then computed the 95% confidence interval around this value, using the harmonic mean of sample sizes. This interval ranges between 5.7% and 8.3%, which shows that the procedure presented here is reasonably precise (see Appendix B for the specific computations).[6] Comparing the point estimate computed here (6.9%) with the overall genetic effect on job satisfaction (29.2%; see Appendix A), we conclude that the Big Five traits mediate 23.6% (6.9/29.2) of all genetic influences on job satisfaction. The 95% confidence interval around the proportion of genetic influences mediated by the Big Five traits ranges between 22.3% and 24.9% (see Appendix B).

The PA–NA model. Using the β values from Table 3 and the h values from Table 4, we computed the partial heritability of job satisfaction through PA and NA to be $h_p^2 = 13.0\%$. The 95% confidence interval around this point estimate ranges between 6.6% and 19.4% (see Appendix B). Comparing the partial heritability through PA and NA with the overall genetic effect on job satisfaction (29.2%; Appendix A) shows that the PA–NA model mediates approximately 45% of the genetic variance in job satisfaction. This proportion is much higher than the proportion mediated by the five-factor model. Thus, it appears that the genetic influences on job satisfaction are mediated primarily by affective traits and not by the broad personality factors. As with the results concerning the five-factor model, we computed the confidence interval around the proportion of genetic variance in job satisfaction mediated by PA and NA; the resulting interval ranges between 42.4% and 47.2% (see Appendix B).

Discussion

Following Arvey et al. (1989) and Judge (1992), who speculated that the heritability in job satisfaction should be explained by personality factors, and given the robustness of the five-factor model (e.g., Digman, 1990) and its relative comprehensiveness in describing "the big picture of personality" (McCrae, 2001, p. 111), we expected a strong mediation effect. However, the results suggest that the Big Five mediate less than one fourth of the genetic variance in job satisfaction. Given the substantial heritability of the Big Five traits and their moderately strong relationship with job satisfaction (as a set, $R = .41$), this result was somewhat surprising. With respect to the affective traits, the mediation effect of the PA–NA model is almost twice as large as the effect of the five-factor model (45% vs. 24%). Even though it appears that PA–NA may be subsumed under the five-factor framework, with PA being an indicator of Extraversion and NA an indicator of Neuroticism (Brief, 1998), it may be that the affective nature of PA–NA, compared with the relatively behavioral nature of the Big Five, makes the former more powerful mediators of the genetic source of job satisfaction.

That the personality frameworks did not explain most of the genetic variance in job satisfaction naturally leads to the question: What might mediate the genetic variance that is not explained by these personological models? There are several possibilities. First, it is possible that job satisfaction is heritable because of reasons other than personality. For example, intelligence is highly heritable (Bouchard, 1997), and one can envision many factors—such as job success—that are linked to both intelligence and job satisfaction. Studies linking intelligence to job satisfaction, however, are not numerous and have not produced consistent results in the literature (Ganzach, 1998). Ganzach (1998), on the basis of a large representative sample, reported a very small ($r = -.02$, *ns*) correlation between intelligence and job satisfaction (a subsequent analysis of a subsample of these respondents found a zero correlation between intelligence and job satisfaction; Ganzach & Pazy, 2001), whereas Judge, Higgins, Thoresen, and Barrick (1999) reported a positive, significant correlation ($r = .30$, $p < .05$). We encourage future research on the intelligence–job satisfaction relationship as well as investigation of the possible role of intelligence in explaining the genetic source of job satisfaction.

Second, one might argue that different results would be obtained if job satisfaction facets or components, or other factors such as vocational interests, were analyzed. We were concerned with overall job satisfaction because that is the focus of the vast majority of research on the dispositional source of job satisfaction (e.g., Judge, Heller, et al., 2002; Judge & Locke, 1993; Staw et al., 1986). But job satisfaction, like other attitudes, has both affective and cognitive components (e.g., H. M. Weiss, 2002). Because broad personality and affectivity factors are mostly influencing the affective component of job satisfaction, these frameworks can only mediate the genetic influences on job satisfaction that are affective in nature. In this respect, the fact that PA and NA mediate 45% of the heritable job-satisfaction variance is illustrative, as this value can be viewed as an estimate of the proportion of heritable variance in job satisfaction that is due to its affective component. It follows

[6] We also computed the 95% confidence interval around the partial heritability of job satisfaction by using the lower confidence limits for both the regression coefficients and the genetic correlations in a path analysis and the upper confidence limits for these point estimates in another. The confidence interval constructed this way ranges between 6.0% and 7.8%.

that a substantial proportion of heritable variance may be caused by the cognitive aspects of or influences on job satisfaction. In addition, job satisfaction can be decomposed into intrinsic and extrinsic satisfaction. Thus, perhaps the mediating role of these components in explaining heritable job satisfaction should be investigated separately. However, there appears to be less variance to be mediated by genes for extrinsic factors. Arvey et al.'s (1989) study revealed essentially no heritability for extrinsic job satisfaction.

As for vocational interests, research indicates that they are roughly as heritable as personality (Lykken, Bouchard, McGue, & Tellegen, 1993). Thus, perhaps interests might explain some of the heritability of job satisfaction. On the other hand, vocational interest congruence does not appear to be related to job satisfaction (Tranberg, Slane, & Ekeberg, 1993). Nevertheless, whether different results were obtained for different job satisfaction facets or measures of vocational interests would be an interesting issue to explore in future research.

Third, it is possible that the combination of component traits from both the five-factor model and the PA–NA model would explain a higher proportion of genetic variance in job satisfaction as compared with the variance explained by each model alone. Thus, one may argue that mediating effects of traits from both models should be studied in combination. We do not present such analysis for two primary reasons. First, on a conceptual level, the precise integration of the PA–NA model and the Big Five model has not yet been accomplished. Second, from a methodological perspective, the nature of our modeling method does not allow us to investigate such joint effects, as we acknowledge in the following paragraph.[7]

Like all studies, this is not a study without limitations. A limitation inherent in the nature of the data concerns the modeling of the heritable effects on job satisfaction. First, we assumed that the genotypic influences on the Big Five traits are distinct from one another. Conceptually, the Big Five factors are considered orthogonal (Costa & McCrae, 1992), and at least with respect to Neuroticism and Extraversion, there is empirical evidence that these traits reflect individual differences in the functioning of distinct neurobiological systems (see Matthews & Gilliland, 1999). Furthermore, given that the Big Five traits (i.e., the phenotypic manifestation of genetic causes) are only weakly interrelated (Viswesvaran & Ones, 2000) and because our model accounts for the intercorrelations among the traits, this assumption seems reasonable. However, the *distinct genotypic effects* assumption would be violated if we were testing a model that includes the mediating effect of the seven traits included in the five-factor model and in the PA–NA model (because Neuroticism and NA and Extraversion and PA are thought to have the same neurobiological substrates; see Clark & Watson, 1999).

Second, the path models used to estimate the heritability of the traits were not the only models that reasonably fit the data. The heritability estimates for the Big Five factors, for example, were estimated by models that assumed additive and epistasis genetic effects and equally similar environments for MZ and DZ twins (the *equal environments* assumption; Loehlin, 1992). An alternative model, which relaxed the equal environments assumption and allowed only additive genetic effects, provides slightly lower heritability values for the Big Five factors (see Loehlin, 1992, p. 67); if these alternative values were used in the path analysis, the five-factor model would mediate an even lower proportion of the genetic variance in job satisfaction.

Another possible limitation is that the results are based on a diverse set of meta-analyses, which themselves were based on a diverse set of studies. For example, the basis for estimating the correlations between the Big Five traits and job satisfaction (Judge, Heller, et al., 2002) used both direct and (mostly) indirect measures of the traits. One might question, for example, whether direct measures would have higher validities and how this unexplained source of variance would affect the results. With respect to this particular issue, Judge, Heller, et al. (2002) found that the validities of direct and indirect measures of the Big Five traits were quite similar and the results slightly favored indirect measures. With respect to the issue more generally, it certainly is possible that variability in meta-analytic estimates might have affected the results. This is a limitation common to any path or regression model based on meta-analytic data, of which an increasing number are appearing (e.g., Colquitt et al., 2000, 2001; Judge, Heller, et al., 2002; Tett & Meyer, 1993; Viswesvaran et al., 1999). This, of course, does not make the issue any less of a problem. Providing confidence intervals around the estimates, however, and showing that the intervals exclude zero should allay concerns that the results are not generalizable because they are based on diverse meta-analyses as input.

Disentangling genetic effects on human behavior from environmental influences is the central purpose of behavioral genetics and certainly one of the most prominent—and controversial—issues in general psychology. With respect to industrial–organizational psychology, this issue is of major importance because estimating the relative influence of genotype and environmental influences on work-related constructs helps identify areas in which interventions are likely to lead to positive work outcomes and by indicating the proportion of between-individuals differences that have nongenetic causes (i.e., causes that can be changed), it provides the means to calibrate the systems assessing the effectiveness of such interventions.

Taken as a whole, this study contributes to the understanding of the link between genetic makeup, personality traits, and job attitudes by estimating the extent to which two personological frameworks—the five-factor model and the PA–NA model—mediate genetic effects on job satisfaction. In doing so, this study formulates a general method for estimating the mediation effect of a combination of traits on the relationship between genes and attitudes or behaviors and offers suggestions that should inspire future research. Specifically, future research can use this approach to study other factors that may explain the genetic source of job satisfaction and the genetic source of other attitudes and behaviors relevant to industrial–organizational psychology. In contrast to the results observed here, for example, would the five-factor model

[7] Within the limitation of our method, one way to combine the effects of affective traits (PA and NA) and broad personality traits (Big Five) would be to estimate the mediating effects of two higher order traits indicated by PA and Extraversion and by NA and Neuroticism and by the three remaining traits from the five-factor model. Though such a mixed model is somewhat atheoretical, for point of comparison, mediation analyses concerning this model (based on data from a variety of sources) indicate that it mediates about 41% of the heritability of job satisfaction.

relative to the PA–NA model be superior in explaining the genetic source of behaviors? Are there gene–environment interactions (e.g., Extraversion and social interactions; Watson, 2000) that would provide an even more powerful explanation of job satisfaction? To what degree might our model explain individual differences in the stability of job attitudes? These are just some of the questions that the present study suggests could be addressed in future research.

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Appendix A

Meta-Analysis of Heritability of Job Satisfaction

This appendix presents the meta-analytic estimation of the heritability of job satisfaction. We cumulate the results from three twin studies that are reported in two behavior genetics articles (Arvey et al., 1989, 1994).

The first sample ($N = 34$) consisted of monozygotic twins reared apart who participated in the Minnesota Study of Twins Reared Apart between 1979 and 1987. The mean age of these participants was 41.88 years, and the mean age of the separation for the sample was 0.45 years (Arvey et al., 1989). The sample consisted of 25 female twin pairs and 9 male twin pairs. The authors of the original study computed the intraclass correlation of the twins' scores on general job satisfaction and contended that this correlation represents the heritability of job satisfaction (Arvey et al., 1989).

The second sample (Study 1 reported by Arvey et al., 1994) was recruited from the Minnesota Twin Family Registry of twin pairs who were born in one of the following years: 1939, 1946, 1952, or 1953. One hundred seventy-five pairs of twins provided complete responses (95 monozygotic [MZ] and 80 dizygotic [DZ] pairs).

The third sample (reported by Arvey et al., 1994, Study 2) consisted of 1,165 MZ and 1,236 DZ twin pairs reared together. This sample is based on the National Academy of Sciences and National Research Council twin sample, and it is described in detail in Behrman, Hrubec, Taubman, and Wales (1980).

By fitting a path model that included genetic effects, nonshared environment effects, and shared environment effects to explain the MZ and DZ data (multiple-group analyses), Arvey et al. (1994) estimated the heritability of job satisfaction scores on the basis of the second and third sample at 16% and 27% (uncorrected values), respectively.[A1]

The results of the meta-analysis of the heritability of job satisfaction values computed on the three samples described above are presented in Table A1.

Table A1
Meta-Analysis of the Heritability of Job Satisfaction

N	*r*	*ρ*	SE_ρ	95% CI	%var
2,610	.263	.292	.037	.256, .328	100

Note. To compute the confidence interval, we used Whitener's (1990) formula for the standard error of the mean correlation. N = combined sample size; r = sample-size weighted mean correlation; ρ = corrected correlation; SE_ρ = standard error of corrected correlation; CI = confidence interval; %var = percentage of variance explained by the meta-analysis.

[A1] MZ twins share 100% of their genes, whereas DZ twins share 50%. By comparing the correlations between twins' scores on a specific measure across the two types of twin data, one can estimate the influence of the genotype on the measured construct.

Appendix B

Computations of Confidence Intervals

The Five-Factor Model

Computing the standard error of the partial heritability of job satisfaction mediated by the Big Five ($h_p^2 = 6.9\%$) is a problem of computing the appropriate sample size for estimating the sampling variance of a correlation. The sampling variance of a correlation drawn from a population in which the variables are approximately bivariate normal is given by the following formula:

$$\mathrm{var}(r) = \frac{(1 - r^2)^2}{N - 1}.$$

Following Viswesvaran and Ones (1995) and Colquitt et al. (2001), we used the harmonic mean of the sample sizes used to compute all of the statistics that were used as input in the analyses (the genetic correlations for the Big Five factors, the correlations between Big Five and job satisfaction, and the intercorrelations among the Big Five factors). The harmonic mean of the sample sizes was $N = 22{,}872$.

Because heritability values can be viewed as correlations (for monozygotic twins raised apart [MZA], e.g., the correlations of twins' scores on a trait equals the heritability of that trait; Bouchard, 1997), we can compute the standard error of the partial heritability with the formula above.[B1] It follows that the 95% confidence interval for the partial heritability ranges between 5.7% and 8.3%. (One could also compute the confidence interval around the corresponding genetic correlation and then square the confidence limits [Loehlin, 1992], but the results are not substantively different.)

The Big Five factors mediate 23.6% of the genetic variance in job satisfaction. We compute the variance of this estimate with the standard formula for computing the variance of a proportion:

$$\mathrm{var}(p) = \frac{p(1 - p)}{N}.$$

We used the harmonic mean of the sample size used to estimate the partial heritability of job satisfaction ($N = 22{,}872$; see above) and the sample used to estimate the overall heritability of job satisfaction ($N = 2{,}610$; see Appendix A), $N = 4{,}685$. It follows that the 95% confidence interval around the proportion of genetic variance in job satisfaction mediated by the Big Five personality factors was 22.3% to 24.9%.

The PA–NA Model

Our parallel analyses showed that the partial heritability of job satisfaction through PA and NA was 13.0%. Following the method detailed above, we computed the 95% confidence interval around this value. This interval ranges between 6.6% and 19.4% (on the basis of $N = 899$).

We found that PA and NA mediate about 45% of the genetic variance in job satisfaction. We computed the 95% confidence interval for the proportion of genetic variance in job satisfaction mediated by PA and NA using the same method that we used for the Big Five model (detailed above). The confidence interval was 42.4% to 47.2% on the basis of $N = 1{,}337$.

[B1] When heritability is computed as the intraclass correlation of MZA twins' scores on a specific trait, the standard error should be computed with the formula provided by Shrout and Fleiss (1979, p. 424). Using this alternative method for computing the standard errors, however, makes little substantive difference for this article.

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