Examining the Etiology of Associations Between Perceived Parenting and Adolescents' Alcohol Use: Common Genetic and/or Environmental Liabilities?*

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ABSTRACT. Objective: Although twin studies yield consistent evidence of heritability in the frequency of adolescent alcohol use, parallel findings on parenting are more equivocal, supporting the role of genes in affective parenting but not as supportive in relation to parental control. The extent to which these patterns generalize to more nuanced forms of parenting is less clear. Furthermore, despite evidence linking parents' socialization practices with adolescents' alcohol-use behaviors, this study is the first attempt to determine the sources of this covariation. **Method:** The present study used epidemiological data from 4,729 adolescent twins (2,329 females) to examine the nature of associations between their perceptions of parenting at age 12 and frequencies of alcohol use at age 14. Univariate analyses assessed the relative contributions of genetic and environmental influences on variability within six domains of parenting. Among those displaying consistent evidence of heritability,

bivariate models were used to explore sources of covariation with drinking frequency. **Results:** Univariate models suggested both genetic and environmental sources of variability across parenting phenotypes, including sex-specific sources of genetic liability within one dimension of parenting. However, despite evidence for heritability, bivariate analyses indicated that the covariation between alcohol use and perceptions of parental knowledge and warmth were entirely mediated through shared environmental pathways. **Conclusions:** This study elucidates genetic and environmental sources of variability within individual parenting behaviors and characterizes the etiological nature of the association between parental socialization and adolescent alcohol use. The identification of specific and modifiable socialization practices will be crucial for the future development of parent-based prevention/intervention strategies. (*J. Stud. Alcohol Drugs*, 71, 313-325, 2010)

ADOLESCENCE IS A PERIOD ASSOCIATED WITH increased risk for a range of alcohol-related behaviors. Across the secondary school years, for example, rates of regular alcohol consumption increase roughly twofold among youth living in the United States (Blum et al., 2000; O'Malley et al., 1998). In addition, adolescent drinking has been linked with many psychosocial and public health problems (Peterson et al., 1994; Pitkänen et al., 2005, 2008). Thus, a more complete understanding of the specific factors accounting for alcohol-use behaviors may yield insight

into the etiology of adolescent risk, as it is defined more broadly.

Among those influences most frequently examined in relation to adolescent drinking are several dimensions of parenting. Despite the increasing number of socialization agents that accompany the transition into adolescence (e.g., teachers and peers), many aspects of earlier parenting have been prospectively linked with offspring outcomes throughout the adolescent years (Brown et al., 1993; Doyle and Markiewicz, 1996). In relation to adolescent drinking, for example, parental warmth (Hops et al., 1999; Nash et al., 2005; White et al., 2000), parental autonomy granting (Herman et al., 1997), parental engagement/involvement (Simons-Morton and Chen, 2005), and parental knowledge of offspring's activities/whereabouts/peer relationships (Ary et al., 1999; Rose et al., 2001b) have all been linked with decreased risk, whereas parent-adolescent relational tension (Ary et al., 1999) and excessive parental discipline (Laten-dresse et al., 2008) have been associated with increases in alcohol-use behaviors. In addition, we know that parenting partially mediates the influence of parents' drinking-related behaviors on the same behaviors in their offspring. That is, adolescents whose parents drink and/or become intoxicated more frequently perceive relative deficits in the parenting

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that they receive, and perceptions of poorer parenting are positively associated with adolescents' subsequent reports of their own drinking and intoxication (Latendresse et al., 2008).

The studies mentioned above suggest the importance of parents' socialization practices in relation to the drinking behaviors of their children; however, they offer little, if any insight into the factors underpinning these associations. Although parenting behaviors were temporally ordered to precede the alcohol-use behaviors under examination in these studies, it is still not possible to infer cause and effect. Therefore, although variability in parents' socialization practices could directly influence adolescents' drinking outcomes, it could also be that some unexamined "third" factor, or set of factors, that is related to both parenting and drinking behaviors, influences the associations that have been found. Temperament, for example, might influence the parenting that children elicit while also predisposing them to more or less risky drinking behaviors. To the extent that these relevant temperamental characteristics are heritable, genes may account for some measure of variability in the associations between parenting and alcohol use. Likewise, exposure to certain environmental conditions could function in a similar way, influencing aspects of the parenting relationship as well as alcohol use among adolescents. It is also possible that both genetic and environmental factors are each responsible for some portion of this covariation between parental socialization and adolescents' alcohol-use behaviors.

Findings from the literature on twins illuminate the genetic and environmental sources of variation within each of these two broad domains of behavior, albeit independently. In relation to drinking behaviors, for example, twin studies have provided strong evidence that the initiation of alcohol use is largely accounted for by environmental factors, whereas the frequency of use, when controlling for initiation, is more sensitive to genetic variation (Heath et al., 1991; Hopfer et al., 2003; Koopmans and Boomsma, 1996; Rose et al., 2001a).

Parallel to patterns observed within the literature on drinking behaviors, findings from genetically informative research suggest some degree of heritability in measures of parenting. In general, twin studies have focused largely on broad dimensions of parenting, providing evidence of significant genetic contributions in relation to both positive and negative aspects of parental affect (e.g., warmth, negativity), but there is less support for the role of genes with regard to parental control (Braungart, 1994; Elkins et al., 1997; Goodman and Stevenson, 1991; Plomin et al., 1989, 1994; Rowe, 1981). Although these findings are not entirely consistent across studies (Reiss et al., 2000) or sources of reports within studies (Deater-Deckard, 2000), it does appear clear that affective dimensions of parenting yield greater genetic sources of variation than nonaffective control-related dimensions (e.g., see Lichtenstein et al., 2003; Losoya et al.,

1997). What is less clear, however, is the extent to which these patterns hold true for more nuanced forms of parenting. Questions remain as to whether all affective parenting practices are attributable to both genetic and environmental factors and whether all facets of control are free of genetic influences. At least one recent study suggests the need to examine this more closely by showing that punitive parental discipline, presumably a control-related effort, is based in part on genetic factors (Button et al., 2008).

Despite known links between adolescents' perceptions of the parenting that they receive and reports of their own alcohol use (Latendresse et al., 2008, 2009), and despite prior evidence of heritability within each of these two domains, we are not aware of any studies that have examined associations between the genetic and environmental sources of variation in these phenotypes. Such an examination would help to determine whether heritable variability in perceived and/or elicited parenting behavior is simply a reflection of a common set of genetic influences on adolescent drinking. Is a genetic predisposition toward drinking related to the perception or elicitation of various forms of parenting? And could that, in part or in full, contribute to the genetic variation that is detected in measures of perceived parenting? These questions are addressed in the present study, which aims to (1) identify the relative contributions of genes and the environment to variability in adolescents' perceptions of parenting, across a broad range of behaviors, and (2) identify the etiology underlying associations between these perceptions of parenting and adolescent alcohol use.

Method

Sample and procedure

FinnTwin 12 is a population-based, developmental twin study of health-related behaviors and correlated risk factors (Kaprio et al., 2002). It consists of five consecutive birth cohorts (1983-1987) of twins identified through Finland's central population registry, assuring exhaustive and unbiased ascertainment. Of the 2,724 families with twins born in the period from 1983 to 1987, 2,418 (~89%) consented to participate. Self-report questionnaires were mailed to co-twins late in the autumn of the year in which their birth cohort reached age 11, with only a small minority (~10%) delaying the return of the questionnaires until very early in the year in which the cohorts turned 12. Mean age at return of baseline questionnaires was 11.45 years. To simplify, baseline age is referred to as 12. All twins were sent a follow-up questionnaire in the month that they reached 14 years of age; approximately 90% completed and returned it. Mean age at response was 14.05, with 95% responding by the age 14.2 years. Age at follow-up is hence referred to as 14, for ease of presentation.

Zygosity was determined on the basis of co-twins' completion of a well-validated and discriminatory questionnaire at baseline (Sarna et al., 1978), parental responses to items developed for zygosity classification of twin children (Goldsmith, 1991), and when necessary comparisons of co-twins' school photographs and supplemental information gathered from the twins' mothers. Of 250 same-sex twin pairs from whom blood samples were obtained to confirm zygosity, questionnaire assessments proved correct in ~97% of the pairs, and all pairs judged to be monozygotic from questionnaires were confirmed monozygotic; only those pairs for whom questionnaires yielded a definitive diagnosis of zygosity were included in the present sample. As such, the descriptive analyses presented here reflect data from the 4,729 individual twins for whom zygosity, sex, and phenotypic information were available: 790 female and 764 male monozygotic twins, 746 female and 845 male same-sex dizygotic twins, and 793 female and 791 male opposite-sex dizygotic twins. Only data from same-sex twin pairs were used in the fitting of bivariate twin models: 386 monozygotic and 364 dizygotic female twin pairs and 376 monozygotic and 414 dizygotic male twin pairs.

Measures

Perceived parenting. Baseline questionnaires (i.e., at age 11-12) assessed adolescents' combined perceptions of both parents along several dimensions. Each of the parenting scores was derived by summing across a set of individual items. First, a measure of adolescents' perceived home atmosphere yielded a four-item subscale of parental warmth ("warm, caring," "creative, supportive," "trusting, understanding," and "open"), and a three-item subscale of relational tension between adolescents and their parents ("unjust," "argumentative," and "indifferent"), with items rated on a 5-point scale, ranging from *does not hold true* to *holds completely true*. The resulting reliability coefficients were .79 and .68, for the parental warmth and relational tension scales, respectively. Four additional items, rated on a 5-point scale from *every day* to *never*, tapped into how often adolescents engaged in shared activities with their parents ("do sports," "do favorite hobbies," "take trips, travel, visit," and "engage in recreation"; Narusk and Pulkkinen, 1994). This scale had an internal consistency of .72. Another four items ($\alpha = .67$), rated on a 4-point scale from *not at all* to *very much*, were taken from a larger measure of parents' child-rearing ideals and practices ("parents listen to my opinions," "parents thank and encourage me," "parents encourage me to be independent," and "parents try to sort it out and discuss it if I've behaved badly"; Metsapelto and Pulkkinen, 2003) and used to assess the degree of autonomy granting in parent-adolescent relationships. An additional item taken from the same scale ("parents punish me if I do something I'm not supposed to"; Metsapelto and Pulk-

kinen, 2003) was combined with a single item from the home atmosphere scale ("strict"), resulting in a smaller and, therefore less reliable, two-item scale of perceived parental discipline ($\alpha = .52$). Last, three items ($\alpha = .73$), rated on a 4-point scale from *almost always* to *almost never*, were used to assess parental knowledge ("parents know my daily program," "parents know my interests, activities, whereabouts," and "parents know where I am and who I am with when not at home"; Chassin et al., 1993). Accordingly, the present study assesses a relatively comprehensive set of diverse, but related, dimensions of parenting, especially for such a large, population-based epidemiological sample.

Drinking frequency. In addition to assessing dimensions of perceived parenting, adolescents' frequency of alcohol use was assessed via self-report questionnaires at age 14. Our analysis was based on a single item ("How often do you drink alcohol at all?") with the following four, ordered response options: "never, I don't drink," "less than monthly," "about one to two times per month," and "once a week or more."

Statistical analyses

All descriptive analyses were carried out in STATA Version 10.1 (StataCorp LP, College Station, TX) to account for the nesting of individuals within twin pairs. Explicit twin modeling was conducted by way of maximum likelihood estimation, using either the rectangular (for univariate models of quasicontinuous measures of parenting) or raw ordinal (for bivariate models of parenting and alcohol use) data options in the statistical package Mx (Neale et al., 1999). We fit a series of univariate twin models to determine the degree to which genetic, and common and unique environmental influences contributed to the variability in adolescents' perceptions of parenting. For parenting phenotypes with evidence of gender-related differences in genetic sources of variability (i.e., the magnitude of the differences in monozygotic/dizygotic correlations varies by sex), and for which the magnitude of opposite-sex dizygotic correlations were somewhat lower than both female and male same-sex dizygotic pairs, a sex-limited model was fit to assess the extent to which genetic sources of phenotypic variability could be accounted for by the same and/or different genes across the sexes.

We then fit bivariate Cholesky models to the data for those dimensions of perceived parenting that were both heritable (as evidenced by significant additive genetic variance components within univariate twin models, and for which raw monozygotic twin correlations exceeded those of their same-sex dizygotic twin counterparts), and moderately and consistently correlated with alcohol use (for which heritability estimates had previously been established; Dick et al., 2007a; Pagan et al., 2006; Rose et al., 2001b), among both girls and boys. The bivariate Cholesky model (illustrated,

FIGURE 1. Bivariate Cholesky model fit to perceived parenting dimensions at age 12 and drinking frequency at age 14. Significant cross-paths (a_{21} , c_{21} , e_{21}) denote common liability between two phenotypes (i.e., correlated genetic, common environmental, and shared environmental variance components). Pathways shown are for a single twin.

with respect to a single twin, in Figure 1) uses information from cross-twin, cross-trait correlations to estimate the extent to which phenotypic covariation (in this case, between adolescents' perceptions of parenting and their alcohol use) can be attributed to shared genetic and/or environmental influences.

In both univariate and bivariate models, the significance of individual model parameters was tested by dropping a parameter and evaluating the change in -2 log likelihood between the initial model, in which the parameter was freely estimated, and the nested submodel, in which the parameter had been dropped (in effect, fixed at a value of zero). This change was evaluated using a chi-square distribution, wherein a significant decrement in -2 log likelihood ($p \leq .05$) for a given difference in degrees of freedom suggests that the parameter in question significantly contributes to model fit, thus justifying retention of that parameter in the model.

Results

Descriptive statistics

Means and standard deviations for perceived parenting dimensions, as well as percentage endorsement within ordinal response categories corresponding to drinking frequency are displayed separately for girls and boys, and by zygosity,

in Table 1. Univariate analyses of variance indicated that girls perceived higher levels of autonomy granting, $F(14, 1526) = 5.82, p \leq .001$, parental knowledge, $F(10, 1530) = 23.36, p \leq .001$, and parental warmth, $F(18, 1522) = 5.47, p \leq .001$. Boys reported higher levels of shared activities, $F(23, 1517) = 8.40, p \leq .001$, and perceived higher levels of relational tension, $F(14, 1526) = 3.32, p \leq .001$, and parental discipline, $F(18, 1522) = 8.77, p \leq .001$. Monozygotic twins reported higher levels of autonomy granting, $F(14, 1526) = 2.44, p = .002$, parental knowledge, $F(10, 1530) = 2.57, p = .004$, parental warmth, $F(18, 1522) = 2.02, p = .007$, and shared activities, $F(23, 1517) = 2.14, p = .001$. Dizygotic twins reported higher levels of relational tension, $F(14, 1526) = 1.70, p = .05$. Although several tests of mean differences in the parenting variables by zygosity reached statistical significance, the magnitudes of these differences were uniformly small, indicating that the significance likely reflects the substantial size of the sample rather than clinically meaningful differences. With respect to drinking frequency, findings indicated significant differences in the distribution of responses by sex, $F(2.77, 3774.87) = 3.66, p = .014$, but not zygosity, $F(2.78, 3781.20) = 1.23, p = .296$.

Although modest in size, the phenotypic correlations between perceived parenting dimensions and drinking frequency in the full sample were mostly significant, as shown in Table 2. Among girls, perceptions of autonomy granting,

TABLE 1. Mean and frequency comparisons across sex, zygosity, and sex by zygosity subgroups

Variable	Girls				Boys				OSDZ		F_{Sex}	F_{Zygosity}
	MZ		DZ		MZ		DZ					
	M	SD	M	SD	M	SD	M	SD	M	SD		
Perceived parenting												
Autonomy granting	13.72	2.05	13.61	2.09	13.45	2.06	13.23	2.19	13.41	2.02	5.82***	2.44**
Parental knowledge	11.04	1.26	11.01	1.28	10.67	1.49	10.45	1.54	10.76	1.40	23.36***	2.57**
Parental warmth	17.87	2.28	17.63	2.26	17.51	2.10	17.41	2.30	17.48	2.20	5.47***	2.02**
Shared activities	12.60	3.07	12.19	3.18	13.12	3.46	13.06	3.40	12.80	3.28	8.40***	2.14***
Relational tension	4.80	1.91	5.03	2.00	5.15	2.07	5.22	2.14	5.12	2.02	3.32***	1.70*
Parental discipline	5.18	2.01	5.36	1.93	5.77	1.93	5.66	2.06	5.59	2.02	8.77***	1.61
Drinking frequency											3.66*	1.23
Never	66.4%		65.6%		69.5%		66.1%		61.5%			
<Monthly	17.4%		19.2%		19.9%		20.2%		22.3%			
1-2 times/month	12.9%		12.6%		8.2%		11.1%		13.6%			
≥Weekly	3.3%		2.6%		2.4%		2.6%		2.6%			

Notes: MZ = monozygotic twins; DZ = same-sex dizygotic twins; OSDZ = opposite-sex dizygotic twins. Formal mean comparisons were conducted using same-sex twin pairs while accounting for the nesting of individuals within sibships. The effects of parenting variables were tested using Wald's F statistics with $(r - 1) \times (c - 1)$, $n / 2 - [(r - 1) \times (c - 1)]$ degrees of freedom. Comparisons of the drinking frequency distributions were tested using likelihood ratio chi-square statistics that were corrected for the nested structure of the data (Rao and Scott, 1984) and converted into F statistics with the appropriate degrees of freedom for sex (2.77, 3774.87), zygosity (2.78, 3781.20).

* $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$.

parental knowledge, parental warmth, and shared activities were negatively associated with drinking frequency, whereas relational tension was positively associated. Likewise, among boys, drinking frequency was negatively associated with perceived autonomy granting, parental knowledge, parental warmth, and shared activities, and positively associated with relational tension and parental discipline. As expected, many of the cross-trait correlations between parenting dimensions were significant (ranging from $-.41$ to $.52$), but not completely overlapping, for both girls and boys.

Intraclass twin correlations are presented in Table 3, first by zygosity, then for sex by zygosity subgroups. In all cases, dizygotic correlations were greater than half the magnitude of monozygotic correlations, indicating a significant role of environmental influences that function to make twins more similar on these outcomes. In the overall sample, the monozygotic twin correlations exceeded those of the same-sex dizygotic twins (as well as those of opposite-sex dizygotic pairs) across all dimensions of perceived parenting and drinking frequency, which indicates some measure of genetic

influence in relation to each of the phenotypes. Moreover, despite general consistency in these patterns within sex, the relative magnitude of the correlations and their differences across zygosity appeared somewhat variable. Correlations between the opposite-sex dizygotic twins were somewhat lower than those of both female and male same-sex dizygotic pairs. Together, this pattern of associations appears to suggest potential sex differences in genetic influences on these phenotypes.

Model fitting analyses

Table 4 provides fit statistics for a series of nested univariate twin models corresponding to each dimension of perceived parenting. For each phenotype, the initial model (Model S in Table 4) independently estimated latent genetic (A), shared environmental (C), and unique environmental (E) sources of variability for both girls and boys, as well as a sex-specific genetic source of variability (G) modeled for girls. The second model (Model 1 in Table 4) constrained

TABLE 2. Intra-individual correlations

	1.	2.	3.	4.	5.	6.	7.
1. Drinking frequency	—	-.06*	-.17***	-.11***	-.09**	.09**	.07*
2. Autonomy granting	-.11***	—	.41***	.51***	.16***	-.34***	-.06**
3. Parental knowledge	-.28***	.41***	—	.37***	.13***	-.28***	-.06**
4. Parental warmth	-.15***	.52***	.36***	—	.24***	-.41***	-.07**
5. Shared activities	-.08**	.18***	.08**	.24***	—	-.08***	.02
6. Relational tension	.12***	-.32***	-.23***	-.43***	-.13***	—	.30***
7. Parental discipline	.05	-.03	-.05*	-.08***	.01	.29***	—

Notes: Correlational analyses were conducted while accounting for the nested nature of the data. Cross-trait associations between drinking frequency and the six measures of parenting are depicted as polyserial correlation coefficients; all others reflect Pearson's correlations. Coefficients for girls are below the diagonal and shaded; coefficients for boys are above the diagonal and unshaded.

* $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$.

TABLE 3. Cross-twin correlations by zygosity and sex, by zygosity subgroups

Phenotype	MZ twins			Same-sex DZ twins			OSDZ twins
	Overall	Girls	Boys	Overall	Girls	Boys	Overall
Autonomy granting	.63	.66	.59	.49	.54	.46	.37
Parental knowledge	.60	.60	.58	.48	.50	.43	.42
Parental warmth	.66	.67	.65	.52	.54	.50	.44
Shared activities	.71	.76	.66	.59	.64	.54	.43
Relational tension	.58	.65	.51	.54	.64	.46	.38
Parental discipline	.62	.70	.51	.57	.63	.53	.49
Drinking frequency	.84	.90	.74	.67	.73	.62	.51

Notes: MZ = monozygotic twins; DZ = same-sex dizygotic twins; OSDZ = opposite-sex dizygotic twins. All cross-twin correlations were statistically significant at $p < .001$. Pearson product-moment correlation coefficients were used to reflect cross-twin associations on the pseudo-continuous parenting dimensions; polychoric correlation coefficients were used as an indicator of cross-twin associations in relation to the ordinal drinking frequency data, which assumes an underlying latent continuous distribution.

the sex-specific genetic variance to zero but continued to estimate A, C, and E components independently for girls and boys. Dropping the latent G factor resulted in significantly worse fitting models but only for shared activities and parental discipline, suggesting some measure of unique genetic influences (i.e., sex-specific genetic influences on perceptions of these parenting behaviors) on these dimensions. The third model (Model 2 in Table 4) constrained the phenotypic means to be equal across sex, which resulted in a significant decrement in fit when compared with the best fitting prior model for all dimensions of perceived parenting. Thus, consistent with findings from the descriptive analyses presented in Table 1, girls and boys were shown to differ, in terms of average values, across all parenting dimensions. The fourth model (Model 3 in Table 4) tested whether the variance structure of each phenotype was similar among girls and boys by constraining standardized estimates (i.e., relative to the total variance estimated) of A, C, and E to be equal across sex. Doing so caused significant decrement in fit in relation to shared activities and parental discipline, which was not surprising, because both were previously shown to have a fourth, sex-specific source of variance.

Equating the standardized variance components of relational tension across sex also resulted in a worse fitting model, indicating that the magnitude of genetic, and shared and unique environmental sources of variance within these three dimensions of parenting differed for girls and boys. Among these phenotypes a set of less restrictive models (Models 4, 5, and 6) assessed the change in fit with respect to equality constraints placed on each of the individual standardized variance components regarding sex (e.g., equal A across girls and boys). Results of these models indicated that both the A component for parental discipline and the C component for shared activities could be equated across girls and boys. With respect to relational tension, we were unable to restrict any of the sources of variability to be proportionally equivalent across the sexes. After establishing which of the model parameters could be equated across sex, a series

of submodels was fit, wherein (1) A, (2) C, and (3) A and C components were constrained to equal zero (i.e., dropped) and then constrained to be equal across and (when not ruled out in the first stage of modeling) within sex. This allowed for tests of the significance of each individual variance component.

Formal chi-square difference tests comparing the change in -2 log likelihood values between nested models indicated that perceptions of many of these parenting dimensions were best described by models that included both genetic and environmental (shared and unique) sources of variability. Among these, three phenotypes yielded similar variance structures among girls and boys: autonomy granting ($A = .40$, $C = .23$, $E = .37$), parental knowledge ($A = .32$, $C = .28$, $E = .40$), and parental warmth ($A = .38$, $C = .28$, $E = .33$). Although the A component could be dropped from the variance structure of shared activities among girls, the inability to drop the G component indicated the presence of sex-specific genetic sources of variability ($C = .45$, $E = .23$, $G = .33$ for girls; $A = .20$, $C = .45$, $E = .35$ for boys) along with both shared and unique environmental components. Sex differences also emerged in the variance structures of perceived relational tension and parental discipline, wherein the A component was able to be dropped among girls in the former ($C = .64$, $E = .36$ for girls; $A = .27$, $C = .26$, $E = .47$ for boys) and across sex in the latter, although sex-specific genetic sources of variability were not able to be dropped among girls ($C = .50$, $E = .30$, $G = .20$ for girls; $C = .52$, $E = .48$ for boys).

Standardized estimates for the variance components (A, C, E, G) of all seven phenotypes are presented separately for girls and boys in Table 5. Point estimates and corresponding 95% confidence intervals for the variance components are drawn from both the saturated models (Model S in Table 4) and the more parsimonious models, in which nonsignificant parameters were dropped. Among those dimensions of perceived parenting for which univariate models provided evidence of significant genetic liability, simple correlations

TABLE 4. Fit statistics for univariate models of perceived parenting dimensions

Variable	Fit statistics			
	-2LL	df	$\chi^2\Delta$	p
Autonomy granting				
Model S: Sex independent ACE(G)	19,605.41	4720	—	—
Model 1: Sex independent ACE	19,608.72	4721	3.31	.07
Model 2: Sex independent ACE, equal means	19,621.09	4722	12.37	<.01
Model 3: Equal ACE across sex	19,615.72	4724	7.003	.07
Submodels (compared with Model 3)				
AE model	19,642.53	4726	26.81	<.01
CE model	19,664.54	4726	48.82	<.01
E model	20,316.42	4728	700.70	<.01
Parental knowledge				
Model S: Sex independent ACE(G)	15,952.32	4720	—	—
Model 1: Sex independent ACE	15,952.52	4721	0.21	.65
Model 2: Sex independent ACE, equal means	16,019.34	4722	66.82	<.01
Model 3: Equal ACE across sex	15,955.97	4724	3.45	.33
Submodels (compared with Model 3)				
AE model	15,994.56	4726	38.59	<.01
CE model	15,985.70	4726	29.71	<.01
E model	16,617.79	4728	661.83	<.01
Parental warmth				
Model S: Sex independent ACE(G)	20,188.79	4720	—	—
Model 1: Sex independent ACE	20,189.91	4721	1.12	.29
Model 2: Sex independent ACE, equal means	20,199.35	4722	9.44	<.01
Model 3: Equal ACE across sex	20,193.68	4724	3.77	.29
Submodels (compared with Model 3)				
AE model	20,236.62	4726	42.95	<.01
CE model	20,246.08	4726	52.40	<.01
E model	21,022.46	4728	828.78	<.01
Shared activities				
Model S: Sex independent ACE(G)	23,599.36	4720	—	—
Model 1: Sex independent ACE	23,611.82	4721	12.47	<.01
Model 2: Sex independent ACE(G), equal means	23,637.19	4721	37.84	<.01
Model 3: Equal ACE across sex	23,636.70	4723	37.34	<.01
Model 4: Equal A across sex	23,608.40	4721	8.04	<.01
Model 5: Equal C across sex	23,600.14	4721	0.78	.38
Model 6: Equal E across sex	23,615.15	4721	15.80	<.01
Submodels (compared with Model 5)				
AE (girls and boys)	23,678.72	4723	78.58	<.01
CE (girls and boys)	23,627.33	4723	27.20	<.01
CE (girls only)	23,600.24	4722	0.10	.75
Submodel: G (girls) = A (boys)	23,606.93	4723	6.69	<.01
Submodel: No G	23,700.50	4723	100.36	<.01
CE (boys only)	23,627.33	4722	27.20	<.01
E (girls and boys)	24,250.51	4725	650.37	<.01
E (girls only)	23,840.91	4723	240.77	<.01

(continued)

suggested that only perceptions of parental knowledge and parental warmth consistently accounted for meaningful portions of the variability in drinking frequency ($r_s > .10$; see Table 1).

To decompose the relative contributions of genetic and environmental (shared and unique) influences on the covariation between these dimensions of perceived parenting at age 12 and adolescents' drinking frequency at age 14, we fit bivariate Cholesky models to the data. Figure 1 depicts the general bivariate Cholesky model, with a set of latent variance components corresponding to the additive genetic (A2), shared environmental (C2), and unique environmental factors (E2) that only influence drinking frequency (via direct paths

a22, c22, and e22), and a second set of variance components corresponding to the additive genetic (A1), shared environmental (C1), and unique environmental factors (E1) that jointly influence both perceived parenting (via direct paths a11, c11, and e11) and drinking frequency (via cross-paths a21, c21, and e21). Thus, each cross-path (a21, c21, and e21) represents a common liability.

Because earlier analyses of data from the FinnTwin 12 sample found significant sex differences in the sources of variability in alcohol-use behaviors (Dick et al., 2007a; Pagan et al., 2006; Rose et al., 2001b), bivariate models in the present study were fit separately for girls and boys. Table 6 displays fit statistics for a series of bivariate models assess-

TABLE 4. Fit statistics for univariate models of perceived parenting dimensions (*continued*)

Variable	Fit statistics			
	-2LL	df	$\chi^2\Delta$	p
Relational tension				
Model S: Sex independent ACE(G)	19,380.81	4720	—	—
Model 1: Sex independent ACE	19,380.81	4721	0.00	1.00
Model 2: Sex independent ACE, equal means	19,404.63	4722	23.82	<.01
Model 3: Equal ACE across sex	19,422.37	4724	41.56	<.01
Model 4: Equal A across sex	19,395.35	4722	14.45	.01
Model 5: Equal C across sex	19,386.86	4722	6.05	<.01
Model 6: Equal E across sex	19,393.52	4722	12.71	<.01
Submodels (compared with Model 1)				
AE (girls and boys)	19,466.11	4723	85.31	<.01
AE (girls only)	19,463.55	4722	82.74	<.01
AE (boys only)	19,422.31	4722	61.51	<.01
CE (girls and boys)	19,408.85	4723	28.04	<.01
CE (girls only)	19,383.78	4722	2.98	.09
CE (boys only)	19,393.18	4722	12.37	<.01
E (girls and boys)	20,117.62	4725	736.82	<.01
E (girls only)	20,117.62	4725	736.82	<.01
E (boys only)	20,117.62	4725	736.82	<.01
Parental discipline				
Model S: Sex independent ACE(G)	19,071.38	4720	—	—
Model 1: Sex independent ACE	19,078.63	4721	7.25	.01
Model 2: Sex independent ACE(G), equal means	19,104.75	4721	33.37	<.01
Model 3: Equal ACE across sex	19,207.99	4723	136.61	<.01
Model 4: Equal A across sex	19,071.43	4721	0.05	.83
Model 5: Equal C across sex	19,192.65	4721	121.27	<.01
Model 6: Equal E across sex	19,087.91	4721	16.53	<.01
Submodels (compared with Model 4)				
AE (girls and boys)	19,575.65	4723	503.88	<.01
AE (girls only)	19,200.79	4722	129.36	<.01
AE (boys only)	19,520.86	4722	449.43	<.01
CE (girls and boys)	19,073.74	4723	2.31	.32
Submodel: No G	19,088.71	4724	14.98	<.01
Submodel: E (girls and boys)	19,590.11	4725	516.38	<.01
Submodel: E (girls only)	19,340.77	4724	267.03	<.01
Submodel: E (boys only)	19,536.29	4724	462.55	<.01

Notes: LL = log likelihood. Model descriptors correspond to additive genetic (A), common environmental (C), unique environmental (E), and sex-specific additive genetic (G) influences.

TABLE 5. Standardized estimates [95% confidence intervals] for univariate twin models of perceived parenting dimensions

Variable	Girls				Boys		
	A	C	E	G	A	C	E
Saturated models							
Autonomy granting	.06 [.00, .34]	.38 [.23, .51]	.34 [.29, .39]	.22 [.00, .37]	.33 [.17, .51]	.26 [.11, .41]	.40 [.35, .47]
Parental knowledge	.18 [.00, .43]	.38 [.22, .52]	.38 [.33, .44]	.06 [.00, .26]	.33 [.14, .48]	.25 [.13, .40]	.42 [.36, .48]
Parental warmth	.12 [.00, .38]	.42 [.27, .55]	.35 [.30, .40]	.12 [.00, .27]	.41 [.25, .56]	.27 [.14, .27]	.32 [.28, .38]
Shared activities	.00 [.00, .29]	.50 [.38, .60]	.23 [.20, .27]	.28 [.00, .39]	.23 [.08, .39]	.42 [.28, .54]	.35 [.30, .40]
Relational tension	.08 [.00, .20]	.59 [.47, .67]	.34 [.29, .39]	.00 [.00, .20]	.16 [.05, .33]	.35 [.21, .45]	.48 [.42, .55]
Parental discipline	.13 [.00, .26]	.57 [.45, .66]	.30 [.26, .35]	.00 [.00, .26]	.05 [.00, .20]	.49 [.36, .56]	.46 [.40, .52]
Best fitting models							
Autonomy granting	.40 [.29, .50]	.23 [.15, .32]	.37 [.33, .41]	—	.40 [.29, .50]	.23 [.15, .32]	.37 [.33, .41]
Parental knowledge	.32 [.21, .42]	.28 [.20, .37]	.40 [.36, .44]	—	.32 [.21, .42]	.28 [.20, .37]	.40 [.36, .44]
Parental warmth	.38 [.29, .48]	.28 [.20, .36]	.33 [.30, .37]	—	.38 [.29, .48]	.28 [.20, .36]	.33 [.30, .37]
Shared activities	—	.45 [.40, .49]	.23 [.19, .26]	.33 [.27, .38]	.20 [.13, .27]	.45 [.40, .49]	.35 [.31, .41]
Relational tension	—	.64 [.60, .68]	.36 [.32, .40]	—	.27 [.17, .36]	.26 [.20, .33]	.47 [.41, .54]
Parental discipline	—	.50 [.42, .59]	.30 [.26, .34]	.20 [.10, .30]	—	.52 [.47, .56]	.48 [.44, .53]

Notes: Model descriptors correspond to additive genetic (A), common environmental (C), unique environmental (E), and sex-specific additive genetic (G) influences. Estimates are presented separately for the saturated (all variance components independently estimated for girls and boys) and best fitting models.

TABLE 6. Fit statistics for bivariate models of perceived parenting dimensions and drinking frequency

Variable	Girls' models				Boys' models			
	-2LL	df	$\chi^2\Delta$	p	-2LL	df	$\chi^2\Delta$	p
Parental knowledge and drinking frequency								
Full Model (all cross-paths)	5,889.73	2899	—	—	6,924.53	2996	—	—
Submodels (compared with the full model)								
Drop a21	5,891.15	2900	1.42	.23	6,924.70	2997	0.17	.68
Drop c21	5,897.30	2900	7.57	.006	6,927.34	2997	2.81	.09
Drop e21	5,890.88	2900	1.15	.28	6,924.66	2997	0.12	.73
Drop a21 & c21	—	—	—	—	6,939.28	2998	14.75	<.01
Drop a21 & e21	5,891.47	2901	0.74	.69	6,924.72	2998	0.19	.91
Drop c21 & e21	—	—	—	—	6,928.53	2998	4.00	.14
Parental warmth and drinking frequency								
Full Model (all cross-paths)	6,886.25	2898	—	—	7,414.42	2995	—	—
Submodels (compared with the full model)								
Drop a21	6,886.28	2899	0.03	.86	7,414.67	2996	0.25	.62
Drop c21	6,892.65	2899	6.40	.011	7,417.73	2996	3.30	.07
Drop e21	6,886.80	2899	0.55	.46	7,415.95	2996	1.52	.22
Drop a21 & c21	—	—	—	—	7,421.58	2997	7.16	.03
Drop a21 & e21	6,886.84	2900	0.59	.74	7,416.06	2997	1.64	.44
Drop c21 & e21	—	—	—	—	7,418.03	2997	3.61	.16

Notes: LL = log likelihood. Model descriptors correspond to additive genetic (A), common environmental (C), unique environmental (E), and sex-specific additive genetic (G) influences. Cross-paths (a21, c21, e21) correspond to parameters specified in Figure 1.

ing covariation between two specified phenotypes. In addition to six direct paths, the first (i.e., full) model included all cross-paths and, as such, assumed that the association between perceived parenting and drinking frequency was the result of three common latent liabilities: additive genetic factors, shared environmental factors, and unique environmental factors (unstandardized path coefficients from each of the full bivariate models are presented in Table 7). To test this assumption, a set of nested submodels was run, in which each individual cross-path and all pairwise combinations of two cross-paths were constrained to equal zero and then tested against the full model to determine whether the constrained path(s) significantly contributed to covariation in the two phenotypes.

Comparative fit indices showed that, among girls, shared environmental influences were entirely responsible for associations between drinking frequency and both parental knowledge ($r_{c1c2} = -.56$) and parental warmth ($r_{c1c2} = -.32$),

because dropping the additive genetic and unique environmental cross-paths did not significantly decrease model fit. The best fitting models dropped the a21 and e21 pathways, indicating that all of the shared variance between female adolescents' frequencies of alcohol use and their perceptions of parental knowledge and parental warmth was mediated via common environmental pathways.

For the bivariate models with both parental knowledge and warmth among boys, dropping each of the individual cross-paths resulted in a nonsignificant decrease in fit. The decrement in fit was far greater, however, when the c21 cross-path (i.e., the path running from the component representing shared environmental influences in the parenting variables to alcohol use) was dropped, suggesting that the associations with drinking frequency were most likely the result of shared environmental paths for both parental knowledge ($r_{c1c2} = -.34$) and warmth ($r_{c1c2} = -.24$). Failure to reach significance likely reflects low power resulting from the relatively low magnitude of correlation between the variables; accordingly, there is minimal shared variance to partition into shared genetic, shared environmental, and unique environmental components. Fitting a series of submodels in which all pairwise combinations of cross-paths were jointly dropped (i.e., constraining a21 and c21, a21 and e21, and c21 and e21 cross-paths to zero in three separate models) provided additional evidence suggesting that all of the shared variance between male adolescents' frequencies of use and their perceptions of parental knowledge and parental warmth were mediated via common environmental pathways. Dropping the c21 pathway significantly decreased model fit if the nonsignificant a21 pathway had already been dropped ($p < .01$ for parental knowledge/alcohol use and warmth/alcohol-use associations).

TABLE 7. Unstandardized path coefficients for full bivariate models

Paths	Parental knowledge and drinking frequency		Parental warmth and drinking frequency	
	Girls	Boys	Girls	Boys
a11	.60	.54	.48	.50
a21	-.15	-.06	.03	.08
a22	.52	.49	.54	.50
c11	.61	.62	.70	.66
c21	-.33	-.20	-.25	-.20
c22	.70	.68	.73	.67
e11	.52	.57	.53	.56
e21	.04	.02	-.02	-.06
e22	.32	.50	.33	.49

Note: All paths correspond to parameters specified in Figure 1, with shading denoting cross-path coefficients.

Discussion

We conducted a series of analyses of genetically informative data from adolescent twins to examine the etiology of associations between their perceived parenting and their use of alcohol. Our aim was to determine whether genetic and/or environmental factors contribute to the variability in adolescents' perceptions of the parenting that they receive (autonomy granting, parental knowledge, warmth, shared activities, relational tension, and discipline), as well as the extent to which associations between certain dimensions of parenting and frequency of alcohol use are attributable to heritable and/or environmental influences. We found that adolescents' perceptions of parenting showed evidence of genetic contributions across dimensions, with some sex limitations, and that the magnitude of the point estimates varied. Girls' and boys' perceptions of autonomy granting, parental knowledge, and parental warmth, specifically, were influenced by genetic factors, with heritability estimates ranging from .32 to .40. In contrast, only boys' perceptions of relational tension and girls' perceptions of parental discipline were attributable to shared and unique environmental factors. Only perceptions of shared activities suggested independent sources of genetic liability for girls ($G = .33$) and boys ($A = .20$); genetic influences on all other dimensions of parenting appeared to be shared across girls and boys.

Overall, the results from the present study are consistent with the dimensional dichotomy described in Rowe's early work (1981) on the heritability of behavioral control versus affective dimensions of parenting, in that the latter (autonomy granting, warmth, parental knowledge) yielded larger and more consistent estimates of additive genetic influences across the sexes. The work of Deater-Deckard (1996) suggests that these differences might actually reflect a generally higher degree of within-family variability in the administration of affective socialization practices, and perhaps a more objective distribution of control-related behaviors. Sex differences in the genetic sources of variability may, however, indicate that girls and boys perceive varying degrees of objectivity across these dimensions. A higher mean and standard deviation among girls on the item, "parents punish me if I do something that I'm not supposed to," may indicate a greater sensitivity to parental admonishment, for example, and could explain why the univariate model of parental discipline for girls suggests heritability, whereas the model for boys reflects only environmental influences. Thus, in future studies, it may aid our understanding of sex differences in adolescents' perceptions of parenting to further decompose these dimensions at the item level.

It is also important to consider the meaning of heritability estimates of parenting behavior. When twins report on their parents' behaviors, as is the case in this study, heritability estimates indicate the degree to which genes influence one's perceptions of the parenting that is received and the extent to

which individuals elicit varying forms of parenting, perhaps via genetically influenced temperaments and behaviors. This is in contrast to twins' reports on their own parenting practices as adults, for which heritability estimates may actually reflect the degree to which the parents' genotypes influence their provision of parenting, for example, through their own temperamental predispositions. Although twins' reports on their own parenting behaviors could introduce some measure of self-perception bias, it would not be possible to assess the genetics of parenting behavior in the absence of twins who are parents.

Parents have long been among the primary contextual influences under examination in relation to adolescent risk behaviors, including those related to alcohol. Despite evidence of prospective links with drinking frequency across the entire range of parenting dimensions assessed in the present study, the magnitudes of these associations were relatively modest, however. This may reflect a theme consistent in the literature on adolescence, which is that the familial environment, so pertinent during childhood, is increasingly competing with novel proximal influences as youths transition into a broader arena of self-selected environments (e.g., school, peers, extracurricular activities). As such, a particularly important strategy in moving forward will be to examine factors that might magnify or diminish the influence of prior parenting on subsequent alcohol use. It is also possible that the importance of parents will not be found in main effects on their adolescents' behavior but in more complex interactive relationships with the adolescents' genetic and other environmental influences. This has already been demonstrated with respect to adolescent smoking. For example, genetic influences on the variability in smoking decreased, and common environmental influences increased as adolescents reported higher levels of parental knowledge (Dick et al., 2007b; Dick et al., 2007c). Conversely, increases in the amount of time adolescents reported spending with their parents corresponded with higher estimates of heritability and lower estimates of shared environmental influences with respect to variability in the same smoking behavior (Dick et al., 2007b). Thus, individual parenting practices may also differentially modify the influences of genes and environments on adolescent drinking.

Adolescents' perceptions of many aspects of parenting did show evidence of a contribution from genetic influences. It was possible, therefore, to determine whether the latent genetic factors that influence variability in perceived parenting also contribute to variability in alcohol use. It has been posited, for example, that alcohol use among some adolescents might simply reflect their genetic susceptibility to a more general form of problematic externalizing behavior. As a consequence, youth with this disposition may be more likely to restrict their disclosure of information to their parents and/or less likely to elicit positive responses from their parents because of their overall behavior. This, however, does

not appear to be the case, at least in terms of adolescents' perceptions of the extent to which their parents are aware of their whereabouts, activities, and peers, and the degree to which their parents express warmth, because the associations evidenced between adolescents' drinking frequencies and these perceived parenting practices were primarily explained by environments shared by twins.

The unique environmental influences on adolescents' perceptions of parenting are not the same ones that influence their frequency of alcohol use. Although small effects of this nature cannot be ruled out entirely, they are clearly not adequate to explain the association between perceptions of parenting and drinking. Instead, it appears that a shared set of environmental factors that serve to make twin siblings more alike (irrespective of zygosity) are largely responsible for the links between these perceptions of parenting and adolescents' drinking frequencies. Many twin studies have shown a significant influence of the shared environment on adolescents' drinking behaviors. In turn, interpretation of these findings has typically suggested that parenting, often the most consistently shared environment, is likely to play an important role in adolescents' alcohol consumption. To our knowledge, however, this is the first such study that has identified the extent to which specific parenting characteristics account for the common environmental component of the variability in adolescent drinking. The cross path representing common environmental influences shared by perceptions of parenting and alcohol use represents between 6% and 32% of the total common environmental effects on adolescent alcohol use. As such, we note that the majority of the shared environmental influences on drinking frequency are yet to be accounted for. This large residual suggests the need to examine additional sources of environmental similarities.

There are also some notable limitations arising from the use of extant data. It is often suggested that the inclusion of multiple informants is superior to reliance on a single source of data; however, in this study we relied solely on adolescents' perceptions of the parenting that they received, as well as their own self-reported frequencies of alcohol use. Although multiple independent reports would allow us to focus more intently on a set of perceptions commonly held by several informants, we believe that adolescents' perceptions are particularly relevant with respect to influencing their own behaviors. In a study examining the predictive utility of adolescents' versus parents' perceptions of the general parenting milieu in relation to subsequent alcohol-use behaviors, for example, adolescents' perceptions of parenting explained a significant portion of the residual (i.e., nonoverlapping) variability in drinking outcomes, whereas parents' reports contributed very little over and above adolescents' self-reports (Latendresse et al., 2009).

Moreover, the importance of the central finding of this study, that associations between adolescents' perceptions of the parenting that they receive and their frequencies of alco-

hol use can be entirely attributed to common environmental influences, is tempered by the fact that the phenotypic associations are relatively modest. Several factors may have contributed to this. First, we took a straightforward approach to measuring frequency of alcohol use with a single item. A more comprehensive assessment of problematic drinking practices (e.g., simultaneous consideration of one's intensity of use) may have yielded additional information, via stronger associations, about particularly adverse and/or protective parenting practices. In addition, parenting constructs in FinnTwin 12 were generally assessed across parents and not with respect to individual maternal and paternal behaviors. Each of the dimensions of parenting examined in this study has previously been shown to play an important role in relation to adolescent adjustment; however, it is possible that mothers' and fathers' influences on their offspring are differentially distributed across these behaviors. Fathers, for example, may play a more central role in discipline and other control-related dimensions, whereas mothers may influence their children's development through nurturing and other affective aspects of parenting. Thus, future studies should attempt to examine whether discrete assessments of maternal and paternal parenting behaviors yield unique phenotypic associations with adolescent drinking frequencies. Parental influences on adolescents' drinking behaviors might also vary as a function of family structure. Being reared within a single-parent household may, for example, exacerbate the effects of poor parenting and/or negate otherwise protective influences. It is also not clear whether nontraditional custodians (e.g., grandparents, stepparents, and boyfriend/girlfriend of the custodial parent) are any more or less effective as agents of socialization than are biological parents. Both of these issues warrant additional consideration in appropriately powered analyses.

Last, the choice to focus on specific parenting characteristics, in lieu of the more broadly encompassing dimensions of parental affect and control, resulted in the use of fewer items in the measurement of each construct. This was particularly relevant in relation to parental discipline, for which the only two indicators yielded a lower level of internal consistency ($\alpha = .52$). Post hoc exploratory factor analyses validated our operationalization of six distinguishable parenting constructs, however, including the fact that despite their relatively modest association, the aforementioned pair of items did tap into a common aspect of parental control.

In conclusion, our analyses provide further evidence of the contribution of inherited factors to subjectively perceived parenting. We were able to extend the present twin literature on the genetic and environmental etiology of parenting, which has typically asserted a dichotomy between two broad dimensions of behavior (i.e., a genetically influenced form which encompasses all affective parenting, and a uniquely environmentally influenced form reflecting all control-related behavior), through the examination of several nuanced forms

of these more general constructs. Moreover, by disaggregating affective and control-related parenting into several discrete parenting practices, we were able to determine which specific parenting behaviors were most highly associated with adolescent drinking and, what is most interesting, that environmental sources shared by twins accounted for this covariation.

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