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Personality and Reproductive Fitness

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The relationship between reproductive success (number of biological children) and personality was explored in 1101 postmenopausal females from the Australian twin registry. The quadratic response surface relating fitness to extraversion (E) and neuroticism (N) showed a saddle point at intermediate levels of E and N. Selection was shown to be stabilizing, i.e., having an intermediate optimum, along the axis low E, low N–high E, high N and more mildly disruptive, having greater fitness in the extremes, along the axis low N, high E–high N, low E. Neither dimension of personality considered by itself showed a significant linear or quadratic relationship to reproductive success. Sections through the fitness surface, however, show selection tends to favor high neuroticism levels in introverts and low neuroticism levels in extroverts.

KEY WORDS: personality; fertility; family size; fitness; extraversion; neuroticism; impulsivity; genetic architecture; evolution.

INTRODUCTION

The intrinsic appeal of integrating sociobiology and human behavioral genetics lies in the possibility of providing an evolutionary framework for the understanding of those aspects of behavior which appear to be characteristically hu-

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man. The dearth of empirical data relating differences in human behavior to variation in fitness is a significant "missing link" between our genetic analyses of human behavior and the theories of sociobiology. A major obstacle is the fact that the amount of purely stochastic variation in family size is so great that sample sizes have to be quite large for relatively small nonstochastic fluctuations in fitness to stand out against background noise. A further difficulty is the fact that most behavior-genetic studies are not confined to subjects whose reproductive history is complete.

DATA

This study is confined to a relatively large sample of females who participated in an Australian study of twins conducted in 1981 (Martin and Jardine, 1986). Data were gathered by questionnaire from adult male and female volunteer twins. The Eysenck Personality Questionnaire (EPQ) was incorporated in the questionnaire, and questions dealing with menstrual history and number of children which allowed us to count the number of biological children of all subjects. Our analysis is confined to those 1101 women who answered "Yes" to the question "Have your periods stopped?"

PRELIMINARY ANALYSIS

Raw personality scores on the extroversion and neuroticism scales were grouped into five classes in each dimension, and the average number of biological children computed within each of the 25 possible combinations of extroversion and neuroticism classes. These values are given in Table I. Although sample sizes are quite small in the extreme cells, inspection of the data suggests that the fittest individuals are stable extroverts (low N, high E) and neurotic introverts (high N, low E). These individuals characterize the extremes of Gray's (1982) dimension of Anxiety. Fitness is lowest at the extremes of the orthogonal dimension, Gray's Impulsivity dimension, characterized by stable introverts (low N, low E) at one end and by extrovert neurotics (high N, high E) at the other.

MODELING THE FITNESS SURFACE

The response surface relating the expected total number of biological children (F) to individual raw extraversion (E) and neuroticism (N) scores was approximated by the quadratic regression,

$$F = \text{const} + l_E E + l_N N + q_E E^2 + q_N{}^{n2} + \rho_{EN}{}^{EN}.$$

The linear (l), quadratic (q), and cross-product (p) regression coefficients were estimated by least-squares using the SAS program RSREG (SAS Institute Inc.,

Table I. Mean Number of Children as a Function of Personality Scores in Postmenopausal Women[a]

Neuroticism score	Extroversion score					
	<5	5–9	10–14	15–19	>19	All E
<5	1.22	2.32	2.27	2.72	2.86	2.42
	(9)	(28)	(55)	(64)	(7)	(163)
5–9	3.57	2.80	2.73	2.76	2.00	2.79
	(23)	(67)	(110)	(113)	(13)	(326)
10–14	2.71	2.54	2.34	2.53	1.86	2.47
	(24)	(94)	(76)	(85)	(14)	(293)
15–19	2.23	2.73	2.18	2.48	1.71	2.39
	(35)	(68)	(83)	(50)	(7)	(243)
>19	3.86	2.92	2.09	2.63	1.67	2.63
	(7)	(24)	(23)	(19)	(3)	(76)
All N	2.68	2.66	2.40	2.64	2.02	2.55
	(98)	(281)	(347)	(331)	(44)	(1101)

[a] Sample sizes in parentheses. Total variance in family size = 3.159.

Table II. Quadratic Response Model for Personality and Reproductive Success

Parameter	Estimate ± SE	
	Extroversion	Neuroticism
Mean	11.665 ± .150	10.829 ± .167
Linear regression	.0475 ± .0549	.0477 ± .0480
Quadratic regression	−.00072 ± .00206	−.00058 ± .00170
Cross-product regression	−.00403 ± .00200	
Intercept	2.174 ± 0.453	
Critical value	9.397	8.427

1988) for response-surface modeling. The results of the regression analysis are summarized in Table II. The estimated parameters of the response surface can be substituted in the regression equation and the first derivatives equated to zero to solve for the values of E and N for which fitness is maximized or minimized. In our case these values are $E=9.40$ and $N=8.43$. The corresponding expected family size at this point is $F=2.60$. The 2×2 matrix of second derivatives has one positive and one negative eigenvalue, .001367 and −.002670, respectively, indicating that the stationary point is a saddle point. These second derivatives indicate the local curvature of the fitness surface around this point and are a guide to the type of selection operating along the principal axes. In our case, selection is apparently stabilizing in one direction (having an intermediate optimum fitness) and disruptive in the orthogonal direction (having greater fitness at the two extremes). The direction of the stabilizing component is given by the vector corresponding to the negative eigenvalue. In our example this vector is $0.719E + 0.695N$. That is, selection is stabilizing along the Impulsivity axis, from low E–low N to high E–high N. The orthogonal vector corresponding to the disruptive component is $0.719N - 0.695E$, i.e., fitness tends also to be elevated in the extremes of the Anxiety dimension, high E–low N and low E–high N.

The ordinates of the least-squares fitness surface were computed for EPQ scores in the range $E = 0–20$ and $N = 0–20$. Figure 1 gives the contours of the surface and Fig. 2 shows one three-dimensional view of the surface. The contours show that the surface is relatively flat over quite a wide range of intermediate personality test scores. The shape of the predicted fitness surface shows features that would not be obvious if the study of the fitness–personality relationship was confined to either personality dimension alone. Thus, it may be seen that the direction of selection with respect to neuroticism can be seen to change as we go from introverts in whom high N scores are more adaptive to extroverts in whom low N scores are more adaptive.

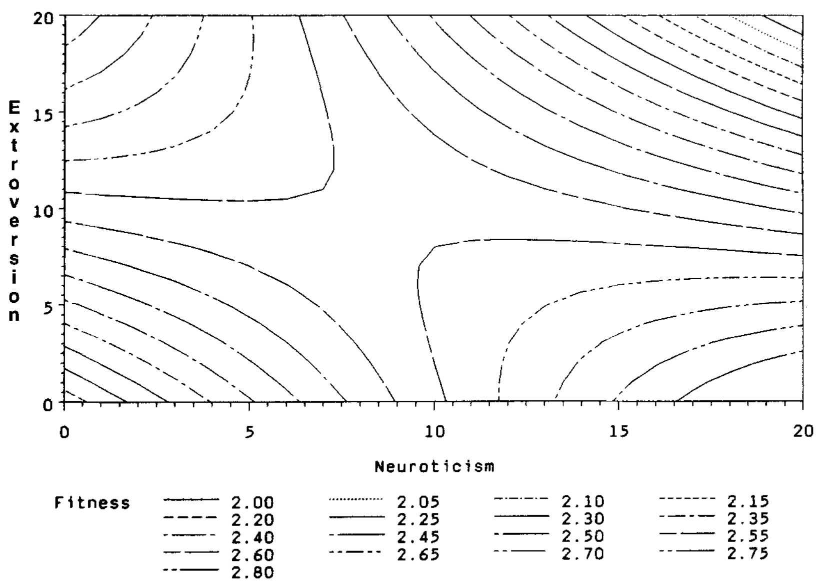

Fig. 1. Contours of fitness surface as a function of extroversion and neuroticism.

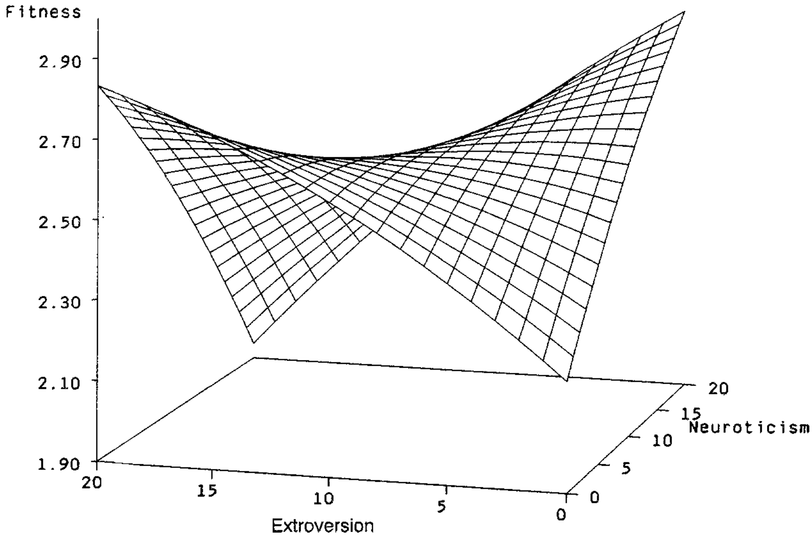

Fig. 2. Three-dimensional plot of fitness as a function of personality.

DISCUSSION

A continuing controversy among personality theorists (e.g., Eysenck, 1967; Gray, 1982; Cloninger, 1986) relates to whether the dimensions of Eysenck's theory, extroversion and neuroticism, are more fundamental biologically than the dimensions of anxiety and impulsivity which correspond to Eysenck's original dimensions rotated through 45° (Gray, 1982). If anything, our findings support Gray's theory because a 45° rotation of Eysenck's factors corresponds to the two main axes of the fitness surface, which are apparently related to fitness in quite different ways, stabilizing selection along the +E, +N axis and disruptive selection along the orthogonal dimension −E, +N.

Given the relatively large standard errors attached to the individual response parameters, it is clear that early replication of our results is desirable. If replication is forthcoming, then we may begin to solve some further puzzles which are beginning to emerge from family and twin studies of personality. We might expect there to be strong assortative mating (positive or negative) for traits which show a strong relationship to fitness. However, mating is random with respect to extroversion and neuroticism (Eaves *et al.*, 1989), which has led to our suggestion that personality has little to do with fitness. On the other hand, we expect strong selection to lead to marked non-additive genetic variation in a trait

(Mather, 1966, 1967) for which there is growing support from genetic studies of personality (Martin *et al.*, 1988; Eaves *et al.*, 1989).

Our results show that personality dimensions considered separately show little marked relationship with fitness. The response surface looks relatively flat when projected onto either extroversion or neuroticism alone. However, when the two dimensions are considered together, some (though not highly significant) variation in the adaptive landscape is apparent. This finding might explain why genetic effects are not purely additive since any kind of selection might increase the contribution of nonadditive effects.

So far, our findings characterize only the relationship between fitness and personality at the phenotypic level. Nothing in our analysis addresses the question of whether the relationship we claim is a function of genetic or environmental effects. Indeed, we have not even addressed the direction of causation between personality and family size. It is conceivable that our empirical relationship could result from the effects of social support (having a large family) on personality test scores. The methods are available to address these and other issues. However, sample sizes will have to be somewhat larger than those currently available to us. Nevertheless, we hope that publication of our findings will stimulate further inquiry in an important but neglected area on the interface between personality theory and human biology.

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