

The genetic epidemiology of parental discipline

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ABSTRACT

Background. Previous studies of parental discipline have identified little influence of heritability on parental control, and some influence of gene–environment correlations, shared environment and child temperament.

Method. Using interview data from 2003 female twins from a population-based twin registry and 1472 of their parents, we examined reports of parental discipline from four perspectives: (1) father and mother reporting separately on the type of discipline they provided for their offspring; (2) each twin reporting on the type of discipline they received from their parents; (3) each parent reporting on the discipline provided by their spouse; and, (4) each twin reporting on the discipline they provided for their own offspring. Using factor analysis and univariate structural equation modelling, we examined the structure of parental discipline, and the genetic and environmental influences thereon.

Results. The seven discipline items yielded two factors, physical discipline and limit setting, which were moderately positively correlated. Parents perceived discipline as largely a common environmental experience for the twins, whereas the twins indicated that discipline was influenced by unique environmental factors and the genotype of the child. Twins as parents indicated no influence of shared environment on discipline, with the majority of influence accounted for by non-shared environment and parental genotype.

Conclusions. Parents recall providing similar discipline to their children, whereas children emphasize the differences in parental discipline. Sources of individual variation in parental discipline vary according to which family member report is examined. In total, parental discipline is partially influenced by the genotype of both the parent and child, and by environmental factors shared by the twins and unique to the individual.

INTRODUCTION

In the examination of family functioning and its association with child outcomes, it has been common to categorize parental style as an environmental variable that can have a profound influence on child development (Whitmore *et al.* 1993). However, there is increasing recognition that parenting style is a complex process, affected by both attitudes from the parent's family of origin, and the genetically influenced tempera-

mental characteristics of both parent and child (Reiss *et al.* 1994; Kendler, 1996). It has also become clear that children are likely to emphasize the differences in treatment that they received, whereas parents emphasize the similarity with which they treated their children (Plomin *et al.* 1994). Thus, parental reports of family environment tend to show the influence of high levels of shared environment and moderate heritability, whereas child reports show little shared environment and moderate genetic influences. In addition, children in the same family experience surprisingly different environments (Dunn & Plomin, 1990), indicating that parenting style is unlikely to solely form a 'common environment', or an environment

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shared by family members (Neale & Cardon, 1992).

There are some indications that parental discipline is likewise affected by a complex interaction of influences. Adolescent twins' perceptions of parental control (discipline) did not show genetic influence despite the same child reports on parental warmth showing genetic influence (Rowe, 1981, 1983). Use of parental report, child report and videotaped observations to measures parental control, parental warmth and personal growth showed that, while parental control was slightly heritable, it had the lowest heritability of all the measures (Plomin *et al.* 1994). Parental reports of young children at genetic risk of antisocial behavioural problems showed that the children were consistently more likely to receive coercive parenting from their adoptive parents than children not at genetic risk. This indicates some influence of an evocative genotype-environment correlation – where the genetically influenced characteristics of the child influence their interactions with others (O'Connor *et al.* 1998). In a large sample of adoptive and non-adoptive sibling pairs using parental report, inconsistent discipline was influenced by the shared environment (Deater-Deckard *et al.* 1999). A comparison of pre-adolescent sons of fathers with substance abuse problems and normal fathers showed that a difficult child temperament disposition placed the child at risk for disciplinary maltreatment by parents (Blackson *et al.* 1996).

In this report we seek to elucidate further the various influences that affect normative parental discipline. To achieve this aim, we examine a large, population-based twin sample from four perspectives: (1) the father and mother reporting separately on the type of discipline they provided for their twin offspring; (2) each twin reporting on the type of discipline they received from their parents; (3) each parent reporting on the form of discipline provided by their spouse; and, (4) each twin reporting on the form of discipline they have provided for their own offspring. By examining multiple reports of normative discipline, we can start to develop a basic understanding of parental discipline from which we can better understand the interactions between family psychopathology, parental discipline and child psychopathology.

METHOD

Participants

The data are from a population-based longitudinal study of Caucasian female twins drawn from the Virginia Twin Registry, formed from a systematic review of all birth records in the Commonwealth of Virginia (USA) after 1918. Twins were eligible to participate if they were born between 1934–1971 and both members had previously responded to a mailed questionnaire, completed over 1987–8 (individual response rate of 64%). In Wave 1 (1987–9), 93% of the eligible individuals ($N = 2163$) were interviewed, including both members of 1033 pairs. Of these interviews, 92% were face-to-face. All twins were recontacted a minimum of 1 year after the Wave 1 interview, and a further wave of interviews were conducted with 2003 twins (93% of the Wave 1 sample) during 1990–1, including both members of 938 pairs. The majority of Wave 2 interviews were completed by telephone (98.6%). The mean age of the twins at time of this second interview was 31.6 years (s.d. = 7.5), with ages ranging from 18.7 to 60.3 years. The mean number of months between the Wave 1 and Wave 2 interviews was 17 (s.d. = 3.7).

Zygoty was determined blindly by standard questions and photographs that have > 95% accuracy (Eaves *et al.* 1989) and 119 pairs of uncertain zygoty were analysed using eight RFLP markers (Spence *et al.* 1988). We recently revalidated zygoty assignment with highly polymorphic PCR markers and found an error rate $\leq 4.5\%$. Of the 938 complete pairs interviewed at Wave 2, 555 were monozygotic (MZ) and 383 were dizygotic (DZ).

Table 1. *Discipline items*

The following is a list of things that parents do to try and discipline their children. For each item, I'd like to know how frequently you used this with (Twin A/B) when she was misbehaving, (and how frequently the other parent used it): often, sometimes, rarely, never.	
1	Taking away privileges
2	Sending her to her room
3	Grounding her
4	Scolding or yelling at her
5	Spanking her
6	Slapping her
7	Hitting her with a brush, belt or stick
8	Hitting her with a fist

When interviewing the twins at Wave 1, the names and addresses of living biological parents were obtained. We identified 1698 parents of the complete Wave 1 pairs, of which 1472 were interviewed, including 855 mothers and 617 fathers. The mean age of the participating parents was 58.6 years (s.d. = 9.3). Information about the interview process and interviewer characteristics has been presented elsewhere (Kendler, 1996). Written informed consent was obtained prior to face-to-face interviews and verbal assent prior to telephone interviews.

Instruments

Parental discipline was assessed using an adapted and expanded version of the discipline items from the Home Environment Interview (Holmes & Robins, 1987). Eight items addressed the type and frequency of the disciplinary approach used when the child was growing up, defined as 'up through the age of 16'. The full items are presented in Table 1. During the parental interview, parents were asked to report on their own disciplinary approach, and also the approach of their spouse, separately for each twin. The same questions were asked of the twins during the Wave 2 interview. At that time, they were asked to rate their mother and father separately. Later in the interview, they were also asked to rate their disciplinary approaches toward their own offspring if they had children aged 4 years or older (both members of 146 MZ and 117 DZ pairs provided this information).

Nearly all parents endorsed 'never' when asked if they had hit their child with their fist. One father and four mothers admitted to using a fist 'rarely' and nine twins endorsed 'rarely' when asked about discipline toward their own children. Due to its low power of discrimination, the item was removed from any further analyses.

Statistical analysis

Factor analysis

Indicators of normality, including skewness, kurtosis, and normal probability plots, showed that responses on the seven discipline items were normally distributed. To examine the factor structure of these seven items, a product-moment correlation matrix for all items was submitted to a factor analysis and varimax rotation, extracting factors with an eigenvalue greater

than unity. Furthermore, a promax rotation method was also examined, in order to investigate the correlations between factors. These analyses were done separately for the seven informants: each twin, mother and father reporting on the paternal discipline to the twin; each twin, mother and father reporting on maternal discipline to the twin; and twins reporting on the discipline they used with their own offspring. Factor derived scales, formed from these identified factors, were used in further analyses. In order to assess the similarity of the factors across the different reporters, Tucker's congruency coefficients were calculated (Deroogatis *et al.* 1972). While there are no tests of significance associated with this statistic, coefficients of 0.90 and higher are generally accepted as indicating a highly stable structure (Tobin *et al.* 1989).

Twin analyses

In order to examine the sources of individual difference of these scales, PRELIS2 (Jöreskog & Sörbom, 1993) was used to produce two 2×2 variance-covariance matrices (one for MZ and one for DZ twins) for each scale and each reporter. These matrices were subjected to univariate model fitting using Mx (Neale, 1997). The population variance in parental discipline can be due to three different influences: additive genes (A), common or shared environment (C), and non-shared or unique environment (E). Initially, a full model (ACE) is fit to the data, followed by an AE model, a CE model, and a model containing only non-shared environment. The goal of model fitting is to explain the observed data as an optimal combination of goodness-of-fit and parsimony. Akaike's Information Criterion (AIC: Akaike, 1987) reflects these criteria, where the smaller (or more negative) the value, the better the fit of the model. As the final part of this procedure, the proportion of variance contributed by genes (a^2), shared environment (c^2), and non-shared environment (e^2) to parental discipline was estimated, along with 95% confidence intervals.

Equal environment assumption

Finally, we used polychotomous linear regression to evaluate the equal environment assumption (EEA). There were two regressions

for both physical discipline and limit setting, for each of the twins' reports, the mothers' reports on their own discipline, and the fathers' reports on their own discipline. In each case, the dependent variable was the absolute value of the difference between the reports for Twin 1 and Twin 2. The independent variables were zygosity and, in turn, two measures of specified common environment. These variables were factor scores from 12 questions of environmental similarity asked of all twins (Kendler & Gardner, 1998). The first is co-socialization, reflecting the tendency of the twins to socialize together during childhood and adolescence (sharing playmates as children and teenagers, sharing friends, going around with the same group, and going out together on dates), as well as an item measuring emotional closeness. The second environmental similarity variable is childhood treatment, examining how similarly the twins were treated as children by their parents, and includes three items (sharing the room, the same classroom, and being dressed alike).

In the cases where the specified common environment (S) predicted differences in reports of discipline between twins, the twin pairs who were rated highly on S (top 50%) were compared to the twins low on S (in the bottom 50%). In each case, the full ACE model was compared to a model where the specified environmental variable was also included – an ACSE model (Hettema *et al.* 1995). In this way we can see if the inclusion of the specified environmental variable significantly changes our estimate of A.

For both these analyses and the factor analyses we used SAS version 6.12 (SAS Institute Inc., 1996).

RESULTS

Structure of parental discipline

Twins as the offspring generation

Factor analyses of the discipline data from all informants identified two factors, shown in Table 2. The first factor (from twin report) and the second factor (from parent report) was a physical discipline factor, including items involving slapping, smacking and hitting. The second factor (from twin report) and the first factor (from parent report) was a limit-setting factor, including items involving grounding, sending to room, taking away privileges. The

item involving 'scolding or yelling' was unstable in that it appeared interchangeably in both factors. It was included in the physical discipline factor when using twin report, mother's report on self, mother's report on father (Twin A only), and father's report on mother (Twin A only). It appeared in the limit setting factor when using father's report on self, father's report on mother (Twin B only) and mother's report on father (Twin B only). Internal consistency (Cronbach's α) for each scale ranged from 0.48–0.82, with the lowest internal consistencies being associated with the three-item scales.

The mean frequencies of each discipline scale were compared across recollections from the twins, mother, and father. Parents consistently saw themselves and each other as using discipline less frequently than the twins did. These means were not significantly different for limit setting by the mother. With respect to physical discipline by the mother, father reported a significantly lower frequency ($P < 0.05$) than both mothers and twins did, and mothers reported a significantly lower frequency than twins did. Limit setting by the father was reported as being significantly less frequent by mothers compared to both twins and fathers. Fathers and mothers reported a significantly lower frequency of physical discipline by the father than did twins.

Pearson's correlations between the reports from twin and mother, twin and father, and mother and father, on four aspects of discipline (physical discipline: mother toward twin and father toward twin, limit setting: mother toward twin and father toward twin) were examined separately for Twin 1 and Twin 2. The correlations, shown in Table 3, ranged from +0.24 to +0.45, indicating low to moderate association between reports (all P s < 0.0001). There tends to be greater agreement about the mother's use of discipline than the father's. In all cases, the twin and mother have the highest agreement concerning the father's use of discipline.

Twins as the parental generation

Two factors were identified from Twin 1's report of discipline toward her own child, with the eigenvalue of the third factor equal to 0.98. Three factors were identified from Twin 2's reports, with the eigenvalue of the third factor equal to 1.06. When Twin 2's factor solution was constrained to two factors, it had a similar

Table 2. Factor loadings of parental discipline items using varimax rotation of each family member's reports of twin parental discipline

Form of discipline	Twin 1's report on mother		Twin 2's report on mother		Mother's report on self – Twin A		Mother's report on self – Twin B		Father's report on mother – Twin A		Father's report on mother – Twin B	
	I	II	I	II	I	II	I	II	I	II	I	II
Of mother towards twin												
Hitting with a brush, belt or stick	78	10	79	11	–02	68	–04	72	01	71	03	70
Slapping	74	08	74	12	06	65	10	66	03	70	10	71
Spanking	77	06	77	07	16	71	19	68	26	64	30	68
Scolding or yelling	61	11	67	08	25	62	31	62	43	48	55	34
Taking away privileges	11	86	06	86	85	05	87	10	81	12	84	11
Grounding	16	80	12	83	79	13	79	18	77	17	77	17
Sending to room	04	70	12	61	70	13	77	13	80	04	83	03
Form of discipline	Twin 1's report on father		Twin 2's report on father		Father's report on self – Twin A		Father's report on self – Twin B		Mother's report on father – Twin A		Mother's report on father – Twin B	
	I	II	I	II	I	II	I	II	I	II	I	II
Of father towards twin												
Hitting with a brush, belt or stick	83	06	82	07	05	72	–01	78	06	78	11	80
Slapping	74	08	72	08	04	71	13	63	12	76	14	78
Spanking	79	20	81	15	44	58	41	67	37	68	50	58
Scolding or yelling	51	37	64	19	55	34	54	39	41	50	56	38
Taking away privileges	21	83	13	84	81	06	85	10	86	17	88	14
Grounding	15	81	14	83	77	10	78	14	78	17	80	15
Sending to room	07	75	11	68	80	05	82	11	79	19	83	17

Within each report, the highest factor loading for each item is shown in boldtype.

Table 3. *Level of agreement (Pearson's correlations) between family member's reports of the two forms of disciplines*

Form of discipline	Twin 1			Twin 2		
	Twin Mother	Twin Father	Mother Father	Twin Mother	Twin Father	Mother Father
Mother						
Physical discipline	0.27	0.28	0.28	0.32	0.23	0.26
Limit setting	0.38	0.34	0.34	0.31	0.29	0.33
Father						
Physical discipline	0.45	0.33	0.27	0.35	0.31	0.30
Limit setting	0.39	0.31	0.33	0.35	0.32	0.34

factor structure to that of Twin 1 (Table 4). Internal consistency for each scale was 0.58 and 0.52 respectively.

Comparison of factorial similarity

The cross-twin, within-rater congruency coefficients (a total of seven for each factor) ranged from 0.990–0.998 for physical discipline and 0.987–0.999 for limit setting, indicating that the factors were highly similar across twin pair ratings. The cross-rater, within-twin congruency coefficients (a total of 21 for each factor) ranged from 0.954–0.997 for physical discipline. The congruency coefficients for limit setting were also high, ranging from 0.913–0.996, with the exception of the coefficient between the father's report on his limit setting and the twin's report of limit setting with her offspring, which was 0.868.

Correlations between the limit setting and physical discipline factors

The inter-factor correlations between the two factors were computed from promax rotations. The lowest correlations (+0.17–+0.18) were between the twins' reports of discipline towards their own children. The remaining discipline factors were moderately positively correlated, ranging from +0.24 to +0.42, with the exception of the mother's report of her discipline with Twin 1 (–0.27).

Genetic and environmental influences on parental discipline

Physical discipline: twins as the offspring generation

Results from model fitting with physical discipline are summarized in Table 5. The physical

discipline toward each member of the twin pair, as reported by both mother and father (about themselves and each other), is strongly associated (+0.76–+0.94), indicating that parents consider themselves to have disciplined the twins similarly. While physical discipline as reported by the twins is less strongly correlated between the pair (+0.60–+0.74), indicating that frequency of discipline is perceived by the twins to be less similar across twin pairs than reported by the parents, these correlations represent a substantial to very strong association.

The correlations in levels of physical discipline were only moderately greater for MZ than DZ twins for all reports. For parental report, the greatest proportion of the variance of physical punishment, ranging from 62–72%, was due to shared environmental influences. However, when examining twins' reports, the shared environment contributes least to the variance in physical discipline (21–28%), suggesting that twins perceive greater differences in parental discipline that they received than do parents.

In general, the differences between the chi-square of the ACE models and the AE/CE models is large, indicating a substantial degree of power to reject alternative models, given the number of twin pairs used in this study. Reports from mothers and fathers indicate a small influence of heritability on physical discipline (10%–21%), while twins' reports indicate a much larger influence (33%–40%). Similarly, non-shared environment contributes to a small degree to the discipline reported by parents (15%–26%), and to a larger degree to the discipline reported by twins (39%). These findings indicate that, to the extent that parents physically disciplined their children differently, this is due to both the children's genetic

Table 4. Factor loadings of parental discipline items, using varimax rotation, of the twins' reports of their disciplinary style to their own children

	Twin 1		Twin 2*	
	I	II	I	II
Hitting with a brush, belt or stick	64	19	66	-00
Slapping	63	12	62	15
Spanking	72	-03	68	07
Scolding or yelling	70	03	66	09
Sending to room	13	55	18	50
Taking away privileges	08	84	12	82
Grounding	01	78	-07	75

* Constrained to a two factor solution.

Within each report, the highest factor loading for each item is shown in boldtype.

Table 5. Results of model fitting to determine the role of genetic and environmental influences on parental physical discipline

	Correlation of ratings		Goodness-of-fit of model (AIC)				Proportion of variance contributed by each parameter - best fitting model		
	MZ pairs	DZ pairs	ACE df = 3	AE df = 4	CE df = 4	E df = 5	a ² 95% CI	c ² 95% CI	e ² 95% CI
Of mother towards twin									
Twin as informant	0.72	0.62	3.87	8.24	23.52	316.69	40	21	39
555 MZ, 383 DZ pairs							(23-58)	(5-36)	(34-44)
Mother as informant	0.88	0.84	0.91	102.46	26.41	938.04	19	66	15
506 MZ, 346 DZ pairs							(12-28)	(57-73)	(13-17)
Father as informant	0.83	0.76	-1.09	49.20	-0.89	402.64	10	64	26
336 MZ, 215 DZ pairs							(0-24)	(51-75)	(21-31)
Of father towards twin									
Twin as informant	0.74	0.60	1.53	8.77	14.56	332.22	33	28	39
543 MZ, 341 DZ pairs							(16-52)	(10-43)	(35-44)
Mother as informant	0.88	0.85	-1.85	112.29	0.85	817.20	9	72	19
500 MZ, 341 DZ pairs							(1-18)	(63-79)	(17-22)
Father as informant	0.88	0.80	3.36	54.20	17.64	547.74	21	62	17
337 MZ, 217 DZ pairs							(11-34)	(50-72)	(14-20)
Of twin towards own child									
Twin as informant	0.28	0.11	-0.52	-2.52	0.50	2.46	21	—	79
146 MZ, 117 DZ pairs							(6-36)		(64-95)

The AIC of the best-fit model is in boldtype.

resemblance to each other, and to matters unrelated to the child's genetic constitution.

Physical discipline: twins as the parental generation

The specific meaning of the sources of variance differs substantially between examining twins as part of the offspring generation (when the parents of the twins and the twins themselves are reporting on the parental discipline experienced by the twins as children) and examining twins as the parental generation (the discipline twins gave to their own children). These differences have been outlined previously (Kendler, 1996).

Here, the presence of C may indicate that a twin raised her children according to the attitudes and values of her family of origin, but such a variable may operate in a non-shared fashion. The presence of A indicates that the twin's discipline toward her children was influenced by her genotype. The presence of E indicates that discipline used by the twin is unrelated to either her family background or genotype. Hence, when we examine the twin's physical discipline toward their own child (Table 5), we can see that the majority of the variance in the discipline style is influenced by the non-shared environment, with no influence of the shared environ-

Table 6. Results of model fitting to determine the role of genetic and environmental influences on parental limit setting

Limit setting	Correlation of ratings		Goodness-of-fit of model (AIC)				Proportion of variance contributed by each parameter – best fitting model		
	MZ pairs	DZ pairs	ACE df = 3	AE df = 4	CE df = 4	E df = 5	a ² 95% CI	c ² 95% CI	e ² 95% CI
Of mother towards twin									
Twin as informant	0.54	0.47	-4.63	3.72	-3.58	192.45	17	30	53
555 MZ, 383 DZ pairs							(0–38)	(12–46)	(47–59)
Mother as informant	0.89	0.82	-0.54	107.16	24.39	975.18	19	67	14
506 MZ, 346 DZ pairs							(11–27)	(59–74)	(12–16)
Father as informant	0.87	0.84	4.91	82.36	4.76	556.69	—	80	20
336 MZ, 213 DZ pairs								(77–83)	(17–23)
Of father towards twin									
Twin as informant	0.63	0.53	-3.89	0.41	2.28	212.79	28	23	49
543 MZ, 368 DZ pairs							(9–48)	(5–40)	(43–55)
Mother as informant	0.92	0.86	8.49	131.56	40.53	1071.8	19	69	12
500 MZ, 341 DZ pairs							(12–26)	(62–76)	(10–14)
Father as informant	0.94	0.81	-4.49	53.79	28.52	684.42	24	64	12
337 MZ, 217 DZ pairs							(16–36)	(53–72)	(10–14)
Of twin towards own child									
Twin as informant	0.33	0.08	-5.62	-7.62	-4.90	3.80	27	—	73
146 MZ, 117 DZ pairs							(13–41)		(59–87)

The AIC of the best-fit model is in boldtype.

ment, and a small amount of influence of heritability. In other words, the twins' physical discipline of their children is unrelated to her family background, somewhat related to her genotype, and mainly related to factors that are independent of either.

Limit setting: twins as the offspring generation

Results for model fitting with limit setting are summarized in Table 6. As with physical discipline, limit setting is more strongly correlated when reported by mothers and fathers, whether about themselves and each other (0.81–0.94), than when reported by the twins (0.47–0.63). To an even greater degree than with physical discipline, twins perceive limit setting to be less similar between the twin pair than parents. This result is echoed in the findings from the model fitting, where parental reports of limit setting are influenced heavily by shared environment (64–80%), and the twins' reports indicate far less influence of similarity of discipline (23–30%). The role of additive genetic influences is small when reported by parents (and absent all together from father's reports of mother's limit setting), ranging from 0–24%, as is the role of non-shared environmental

influences (12–20%). The twin's reports indicate some influence of heritability on limit setting (17–28%), but the majority of variance of the twins' reports is accounted for by non-shared environment (49–53%). This suggests a larger influence of E on limit setting than observed for physical discipline. Once again, we have substantial power to reject alternative models. In summary, the best fitting twin models find that limit setting, according to parents, is largely a common environmental experience for their children. The remaining variance is accounted for by the genotype of the child and non-shared environment.

Limit setting: twins as the parental generation

Similar to physical discipline, limit setting provided by the twin toward her own children shows no influence of the shared environment (Table 6). The majority of the variance in the discipline style is influenced by the non-shared environment, with about a quarter of the variance accounted for by the twin's genotype.

The equal environment assumption

Of the two measures of the common environment, greater similarity in discipline ratings was

significantly predicted only by co-socialization: for mother's limit setting as reported by the twin ($P = 0.02$), for father's physical discipline as reported by the twin ($P = 0.04$), for father's limit setting as reported by the twin ($P = 0.0003$), and for father's self-reported limit setting ($P = 0.0001$). The probability of a chance occurrence of obtaining 4 significant results in a series of 16 tests of significance, the constituent events being independent, is 0.006 (Brozek & Tiede, 1952).

These four measures of parental discipline were then examined by comparing an ACE model (the best fitting model in all cases), and an ACSE model, where the specified environmental variable was co-socialization. In all four cases, the addition of S did not cause a significant change in the χ^2 value – indeed, the χ^2 value remained the same, but with one less degree of freedom. This indicates that the impact of co-socialization does not significantly change our estimations of the genetic parameters.

DISCUSSION

The goal of this report was to clarify the role of genetic and environmental factors in the aetiology of normative parental discipline. A factor analysis of seven discipline items yielded two factors, physical discipline and limit setting – generally, the internal consistency of each scale was poor to moderate. Each factor was highly similar across the twin pairs and across different reporters, with the major source of instability due to the item related to scolding and yelling. The twins and the mothers tended to see this as a harsher disciplinary behaviour, in line with physical discipline, whereas fathers seemed to view scolding and yelling as being more aligned with limit setting. The two factors were positively correlated, indicating that discipline is a general factor, where parents either use discipline or not, rather than using one type of discipline as opposed to another type. Parents consistently recalled disciplining twins less often than the twins recalled being disciplined.

Consistent with previous research on parenting style, parents appeared to emphasize the similarity with which they disciplined their children (physically or using limit setting), whereas the children appeared to minimize these similarities (Plomin *et al.* 1994). This is true for

both the parent reporting on themselves, or the parent reporting on their spouse. To explain these differences in perception, there are several issues that need to be considered. To some degree, parental report of similar treatment may reflect a social desirability bias, where it is considered desirable to treat all offspring the same. Alternatively, parents may be recalling global parenting strategies rather than child specific strategies. Equally, siblings may be extremely sensitive to any perceived differences in parental treatment, and these are highlighted in memory compared to similarities of treatment. Additionally, evidence suggests that while parent-initiated actions may be similar, parent-responsive actions (responding to the behaviour of the child) are different, varying with the behaviour of each child (Lytton, 1977). Therefore, twins and parents may be reporting on different aspects of the parental actions (Kendler, 1996). These findings underscore the importance of using multiple reporters of parental behaviour in order to gain a complete picture of the nature of parental discipline.

Also consistent with previous research is the finding that MZ twins are treated more similarly than DZ twins. There exist several possible explanations of this finding (Kendler, 1996), including: (1) given the greater similarity in genetically influenced temperament of MZ than DZ twins, one would predict that parent-responsive actions would be more similar between MZ than DZ twins; and (2) MZ twins perceive a greater similarity in parental discipline than DZ twins due to their greater similarity in temperament.

The genetic epidemiology of physical discipline and limit setting is very similar between the two forms of discipline. There are three general influences shown to affect individual variation in both types of discipline. The first suggests that normative parental discipline partially reflects the twin's genetically influenced characteristics. One could predict that this contribution of this influence may increase when parents are dealing with more problematical genetically influenced characteristics, such as antisocial behavioural problems (O'Connor *et al.* 1998). The second suggests that parental genotype partly influences parental discipline. In light of this finding, we would predict that parental psychopathology and personality will influence parental discipline,

as has been found in other areas of parenting (Kendler *et al.* 1997). The third includes non-shared environmental influences that are unique to the individual, are independent either of the genotype of the parent or the child, and are uncorrelated with the parental practice of siblings or close relatives. An example of this type of non-shared environment could be marital quality and distress, which has been shown to influence both parenting (Kendler *et al.* 1997a) and differences in parental perception of parenting (McHale *et al.* 1995). Unlike parental protectiveness and parental authoritarianism (Kendler, 1996), there is no influence of the shared environment on parental physical discipline. This is a surprising finding, as one would predict *a priori* that children would model some of their disciplinary behaviours on what they had experienced as children, or be influenced by the broad social values of their home of origin.

Unlike previous research on parental control (Rowe, 1981, 1983), we found heritability accounted to some degree for all the reports of physical discipline in the family, ranging from 9–40% of the variance. These estimates are generally higher than those found in the Plomin *et al.* (1994) study, where the genetic variance was estimated at about 11%. While we used a different measure of discipline, it may be that this difference is best accounted for by the considerable power we have in the current study. Generally, twin studies have least power to detect genetic influence (Bulik *et al.* 2000), so one would expect that increased power has given us enhanced ability to detect the effect of heritability on physical discipline.

Not surprisingly, we found that twins who reported higher levels of co-socialization (doing more things together when growing up) had more similar disciplinary experiences. Twins who do more together would be expected to have a higher likelihood of getting into trouble for the same offences. There are two possible explanations for this finding. The first is that MZ twins might socialize together more because of social expectations (constituting a violation of the EEA). If the EEA has been violated, one can expect an overestimation of the contribution of heritability and an underestimation of the shared environment. However, in the case of our data, we know that the estimations of heritability do not change when taking into account the

impact of co-socialization. Alternatively, MZ twins may spend more time together for genetic reasons – individuals who are genetically similar will tend to select the same environments (which does not represent a violation of the EEA). This latter process is known as ‘genetic control of exposure to the environment’ (Kendler *et al.* 1986), found to be operating when women at risk for major depression select themselves into high risk environments for stressful life events (Kendler & Kardowski-Shuman, 1997). A previous investigation of these two competing hypotheses in this population used a design that compared co-socialization scores between those twins whose social zygosity (what kind of twin they believe themselves to be) differed from their true zygosity (assigned on the basis of standard questions, photographs, and DNA) (Kendler & Prescott, 1998). Results were supportive of the second hypothesis, that twins have the same friends and go to the same events because of their genetic similarity.

These results should be interpreted in the context of six limitations. The first is that this methodology does not help us to identify the sources of non-shared environment that seem to be important in the aetiology of discipline. Depending on whose report one is examining, the non-shared environment influences anywhere from one-tenth to three-quarters of the variance of parental discipline, and is therefore an important source of individual difference to specifically identify. The second is that our results can be extrapolated to girls only. We would expect that parental discipline issues for boys could well be different, given the elevated rates of conduct disorder and substance abuse in males (Slutske *et al.* 1998). Thirdly, it is unknown how widely these findings are relevant to singletons (non-twins), as twins may represent a unique challenge to families that may affect frequency of discipline (Bryan, 1992). Fourthly, unlike previous studies of genetic epidemiology of parental discipline, these findings come from retrospective reports, and may be affected by recall bias. Fifthly, our reliance on only three- or four-item measures of discipline is likely to increase the contribution of error variance to our estimations. This effect could be compounded by the wide range of internal consistencies of each scale, and the poor internal consistency of some reports. Finally, the reports

on parental discipline have been averaged over the first 16 years of the twins' lives, it is likely that different types (and frequency) of discipline will be more relevant to the different developmental phases of the child, thereby giving a general rather than specific understanding of the genetic epidemiology of normative parental discipline.

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REFERENCES

- Akaike, H. (1987). Factor analysis and AIC. *Psychometrika* **52**, 317–332.
- Blackson, T. C., Tarter, R. E. & Mezzich, A. C. (1996). Interaction between childhood temperament and parental discipline practices on behavioral adjustment in preadolescent sons of substance abuse and normal fathers. *American Journal of Drug and Alcohol Abuse* **22**, 335–348.
- Brozek, J. & Tiede, K. (1952). Reliable and questionable significance in a series of statistical tests. *Psychological Bulletin* **49**, 339–341.
- Bryan, E. (1992). *Twins and Higher Multiple Births: A Guide to Their Nature and Nurture*. Edward Arnold: London.
- Bulik, C. M., Bulik, C. M., Sullivan, P. F., Wade, T. D. & Kendler, K. S. (2000). Twin studies of eating disorders: a review. *International Journal of Eating Disorders* **27**, 1–20.
- Deater-Deckard, K., Fulker, D. W. & Plomin, R. (1999). A genetic study of the family environment in the transition to early adolescence. *Journal of Child Psychology and Psychiatry* **40**, 769–775.
- Derogatis, L. R., Serio, J. C. & Cleary, P. A. (1972). An empirical comparison of three indices of factorial similarity. *Psychological Reports* **30**, 791–804.
- Dunn, J. & Plomin, R. (1990). *Separate Lives: Why Siblings are so Different*. Basic Books: New York.
- Eaves, L. J., Eysenck, H. J., Martin, N. G., Jardine, R., Heath, A. C., Feingold, L., Young, P. A. & Kendler, K. S. (1989). *Genes, Culture and Personality: An Empirical Approach*. Oxford University Press: London.
- Hettema, J. M., Neale, M. C. & Kendler, K. S. (1995). Physical similarity and the equal-environment assumption in twin studies of psychiatric disorders. *Behavior Genetics* **25**, 327–335.
- Holmes, S. J. & Robins, L. N. (1987). The influence of childhood disciplinary experience on the development of alcoholism and depression. *Journal of Child Psychology and Psychiatry* **28**, 399–415.
- Joreskog, K. G. & Sorbom, D. (1996). *Preliis 2: User's Reference Guide*. Scientific Software International: Chicago, IL.
- Kendler, K. S. (1996). Parenting: a genetic-epidemiologic perspective. *American Journal of Psychiatry* **153**, 11–20.
- Kendler, K. S. & Eaves, L. J. (1986). Models for the joint effect of genotype and environment on liability to psychiatric illness. *American Journal of Psychiatry* **143**, 279–289.
- Kendler, K. S. & Gardner, C. (1998). Twin studies of adult psychiatric and substance dependence disorders: are they biased by differences in the environmental experiences of mono- and dizygotic twins in childhood and adolescence? *Psychological Medicine* **24**, 625–633.
- Kendler, K. S. & Karkowski-Shuman, L. (1997). Stressful life events and genetic liability to major depression: genetic control of exposure to the environment? *Psychological Medicine* **27**, 539–547.
- Kendler, K. S. & Prescott, C. A. (1998). Cannabis use, abuse, and dependence in a population-based sample of female twins. *American Journal of Psychiatry* **155**, 1016–1022.
- Kendler, K. S., Sham, P. C. & MacLean, C. J. (1997a). The determinants of parenting: an epidemiological multi-informant, retrospective study. *Psychological Medicine* **27**, 549–563.
- Lytton, H. (1977). Do parents create, or respond to, differences in twins? *Developmental Psychology* **13**, 456–459.
- McHale, S. M., Crouter, A. C., McGuire, S. A. & Updegraff, K. A. (1995). Congruence between mothers' and fathers' differential treatment of siblings: links with family relations and children's well-being. *Child Development* **66**, 116–128.
- Neale, M. C. (1997). *Mx: Statistical Modeling, 2nd edn*. Medical College of Virginia. Department of Psychiatry: Richmond, VA.
- Neale, M. C. & Cardon, L. R. (1992). *Methodology for Genetic Studies of Twins and Families*. Kluwer Academic Publishers Group: Dordrecht, The Netherlands.
- O'Connor, T. G., Deater-Deckard, K., Fulker, D., Rutter, M. & Plomin, R. (1998). Genotype-environment correlations in late childhood and early adolescence: antisocial behavior problems and coercive parenting. *Developmental Psychology* **34**, 970–981.
- Plomin, R., Reiss, D., Hetherington, E. M. & Howe, G. (1994). Nature and nurture: genetic contributions to measures of the family environment. *Developmental Psychology* **30**, 32–43.
- Reiss, D., Plomin, R., Hetherington, E. M., Howe, G., Rovine, M., Tyron, A. & Hagan, M. S. (1994). The separate world of teenage siblings: an introduction to the study of non-shared environment and adolescent development. In *The Impact of Nonshared Environment on Development* (ed. E. M. Hetherington, D. Reiss and R. Plomin), pp. 63–109. Lawrence Erlbaum Associates: Hillsdale, NJ.
- Rowe, D. C. (1981). Environmental and genetic influences on dimensions of perceived parenting: a twin study. *Developmental Psychology* **17**, 203–208.
- Rowe, D. C. (1983). A biometrical analysis of perceptions of family environment: a study of twin and singleton sibling kinships. *Child Development* **54**, 416–423.
- SAS Institute Inc. (1996). *SAS/STAT = AE Software: Changes and Enhancements. Release 6.11*. SAS Institute, Inc.: Cary, NC.
- Slutske, W. S., Heath, A. C., Dinwiddie, S. H., Madden, P. A. F., Bucholz, K. K., Dunne, M. P., Statham, D. J. & Martin, N. G. (1998). Common genetic risk factors for conduct disorder and alcohol dependence. *Journal of Abnormal Psychology* **107**, 363–374.
- Spence, J. E., Corey, L. A., Nance, W. E., Marazita, M. L., Kendler, K. S. & Schieken, R. M. (1988). Molecular analysis of twin zygosity using VNTR DNA probes. *American Journal of Human Genetics* **43**, A159.
- Tobin, D. L., Holroyd, K. A., Reynolds, R. V. & Wigal, J. K. (1989). The hierarchical factor structure of the coping strategies inventory. *Cognitive Therapy and Research* **13**, 343–361.
- Whitmore, E. A., Kramer, J. R. & Knutson, J. F. (1993). The association between punitive childhood experiences and hyperactivity. *Child Abuse and Neglect* **17**, 357–366.