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Sex Differences in Property Crime in a Danish Adoption Cohort

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Sex differences in genetic and environmental influences on criminal behavior against property were studied in a birth cohort of 6129 male and 7065 female Danish adoptees and their biological and adoptive parents. Both genetic and environmental factors were found to contribute to variation in liability to property criminality, the relative proportions of variance explained being similar in males and females. Important shared- and nonshared-family environmental factors were present. In separate analyses of average liability toward property criminality, however, convicted females appeared to be more genetically predisposed than convicted males, a conclusion based on the finding that female property offenders were more likely than male offenders to have convicted biological (but adopted-away) offspring. On the other hand, property-offending males and females did not appear to differ in their average shared-family environmental liabilities, since conviction rates did not differ for adoptees of convicted adoptive mothers and fathers. Also, social class in the adopitive parents of convicted sons and daughters were comparable, further indicating that average shared-family environmental liabilities do not differ between the sexes.

KEY WORDS: Sex differences; liability; adoption study; property criminality; threshold.

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INTRODUCTION

Over the years women have been found consistently to be less criminal than men, regardless of their age, race, or cultural origins (Cloninger *et al.*, 1975). While sex ratios vary by type of crime, most official data show a male-to-female ratio of 4–5:1, and even in self-report studies the ratio is usually about 2:1 (Hindelang *et al.*, 1979). In a study of Danish adoptees and their families, for example, females were convicted of criminal law offenses at least one-third less often than males among adoptees, biological and adoptive parents (Mednick *et al.*, 1984).

Assuming that criminal behavior is characterized by an underlying continuum of liability toward criminality, women must have more extreme thresholds for expression than men and, therefore, must have more severe liability in order to become criminal. Sellin (1938) has described this threshold concept in sociological terms as "group resistance" to criminal involvement. Rural residents, members of higher social classes, and females are all groups who experience relatively strong social pressures against illegal behaviors and, thus, have a high group resistance to crime. Sellin suggests that members of these high-resistance groups who do violate the rules may have more severe liabilities toward criminality: "Offenders who have overcome the greatest and most comprehensive group resistance probably disclose more clearly than others the types of personalities which are important to our aims of research" (Christiansen, 1977, p. 106). Restated, if group resistance has set a more extreme threshold for expression of criminality for women than for men, the few women who do become criminally involved may represent cases of relatively strong individual tendencies toward law-violating behavior.

Given that heritable influences have been found to contribute to variance in liability toward criminal behavior, as suggested from twin, family, and adoption studies (Christiansen, 1977; Cloninger and Gottesman, 1987; Mednick *et al.*, 1986; Raine and Venables, 1988), it may be hypothesized that women who commit crimes are more strongly genetically predisposed on average than men. If so, the proportion of criminals among first-degree relatives of female criminals should exceed that in first-degree relatives of criminal males.

For antisocial personality disorder (ASP), which is characterized in part by frequent criminal behavior during adulthood, such a pattern of results has been reported by Cloninger *et al.* (1975, 1978) in families of ASP individuals in the United States. Although this finding is consistent with the hypothesis of differential genetic predisposition toward ASP in men and women, it is not conclusive, due to the fact that family members share both genes and environment. Thus, if ASP males and females had different rearing environments, the same pattern of results might emerge.

However, in a full adoption design (Plomin *et al.*, 1980), where information concerning criminality is available for adoptees and both biological and adoptive parents, the two hypotheses concerning differential genetic and environmental predispositions may be evaluated separately. Using such a design, more convincing evidence for increased genetic predisposition toward criminality in adopted women has been reported by Cloninger and Gottesman (1987). Based on conviction records in Swedish adoptees and their relatives, the criminality prevalence in biological parents of convicted females (50%) was more than double that in biological parents of convicted males (21%). These authors emphasized further that postnatal environmental factors had varying effects on male and female criminal outcomes. Specifically, prolonged institutional care and urban rearing contributed to increased criminal behavior in females while multiple temporary placements and low social status of the adoptive home increased male criminality (Sigvardsson *et al.*, 1982).

Another way to assess "criminogenic" or adverse rearing environment is to look for higher proportions of criminals in adoptive parents of criminal females. While adoptive parents contribute much more than conviction status to the rearing context which may influence their children, nevertheless, an increased risk would suggest that criminal female adoptees had more negative family environments than their male counterparts.

The present report summarizes further exploration of the genetic and environmental aspects of the sex difference in average liability toward criminal behavior. Our analyses are based on court conviction data for birth cohort of Danish adoptees and their biological and adoptive parents. Both hypotheses concerning differential genetic and environmental predispositions were tested by examining criminal conviction rates in male and female adoptees, as functions of conviction status in biological and adoptive parents, respectively. The effect of adoptive parents' social class on criminal behavior in males and females was also examined.

METHOD

We examined records of criminal convictions for property offenses in a study of Danish adoptees and their biological and adoptive parents located through the adoption register organized by Kety *et al.* (1968). Briefly, the register is based on 14,427 nonfamilial adoptions in Denmark which took place between 1924 and 1947. These include 7727 female adoptees and 6700 male adoptees and their biological and adoptive parents. The present analyses are based only on those individuals who could be fully identified on the basis of date and place of birth and who were not excluded from study because of death, emigration, or other reasons de-

Table I. Property Offenses Under Danish Criminal Law: Conviction Rates in Men and Women

Offense	Percentage	
	Men[a]	Women[b]
Burglary of an apartment or house	.04	.00
Burglary of a business, office, or bank	.07	.00
Burglary of an inhabited summerhouse	.01	.00
Other burglary	.02	.00
Unspecified burglary	.18	.00
Thievery of motor vehicle for use	.61	.01
Thievery of bicycle	.26	.01
Stealing from a motor vehicle	.01	.00
Stealing from a place of work	.16	.03
Stealing from family or friends during a visit	.05	.03
Shoplifting, stealing from vending machines	.06	.02
Other thievery	.88	.07
Unspecified thievery	8.63	2.86
Fraud by intent	.11	.03
Embezzlement	2.26	.31
Other fraud	2.79	.40
Forgery	1.66	.32
Other swindling	.58	.04
Unspecified swindling	.06	.00
Extortion, blackmail	.09	.01
Fencing stolen goods	2.20	.40
Malicious property destruction	.32	.01
Other property crimes	1.63	.21

[a] Includes male adoptees (n = 6123), biological fathers (n = 10,593), and adoptive fathers (n = 13,917)

[b] Includes female adoptees (n = 7061), biological mothers (n = 12,298), and adoptive mothers (n = 14,266)

scribed by Mednick *et al.* (1984). This resulted in 7065 female and 6129 male adoptees (total N = 64,283 including parents) for whom government records were searched in 1976–1978 for evidence of court convictions. The age of the adoptees at the time of data collection ranged from 29 to 52 years. Thus the major part of the risk period for criminality (especially first offense) had been reached. A full description of the data is presented by Mednick *et al.* (1984).

The property-crime offenses which were considered in these analyses are listed in Table I, along with the conviction rates in male and female adoptees. As shown, conviction rates in males exceeded those in females for every offense. The sex difference varies by type of crime, with "unspecified thievery" demonstrating the largest absolute difference. It should be noted that several individuals, both male and female, are represented in more than one category in Table I. Considering all females in the sample (adoptees, biological and adoptive mothers) 1193 of 33,632 (or 3.55%) received at least one property-crime conviction, compared to 3818 of 30,651 (or 12.46%) males (adoptees, biological and adoptive fathers). For these individuals, 11,693 property-crime convictions were received by males and 2169 convictions were received by females, reflecting the greater degree of recidivism in males. It is also interesting that "unspecified thievery" represented the majority of total convictions for both males (49.07%) and females (64.45%).

Due to different transmission patterns for crimes against persons and crimes against property (Bohman *et al.*, 1982; Cloninger and Gottesman, 1987; Mednick *et al.*, 1984), it is important to distinguish between violent offenses and nonviolent property offenses. Thus, analyses were repeated both with and without families where any individual was convicted of a crime against person (such as manslaughter, assault, rape, robbery). Unfortunately, due to the rarity of violent offenders among females, it was not possible to examine separately effects for crimes against persons. For this reason crimes against property are of main concern in this report. Motor-vehicle, traffic-related offenses were not considered in any analyses.

Any individual convicted of at least one offense described in Table I is considered to be criminal in these analyses. In analyses where violent offenders were dropped, noncriminal individuals are those with no record of any violent or nonviolent criminal-law conviction. Otherwise, when violent offenders were included (but their violent offenses ignored), only those individuals with a property offense were considered to be criminal. Although Mednick *et al.* (1984) found the greatest evidence for heritability in males with more serious levels of recidivism (three or more convictions), this criterion is not used in the present analyses because severe recidivism is rare among females.

Analyses. To evaluate the relationships among the adoptee's criminal status (AC) and the criminal status of the biological (BM, BF) and adoptive parents (AM, AF), logistic regression analyses were performed using the LOGIST procedure in the Statistical Analysis System (SAS) (Hastings, 1986). The dependent variable was the probability of adoptee criminality (convicted versus nonconvicted). The logistic transform of this variable is then modeled as a linear function of potential predictor variables which included criminal status of biological and adoptive parents, adoptee sex, and their interactions (entered as products of the main effects). All criminal status variables were treated as dichotomous variables reflecting an individual's past convictions or absence of convictions for property crimes.

The hypothesis of differential genetic predisposition between the sexes would predict a trend in estimated adoptee conviction risk: for those adoptees with a single biological parent convicted of property crime, daughters of convicted biological fathers should be at lowest risk, and sons of convicted biological mothers at greatest risk for criminal conviction. Support for this hypothesis would also be reflected in significantly greater contributions to the risk function for biological mother's criminal status compared to criminal status of biological father. A similar analysis of the differential contribution of criminal status of adoptive mothers and adoptive fathers to the risk of conviction in the adoptee was undertaken to investigate the differential family-environment predisposition. A significant difference in impact of conviction status of adoptive mother versus adoptive father would be indicative of differential risk to sons and daughters associated with shared-family influences.

Separate logistic regression analyses were performed in a similar manner by also including socioeconomic status (SES) of the adoptive father, particularly to investigate its bearing on criminal behavior in sons and daughters. If social class in the foster home exerts a greater effect on women than men, a significant interaction between adoptive father SES and adoptee sex would be found.

Finally, path models were fit to tetrachoric correlations among family members' criminal status indicators, separately for families of daughters and families of sons, including both offenders and nonoffenders. Generalized least-squares (GLS) parameter estimates were compared to examine the differences in heritability (i.e., proportion of genetic variance) for criminal behavior in men and women.

Logistic regression and path analyses were performed only on those families where complete histories of conviction status for each family member were available. This yielded a total of 8296 adoptees (n = 4049 females; n = 4247 males) and their biological and adoptive parents, including both violent and other offenders. The number of adoptees dropped to 7552 (n = 3922 females; n = 3630 males) in analyses where families with violent offenders were omitted.

RESULTS

Observed frequencies of convicted adoptees are presented in Table II, as a function of conviction status (for property crimes) in each of the biological and adoptive parents. For each of the $2^4 = 16$ cells reflecting combinations of parental conviction status (C, convicted; NC, not con-

Table II. Proportions of Convicted Adoptees as a Function of Conviction Status for Property Crimes in Biological and Adoptive Parents[a]

	Parental conviction status[b]				Percentage convicted adoptees $(n)^c$	
Cell No.	BM	BF	AM	AF	Sons	Daughters
1	NC	NC	NC	NC	9.49 (2572)	1.74 (2760)
2				C	12.61 (111)	2.11 (95)
3	NC	NC	C	NC	14.29 (35)	2.78 (36)
4				C	.00 (1)	.00 (3)
5	NC	C	NC	NC	14.01 (621)	3.38 (740)
6				C	20.51 (39)	3.13 (32)
7	NC	C	C	NC	15.38 (13)	.00 (8)
8				C	.00 (2)	.00 (1)
9	C	NC	NC	NC	18.00 (150)	4.71 (175)
10				C	30.77 (13)	25.00 (4)
11	C	NC	C	NC	.00 (3)	.00 (2)
12				C	100.00 (1)	.00 (0)
13	C	C	NC	NC	23.53 (68)	1.67 (60)
14				C	.00 (1)	.00 (4)
15	C	C	C	NC	.00 (0)	.00 (2)
16				C	.00 (0)	.00 (0)

[a] Families with individuals convicted of violent crimes are omitted.
[b] BM, biological mother; BF, biological father; AM, adoptive mother; AF, adoptive father; NC, not convicted; C, one or more convictions.
[c] (n) is the total number of families, used as the denominator for the percentage.

victed), relative frequencies of conviction are presented separately for adopted sons and daughters. An examination of a few key cells in Table II provides a straightforward examination of the differential genetic predisposition hypothesis. Considering the cells where *neither* adoptive parent has received a property conviction and where only *one* biological parent has received conviction (cells 5 and 9), daughters of convicted biological fathers are indeed at lowest risk, and sons of convicted biological mothers are at greatest risk for criminal conviction themselves. This is exactly as predicted if convicted mothers provided greater genetic risk than convicted fathers. It is also noteworthy that, although risk is higher when mother than father is convicted, risk is highest of all when both biological parents are convicted.

Table III summarizes the results of the logistic regression analysis using criminal status of biological and adoptive parents as well as adoptee sex as independent variables. As all two-way interactions were nonsignificant (difference in likelihood ratio for model with main effects and all

Table III. Log-Linear Analysis of Adoptee Property Criminality, as a Function of Adoptee Sex and Biological and Adoptive Parent Property Conviction Status: Logistic Regression Coefficients (*b*), Their Standard Errors, and Odds Ratios

Effect	*b* (SE)	Wald χ^2	*p*
Adoptee sex	1.71 (.12)	205.22	<.01
BM property convictions	.75 (.15)	24.96	<.01
BF property convictions	.43 (.11)	16.40	<.01
AM property convictions	.18 (.36)	.26	.61
AF property convictions	.37 (.20)	3.34	.07

second-order interactions versus model with main effects only = 3.69, df = 6), the final model used included main effects only. The highly significant effect of adoptee sex (χ^2 = 205.22, df = 1, $p < .0001$) is reflective of the much greater risk for conviction of males versus females (odds ratio = $e^{1.706}$ = 5.507). Criminal status of both biological mother and father showed significant effects on the conviction status of the adoptee, thus demonstrating a significant heritable influence in property criminality. Note also that the estimated regression coefficient for criminal status of the biological mother was significantly greater than that for biological father (z = 1.69, $p < .05$, one-tailed test). Estimation of the risk gradient based on criminal status of biological parents (Table IV) demonstrates that children of convicted biological mothers are at greater risk of criminal conviction than children of convicted biological fathers, thus demonstrating support for the differential genetic hypothesis.

The main effect of criminal status of adoptive mother was not significant, although the effect for adoptive father was marginally significant (χ^2 = 3.34, df = 1, $p < .07$). A comparison of estimated regression coef-

Table IV. Relative Risk of Adoptee Conviction Based on Criminal Status of Biological Parents[a]

Biological mother	Biological father	Relative risk in adoptee
Not convicted	Not convicted	1.00
Not convicted	Convicted	1.54
Convicted	Not convicted	2.12
Convicted	Convicted	3.26

[a] Relative risk computed relative to baseline of both parents not convicted as follows: risk = exp[(0.752*BM) + (0.430*BF)], where BM is the criminal status of biological mother and BF is the criminal status of biological father (0 = not convicted, 1 = convicted).

ficients for criminal status of adoptive mother versus father revealed no significant difference, thereby suggesting no differential effect of environment due to sex of adoptive parent.

A highly similar pattern of results was obtained when violent offenders and their families were included in these analyses. Significant main effects were obtained for adoptee sex and both biological parents, and the adoptive father effect was marginally significant. The only discrepancy between the two analyses was that the difference between biological mother and biological father effects was attenuated somewhat and only marginally significant. However, the pattern of adoptee risk appeared highly similar in the two analyses.

Inclusion of adoptive father's SES also yielded similar results, with the exception that the unique contribution of adoptive father criminal status became further attenuated and nonsignificant ($\chi^2 = 2.22$, df $= 1$, $p = .137$). Adoptive father SES did contribute significantly to adoptee risk for conviction ($\chi^2 = 5.97$, df $= 1$, $p < .02$), such that lower SES was associated with greater risk. However, this effect did not depend on sex of adoptee, judging from the nonsignificant SES × Sex of adoptee interaction in this analysis. Thus, lower SES does not appear to exert a greater chance of conviction in sons than daughters, contrary to what one would expect if criminal men and women have different socioeconomic backgrounds.

It must be emphasized that the analyses so far were concerned with the *average* liability toward criminality and exploration of reasons for sex differences in such averages. A mean sex difference in overall liability is revealed by the greater conviction rates in males. In addition, the sexes appear to differ in average genetic liability, since biological offspring of convicted women are at greater risk than those of convicted men. A separate but related issue concerns the heritability and environmentality of liability toward property criminality, or the proportion of *variance* in liability explained by genetic and environmental factors, respectively. Just as the average genetic liabilities appear to differ between the sexes in these data, it may be (but is not necessary) that relative proportions of genetic variance also differ for males and females. It is also possible that these proportions are equivalent for the two sexes, even though their genetic predispositions appear to differ.

To investigate the issue of differential heritability in men and women tetrachoric correlations between property criminality in offspring and that in parents of varying sex were examined (see Table V). Note, in particular, that all biological parent/offspring correlations are significant and that the biological mother/offspring correlations are somewhat higher than the biological father/offspring for both sons and daughters. Also, adoptive par-

Table V. Tetrachoric Correlations Among Biological and Adoptive Parents and Adopted Sons (Above Diagonal) and Adopted Daughters (Below Diagonal)

	Adoptee	BM	BF	AM	AF
Adoptee	—	.20*	.14*	.06	.11*
BM	.15*	—	.15*	.02	.08
BF	.12*	.09*	—	.09	.07
AM	−.02	.04	−.01	—	.09†
AF	.05†	−.02	.07	.15*	—

[a] Violent offenders and their families excluded.
* $p < .05$.
† $p < .10$.

ent/offspring correlations are significant for fathers with sons and marginally significant with daughters, but neither of the correlations of adoptee with adoptive mother is significant. Some assortative mating for property criminality is suggested by the significant spouse correlation between the two adoptive parents of daughters ($r = 0.15$, $p < .05$) and the marginally significant one for adoptive parents of sons ($r = 0.09$, $p < .10$), as well as significant correlations between biological parents of both sons ($r = .15$, $p < .05$) and daughters ($r = .09$, $p < .05$). Since the biological parent/offspring correlations are functions of these spouse correlations, the slightly greater assortative mating in parents of sons may explain the corresponding elevation in parent/child resemblance for sons as compared to daughters. Finally, selective placement for property criminality, or correlations between adoptive and biological parents, is for the most part negligible, with the average correlation being .048.

A multifactorial path model was fit to the correlations in Table V, using a generalized least-squares (GLS) estimation procedure described by Baker (1986). The model was that described by Fulker (1988) in the analysis of cognitive abilities and takes into account polygenic influences, assortative mating, selective placement, passive genotype–environment correlation, and effects of adoptive parents' phenotypes on adoptee's environment. Phenotypic assortative mating, which was allowed to differ in biological and adoptive parents, and selective placement were each accommodated by using conditional paths recommended by Carey (1986). A path diagram in Fig. 1 depicts the relationships among the five family members in the full adoption design.

GLS parameter estimates for this model when fit to tetrachoric correlations are presented in Table VI, separately for families of sons and daughters. Goodness-of-fit indices were statistically significant for both families of sons ($\chi^2 = 13.49$, df $= 1$, $p < .10$) and families of daughters

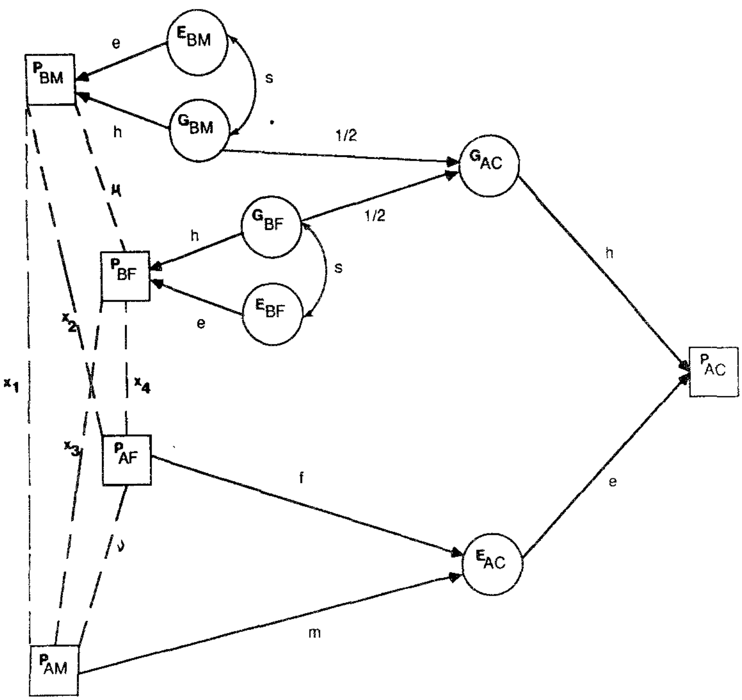

Fig. 1. Path diagram depicting relationships among adopted child (AC), biological mother (BM), biological father (BF), adoptive mother (AM), and adoptive father (BF). P, phenotype; G, additive genotypic value; E, environmental value.

($\chi^2 = 27.28$, df $= 1, p < .01$). However, due to the large number of cases on which the correlations are based (3630 families of sons and 3922 families of daughters), any of the slightest deviations of expected from observed correlations will produce a statistically significant (and poor) goodness of fit. An alternative fit index suggested by Bentler and Bonett (1980) is provided by calculating delta $= (\chi^2_0 - \chi^2_1)/\chi^2_0$, where χ^2_0 and χ^2_1 are, respectively, the chi-square values from the null model (i.e., no familial resemblance) and the hypothesis model (i.e., in Fig. 1). Values of delta which are close to 1.0 indicate that the model is adequate to account for the observed covariance structure, and thus, a less constrained model is unlikely to provide much improvement in fit. In this case, delta $= .997$ and .996 for families of sons and daughters, respectively. Thus, the estimates in Table VI actually yield quite good fit for both sons and daughters.

Most parameters are highly significant in both groups, with the exception of the genotype–environment correlation (s) in families of daugh-

Table VI. Variation in Liability Toward Property Criminality: Generalized Least-Squares Estimates of Genetic and Environmental Parameters

Parameter	GLS estimate (SE)	
	Sons	Daughters
h	.566 (.009)	.507 (.004)
m	.022[a]	−.048[a]
f	.068 (.006)	.049 (.002)
s	.030 (.002)	.000 (.001)
μ	.147 (.010)	.087 (.009)
ν	.092 (.001)	.154 (.001)
x_1	.023 (.001)	.041 (.001)
x_2	.081 (.003)	−.020 (.002)
x_3	.088 (.002)	−.006 (.002)
x_4	.072 (.006)	.074 (.005)
e	.807[a]	.862[a]

[a] Parameter is derived algebraically from others in the model.

ters. The relatively small standard errors are also a function of the large number of cases, so that some could probably be constrained to be zero without considerable worsening of the fit (with respect to delta). However, for purposes of completeness and comparison across the sexes, all estimates were retained in Table VI. The particularly noteworthy aspect of these parameter estimates is that they are remarkably similar for both the sons and the daughters. In fact, fitting the model jointly to both groups still yielded an acceptable goodness of fit (delta = .96). Squaring the parameter h gives the heritability of property criminality in families of sons (h^2 = .32) and daughters (h^2 = .26). The hypothesis that criminal behavior (against property (is more *heritable* for women than for men is clearly not supported in these data, in spite of the greater *average* genetic predisposition in women.

Fitting the same model to the larger sample (N = 8296 families), including violent offenders (but considering only their proeprty offenses as a criterion for criminality), we obtained a remarkably similar pattern of results. In particular, heritability estimates were h^2 = .30 in families of sons and h^2 = .27 in families of daughters. It is clear, then, that heritability of liability toward property-criminal behavior is not greater in females than males, in spite of the significant sex difference in average genetic predisposition.

DISCUSSION

Our findings regarding the inheritance of criminal behavior (with respect to property offenses) in the Danish data are quite similar in a number of ways to those previously reported by Cloninger and Gottesman (1987) concerning Swedish adoptees. First, the relative contributions of familial factors to individual differences (or variation) in property crime, both genetic and shared-family environmental, appear similar in females and males. Estimates of heritability and environmentality are comparable in both sexes. Furthermore, the effects of shared-family environment, as indicated by path coefficients from adoptive parents to adoptee (m and f in Table VI and Fig. 1), are negligible in comparison to the effects of biological parent genotype. It is apparent, then, that the environmental effects themselves must be largely nonfamilial, at least with respect to variation in liability for criminality.

Also consistent with the Swedish data is our finding of increased genetic predisposition for convicted females compared to males. Specifically, the risk for criminal conviction is greater for children of criminal women than criminal men. This finding stems from our log-linear analyses based on the prediction of adoptee risk for criminal behavior, as functions of parental criminality. We considered whether this enhanced effect of biological mother on liability of criminality in her offspring may be due to prenatal environment, rather than genetic effects. This was done by performing separate log-linear analyses where (property-crime) risk rates in *parents* were predicted from *adoptee* sex and criminal status (Baker *et al.*, 1985). In fact, highly similar results were obtained in these analyses, where more convicted daughters (47.66%) than convicted sons (36.69%) had at least one biological parent convicted of a property offense. Judging from this consistent pattern of results, whether predicting parent or child risk, we conclude that prenatal environment cannot entirely explain the increased risk provided by the mother but that criminal women were indeed at greater biological risk as a group than criminal men.

On the other hand, convicted sons and daughters did not have differential proportions of adoptive parents with registered criminal offenses, nor did the distributions of SES in the adoptive home appear different for the two groups of offenders (Baker *et al.*, 1985). This is also consistent with the other log-linear analyses presented in this report. Of course, this is not to say that environmental factors as a whole do not differ for male and female offenders. It is simply that there are no greater risks for either sex in terms of familial environment, at least as measured by adoptive-parent criminality and SES. There may be other aspects of the family

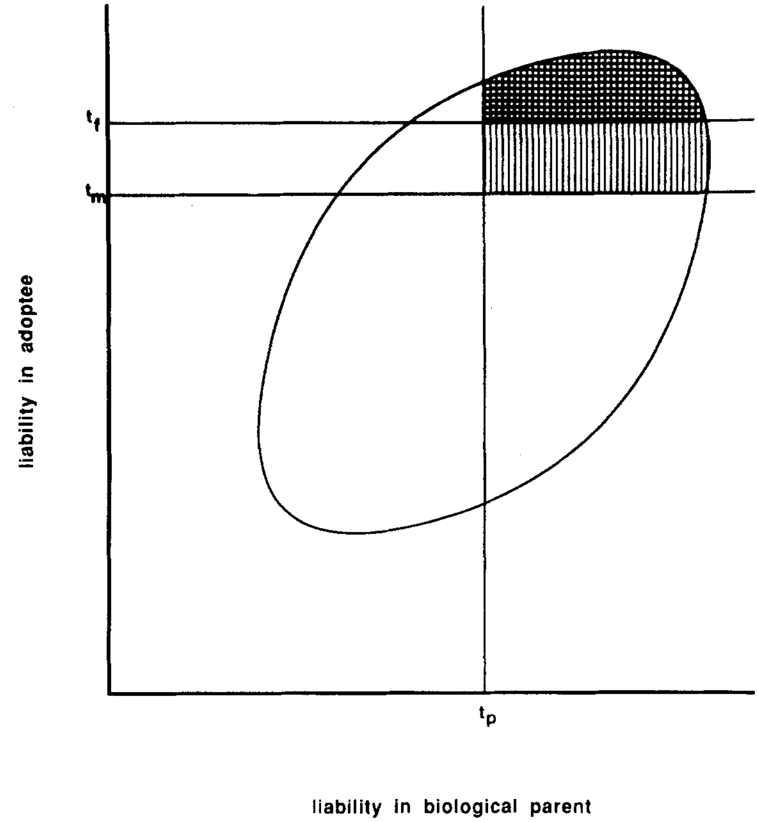

Fig. 2. Bivariate relationship between biological parent and adoptee liability underlying a threshold characteristic. Thresholds vary for male and female adoptees (t_m, t_f) and for parent (t_p), while equivalent parent–offspring correlations are assumed for the two sexes in adoptees. Hatched area and hatched plus double-hatched areas respresent proportions of affected parents of females and males, respectively.

environment or additional nonfamilial environmental factors which differ for men and women and lead them to become registered criminals. As mentioned earlier, the nature of these factors has already been suggested in part by Sigvardsson *et al.* (1982) in the Swedish data.

Regarding the similar portions of genetic variation for property-crime liability in men and women, these results might seem a bit puzzling in contrast to the findings of differential genetic risk in the sexes. Figure 2 is thus presented to help shed light on these seemingly conflicting results. A situation is presented where the biological parent/adopted offspring correlation for the unmeasured liability does not vary for sons and daughters. Thresholds, however, do vary for males (t_m) and females (t_f), to reflect the greater proportion of registered offenders in men. It may be seen how the criminal daughters could have a greater relative portion of "affected" parents (double-hatched area vs. open area above t_f in Fig. 2) than criminal sons (hatched plus double-hatched areas vs. both open areas above t_m), in spite of the comparable parent/child correlations for liability in the two sexes. The average genetic risk for criminal men and women may be roughly compared in Fig. 2 as well, by finding the points on the abcissa which would correspond to the average liability for biological parents of all convicted sons and parents of all convicted daughters. Taking into account the greater area to the left of the parental threshold (t_p) for convicted male adoptees than for convicted females, one may see that the average genetic risk for affected sons is less than that for affected daughters. To summarize, the differences between the log-linear and the path-analytic models are analogous to those in testing means and correlations. Average risk is estimated here in the log-linear analyses, while our correlational analyses reveal information about variation in liability.

Comparable heritability estimates in the two sexes implies that the composition of etiological factors underlying criminal behavior is similar for both men and women in this cohort. What differs between the sexes is the level of severity present in these predisposing factors for those who actually become criminal. To engage in criminal behavior, a woman must have a more severe genetic predisposition and more adverse environmental conditions than a man. The well-documented fact that women as a group are less likely than men to become registered criminals is most likely explained by the existence of different (nonfamilial) environmental influences between the two sexes. Although some have begun to identify the nature of these nonfamilial factors (Sigvardsson *et al.*, 1982), we have yet to understand fully the specifics of this important class of influences in criminal behavior in men or women.

REFERENCES

Baker, L. A. (1983). *Bivariate Path Analysis of Verbal and Non-Verbal Abilities in the Colorado Adoption Project*, Unpublished doctoral dissertation, University of Colorado, Boulder.

Baker, L. A. (1986). Estimating genetic correlations among discontinuous phenotypes: An analysis of criminal convictions and psychiatric-hospital diagnoses in Danish adoptees. *Behav. Genet.* **16**:127–142.

Baker, L. A., Moffitt, T. E., Mednick, S. A., and Sasao, T. (1985). Sex differences in criminal behavior in a Danish adoption cohort. *Behav. Genet.* **15**:584.

Bentler, P. M., and Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychol. Bull.* **88**:588–606.

Bohman, M., Cloninger, C. R., Sigvardsson, S., and von Knorring, A. (1982). Predisposition to petty criminality in Swedish adoptees. I. Genetic and environmental heterogeneity. *Arch. Gen. Psychiat.* **39**:1233–1241.

Carey, G. (1986). A general multivariate approach to linear modeling in human genetics. *Am. J. Hum. Genet.* **39**:775–786.

Christiansen, K. O. (1977). A preliminary study of criminality among twins. In Mednick, S. A., and Christiansen, K. O. (eds.), *Biosocial Bases of Criminal Behavior*, Gardner Press, New York.

Cloninger, C. R., and Gottesman, I. I. (1987). Genetic and environmental factors in antisocial behavior disorders. In Mednick, S. A., Moffitt, T. E., and Stack, S. A. (eds.), *The Causes of Crime: New Biological Approaches*, Cambridge University Press, New York.

Cloninger, C. R., Reich, T., and Guze, S. B. (1975). The multifactorial model of disease transmission. II. Sex differences in the familial transmission of sociopathy (antisocial personality). *Br. J. Psychiat.* **127**:11–22.

Cloninger, C. R., Christiansen, K. O., Reich, T., and Gottesman, I. I. (1978). Implications of sex differences in the prevalences of antisocial personality, alcoholism, and criminality for familial transmission. *Arch. Gen. Psychiat.* **35**:941–951.

Fulker, D. W. (1988). Path analysis of genetic and cultural transmission in human behavior. In Beir, B. S., Eisen, E. J., Goodman, M. M., and Namkoong, G. (eds.), *Proceedings of the Second International Conference on Quantitative Genetics*, Sinauer, Sunderland, Mass.

Hastings, R. P. (ed.) (1986). *SUGI Supplemental Library User's Guide*, Version 5 edition, SAS Institute, Carey, N.C.

Hindelang, M. J., Hirschi, T., and Weiss, J. (1979). Correlates of delinquency: The illusion of discrepancy between self-report and official measure. *Am. Soc. Rev.* **44**:995–1014.

Jencks, C. (1972). *Inequality: A Reassessment of the Effect of Family and Schooling in America*, Basic Books, New York.

Kety, S. S., Rosenthal, D., Wender, P. H., and Schulsinger, F. (1968). The types of prevelance of mental illness in the biological and adoptive families of adopted schizophrenics. In Rosenthal, D., and Kety, S. S. (eds.), *The Transmission of Schizophrenia*, Pergamon, Oxford.

Mednick, S. A., Gabrielli, W. F., and Hutchings, B. (1984). Genetic factors in criminal behavior: Evidence from an adoption cohort. *Science* **224**:891–893.

Mednick, S. A., Moffitt, T. E., Gabrielli, W. F., and Hutchings, B. (1986). Genetic factors in criminal behavior: A review. In Block, J., Olweus, D., and Yarrow, M. R. (eds.), *The Development of Antisocial and Prosocial Behavior*, Academic Press, New York.

Plomin, R., DeFries, J. C., and McClearn, G. E. (1980). *Behavioral Genetics: A Primer*, W. Freeman Press, New York.

Raine, A., and Venables, P. H. (1988). Antisocial behaviour: Evolution, genetics, neuropsychology, and psychophysiology. In Gale, A., and Eysenck, M. (eds.), *Handbook of Individual Differences: Biological Perspectives*, Chichester, Wiley.

Sellin, T. (1938). *Culture, Conflict, and Crime*, Subcommittee on Delinquency of the Committee on Personality and Culture, New York.

Sigvardsson, S., Cloninger, C. R., Bohman, M., and von Knorring, A. (1982). Predisposition to petty criminality in Swedish adoptees. III. Sex differences and validation of the male typology. *Arch. Gen. Psychiat.* **39**:1248–1253.

Van Dusen, K. T., Mednick, S. A., Gabrielli, W. F., and Hutchings, B. (1983). Social class and crime in an adoption cohort. *J. Crim. Law Crim.* **74**:249–269.

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