Social and Genetic Influences on Adolescent Religious Attitudes and Practices

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The authors explore the contributions of social and genetic influences to religious attitudes and practices in a population-based sample of 11-18 year olds and their mothers who responded to a Religious Attitudes and Practices Inventory and Religious Rearing Practices Inventory respectively. Contrary to genetic studies examining adult religious behavior, genetic influences were small, accounting for only 10 percent of the variance. Rather, the effects of the social environment were much larger, greater than 50 percent, and a majority of offspring similarity was explained by familial rearing. In light of the divergent finding between adolescents and adults, one supporting a socialization model and the other a genetic model, the importance of integrating genetic and social science methodology for complex social behaviors is discussed.

Introduction

It has been claimed that the social sciences are embedded in a paradigm that assumes social differences are purely socially determined (Alford, Funk and Hibbing 2005; Wilson 2002; Wozniak 1984), and that humans have long transcended their genetic history. Lumsden and Wilson (2005) characterize this position as the theory of the "Promethean genotype" in which biological evolution has produced an organism whose primary characteristic is the ability to transcend biology. More than half a century of research in psychiatric and behavioral genetics has established almost beyond doubt that this is too simple a view and that a very wide range of normal and abnormal human behavioral differences at the individual level

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are influenced by genetic factors. Indeed, rightly or wrongly, this view has proved powerful in establishing genetics, along with the neurosciences, as a core paradigm of research into the origins of both normal behaviors and disorders.[1] If the findings of recent studies of breast cancer (Laganiere et al. 2005) and diabetes (Sladek et al. 2007) are a model for genetic influence, even in relatively simple cases the number of genes is very large and their individual effects so small that extraordinarily large samples are required for their individual resolution. These effects, though numerous and small, are not mysterious but depend on the precise statistical, mechanical and molecular properties revealed by more than a century of careful biological research (Fisher 1918; Mendel 1865; Watson and Crick 1953). Those studying any human trait should not be surprised, therefore, if the identification of specific molecular-genetic variants lags far behind the initial statistical demonstration that genetic differences play a significant role in still more complex human traits, such as social behaviors.

It is against this background that there has been growing awareness among social and political scientists of a relatively unrecognized strand of behavior-genetic research over the past 30 years or more that addresses the substantial, but not exclusive, role of genetic influences in the transmission of human differences. These differences are normally regarded as falling under the purview of the social sciences, including religious behavior (Koenig et al. 2005; McNamara 2006; Truett et al. 1994), educational attainment (Jencks et al. 1973), social attitudes (Martin et al. 1986) and even how one votes (Hatemi et al. 2007a). However, it remains to be seen whether the recent introduction of genetics as a source for preferences in the political science literature (Alford, Funk and Hibbing 2005) is a rogue wave or a more fundamental challenge to a central theoretical principle of the social sciences, leading to a broader paradigm that encompasses both biological and social influences. While the form of a more unified theory of biological and social influence is still indistinct and awaits another Darwin, charting the extent and boundaries of genetic influence is central to the goal of bringing biological and social theories into mutually critical correlation.

Behavior-genetic studies have shown that the boundaries of genetic influence are very wide (Plomin et al. 2001). Indeed, for many aspects of human behavior, such as personality and generalized measures of intelligence, the role of the environment shared by family members appears relatively modest even when statistically significant (Eaves, Eysenck and Martin 1989). Rather, genetic influences may extend to aspects of human behavior that, it was assumed, the Promethean genotype had long ago immunized against any but purely social influences. However, at the same time there are many aspects of human behavior for which the *a priori* expectation of non-genetic inheritance, such as culture and social

upbringing, is much greater (Rowe 1994). Even here, geneticists contend that the role of genetic differences cannot be discounted. Numerous studies (Eaves and Eysenck 1974; Eaves et al. 1999) have indicated that, contrary to early expectations, the role of genetic factors in the transmission of social attitudes and behaviors is significant, and that when allowance is made for assortative mating (the tendency of "like to marry like") the lasting role of non-genetic inheritance in the transmission of political attitudes can be quite modest (Hatemi et al. 2007b).

The current contribution lies in an attempt to provide the bases for a model system to overcome the mutual abrasiveness between sociological theory, with its implied adoption of a "social" understanding of the transmission of human differences, and behavior genetic and evolutionary theory with their focus on "genetic" differences. The latter has extended to recent speculation about the possible role of genetic differences in religious behavior (Hamer 2004) and it is that phenotype to which we focus our attention.

Religion shares with social attitudes the fact that it presents a model for the potential interplay between individual genetic predilection, including genetic differences in temperament, and the social environment provided by parents and other factors that depend on the shared context which influences the way in which children develop. Twin and family studies of adult religious differences suggest an emerging pattern that supports a model for gene-environment interplay in religious development (D'Onofrio et al. 1999; Eaves 2004). Thus, as might be expected, there is almost no hint of genetic influence on religious affiliation even though family resemblance is substantial. That is, the family transmission of religious affiliation measured in adults is entirely due to socialization (Eaves, Martin and Heath 1990).

In stark contrast, measures of "self-transcendence" that reflect more internal religious values and awareness show a pattern consistent with moderate genetic influence and little social environmental effect (Kirk et al. 1999). Extensive data on twins and their families in large U.S. and Australian samples show that differences in the frequency of church attendance reflect both genetic and social transmission within families (Truett et al. 1994).

Such data focus primarily on the cause of individual differences in religious behavior. No less important are the genetic and social effects of religion and religious values. Religion has been identified as the "forgotten factor" in biomedical research, although it demonstrates pervasive associations with numerous behavioral and clinical outcomes, including substance abuse, prosocial and antisocial behaviors. Boomsma et al. (1999) found that strict religious upbringing modulated the expression of genetic differences in behavioral disinhibition, such that genetic effects were almost entirely precluded by rearing in a strict Calvinist home.

While the overwhelming majority of genetic research on social behaviors is based on adult samples, for a wide range of social, physiological and

clinical traits, what is true of adults is not necessarily true of children and young adults. In particular, genetic influences in social attitudes are only apparent after the age at which most children leave the home environment. During adolescence, genetic factors play a relatively small part, and the influences of the environment shared by children in the same family is paramount (Eaves et al. 1997). Although the volume of data on adult intracultural religious differences is growing, studies of the genetic and social causes of juvenile differences are relatively rare. The aforementioned findings suggest that results for adults in social behaviors may not extrapolate to childhood and that the contribution of genes and the home environment to attitudes may change during development as a function of the changing adaptive role of behavior during the life cycle. The current study characterizes the roles of genes and the family environment on religious experience and practice during adolescence and seeks to establish a benchmark for future studies of developmental change and the roles of genes and environment in the transition from childhood to maturity.

Methods

With the support of the Superintendent of Public Instruction for the State of North Carolina and local school superintendents, principals of every public and private school in the state were asked to supply contact information on every pair of twins in their school. This population was targeted for recruitment by mail, and subsequent maternal questionnaires were mailed to every mother of twins ages 8-18. Mothers of twins 11-18 were also invited to consent to the twins being mailed a questionnaire. The twin study provides a natural experiment allowing a preliminary resolution of the roles of genes, the shared family environment and the unique environment of the individual. The theoretical and statistical foundation of the twin method has been widely discussed, together with its limitations (Eaves 1982; Neale and Cardon 1992).

The study was conducted by mailed self-report questionnaires completed by the mothers of the twins and their 11- through 18-year-old twin children, known as the Maternal Questionnaire (MQ) and Juvenile Questionnaire (KQ). The instruments were developed in collaboration with a panel of nationally recognized experts in the questionnaire assessment of clinically significant adolescent behavioral outcomes, family and social risk and protective factors, and multiple facets of religiosity, religious values and religious behaviors.

Twins were assessed individually by self-report for a 43-item Religious Attitudes and Practices Inventory (see Table 1) designed to measure several dimensions of religious orientation and practice, including spiritual practices and values that did not explicitly indicate belief in God or involvement in formal religious practice. Items relating to forgiveness, vengefulness

and thankfulness were also selected in consultation. In addition, the importance of religion in the home was assessed as part of the MQ by a brief Religious Rearing Practices Inventory (see Table 4) composed of 11 items characterizing parental investment in the transmission of religious tradition, practice, values and non-religious altruism.

Overall, 2,844 mothers completed the MQ and 2,223 adolescent twins completed the KQ. As the mothers reported on both twins, all of their questionnaires represent complete pairs, while the 2,224 individual twin questionnaires, correspond to 984 complete pairs (88.5 percent pairwise completion) for whom zygosity could be diagnosed (955 pairs). The composition of the twin pairs by zygosity and sex is as follows: Monozygotic Male = 156; Monozygotic Female = 266; Dizygotic Males = 129; Dizygotic Females = 186; Dizygotic Opposite-Sex = 218. Twins on whom self-report data were available had a mean age of 14.13 years (s.d. 1.99).

Data Analysis

Data analysis comprised two principal stages: (1. preliminary statistical description of the raw data, factor analysis and extraction of scales to summarize the RAPI and RRPI; and (2. examination and analysis of twin resemblance to assess the roles of genes and the family rearing environment.

The basic statistical analysis of the 43 RAPI items is summarized in Table 1. The wording of the items is reproduced as it was on the KQ. Statistical tests of significance, based on chi-square tests of association for sex differences in item endorsement and the linear age trend, by sex, are also given in the table. The test of age trend utilized the Mantel-Haenszel chi-square statistic (Mantel and Haenszel 1959) for linear trend in a contingency table. All age associations reflected a negative age trend in endorsement frequency. Even the most significant age trends are relatively small and seldom exceed a rank correlation of -0.1 in absolute value.

Table 1 also identifies the factor structure of the RAPI items. Items have been numbered in the table to correspond more closely to the results of the factor analysis, and are referenced as such in subsequent tables. Factors were extracted from the raw inter-item product-moment correlations by iterated principal axis factoring. Five factors were retained after examination of the scree plot of eigenvalues and rotated to oblique simple structure using Hendrickson and White's (1964) Promax algorithm. The analyses were conducted separately for boys and girls, but the high level of agreement in the findings across sexes led us to report a single analysis based on the pooling of all data regardless of age or sex.

Table 2 summarizes the correlations between the five identified factors. The first two factors encompass many items and are highly correlated

Table 1: Factor Analysis of Religious Attitudes and Practices Inventory

		Factor loading					P	P(age)	
Item #	RAPI Items	I	II	III	IV	V	Sex	Boys	Girls
1	I feel like I can always count on God	90	1	5	-3	1	*	***	*
2	My faith in God helps me through hard times	85	5	4	-3	-3	*	***	*
3	I feel thankful to God for my life	84	-7	17	-1	7	—	***	***
4	I believe in God	79	-11	11	-7	8	—	***	**
5	I ask God to help me make important decisions	75	14	-3	-6	-1	—	***	—
6	I feel that without God there would be no purpose in life	74	15	-8	6	2	—	***	—
7	Every day I see evidence God is active in the world	73	15	2	-2	-1	—	***	—
8	I try to live how God wants me to live	72	14	-2	3	-5	—	***	***
9	I think of God as a real person	68	-4	5	4	6	—	***	—
10	My faith in God shapes how I think and act every day	64	23	-5	4	-8	—	***	—
11	I believe the Bible (Torah, Koran etc) is the absolute truth and should be taken literally	59	17	-2	12	6	*	***	***
12	My life is committed to God	58	33	-7	7	-2	—	***	*
13	I believe that God sometimes punished people who commit a sin	51	-10	-1	16	19	—	—	—
14	Spiritual experiences are important to me	48	42	-7	0	-5	—	**	—
15	I take time for periods of private prayer or meditation	46	33	4	-6	-6	—	*	—
16	I often count my blessings	34	29	20	-9	-12	***	*	*
17	I often see my mother (female guardian) going to church or doing other religious things	-5	82	5	-7	10	—	*	—
18	I often attend religious activities such as Bible study, choir practice or youth group	1	81	-9	3	3	—	*	***
19	I often see my father (or male guardian) going to church, praying or doing other religious things	-6	78	2	-5	8	—	**	—
20	I go to Sunday school often	-4	75	-4	4	5	—	***	***
21	I think my mother (or female guardian) is very religious	2	74	6	-6	7	—	*	—
22	I like to worship and pray with others	23	65	-3	3	-3	—	***	—
23	I think my father (or male guardian) is very religious	3	65	8	-1	7	*	**	—

Table 1 *continued*

Item #	RAPI Items	Factor loading I	II	III	IV	V	P Sex	P(age) Boys	Girls
24	I help others with their religious questions and struggles	19	59	-2	-1	-3	—	—	—
25	My friends and I often talk about religious matters	7	57	7	-2	-7	***	**	***
26	I know I can count on people at my church if I need help	27	55	-1	4	2	—	***	*
27	Being with other people who share my religious views is important to me	25	54	2	6	-4	—	*	—
28	I seek out opportunities to help me grow spiritually	30	48	-3	10	-8	—	**	—
29	Most of my best friends are religious	-5	46	29	9	-3	—	***	**
30	I consider myself to be a very spiritual person	36	45	2	3	-8	—	***	—
31	Most of my best friends go to church or other religious services	-2	41	28	12	4	—	***	***
32	I am grateful for what other people have done for me	5	6	70	-3	1	***	—	—
33	I have a lot to be thankful for	10	-5	64	3	4	—	—	—
34	When people in my family hurt me, they let me know that they are sorry	1	2	59	7	1	—	***	***
35	When people do nice things for me, I try to let know that I appreciate it	2	3	58	-1	-5	***	—	—
36	When I hurt people in my family they eventually forgive me	4	2	53	0	-2	*	—	*
37	In our family we don't carry grudges against each other	4	21	33	-5	-8	—	—	—
38	I believe smoking cigarettes is a sin	-3	4	1	83	-2	—	***	***
39	I believe drinking alcohol is a sin	11	0	-5	80	-3	—	***	***
40	I believe smoking marijuana is a sin	7	-2	9	78	1	***	***	***
41	I believe that if someone hurts me, it is alright to get back at them	5	5	-3	0	90	***	—	*
42	I think that if a person hurts me on purpose, I deserve to get revenge	7	7	-2	2	85	***	—	**
43	I would enjoy hearing that someone I dislike had gotten into trouble	2	1	2	-5	61	***	—	—

Notes: * < .10 ** < .05 *** < .01 N = 1305

Table 2: Inter-factor Correlations

Factor	I	II	III	IV	V
I	100	71	47	49	-25
II	71	100	43	47	-34
III	47	43	100	21	-29
IV	49	47	21	100	-14
V	-25	-34	-29	-14	100

(r = .71). The first factor tends to comprise items that reflect the intrinsic attitudes of religious faith and doctrine. The second comprises the more explicit behavioral and social manifestations of religion. Small item clusters display the communality of items specifically chosen to address other aspects of affect and behavior that may exhibit or contribute to religious attitudes. The remaining factors are: "thankfulness and forgiveness," "belief that substance use is sinful," and "vengefulness." All correlations among the first four factors are positive. All correlate negatively with the more anti-social aspects of behavior assessed by the items loading on the fifth factor. Scale scores were derived from the unweighted sum of the item responses for each factor. Means, standard deviations and (linear) age trends in the scale scores are summarized in Table 3.

Sex differences in religious faith and practice are small and not significant in this age group. Sex differences are marked and highly significant with regard to the perceived sinfulness of substance use and vengefulness. In both cases, scores are higher for boys than girls. The male excess in vengefulness is consistent with an ample literature showing that boys show more anti-social behavior and behavioral disorders than girls (Cohen et al. 1993). The higher perceived sinfulness of substance use among boys requires further exploration as a function of the effects of parents and peers on drug involvement and sex differences in exposure to and use of illegal substances.

Table 3: Effects of Age and Sex on RAPI Scales

	Boys				Girls				
Scale	N	Mean	s.d.	Age	N	Mean	s.d.	Age	P(sex)
Religious Faith	595	31.27	12.86	-.16***	904	32.17	12.27	-.04	-
Religious Observance	601	24.58	11.76	-.14***	918	24.74	11.80	-.06	-
Thankful and Forgiving	618	14.42	3.01	-.09*	947	14.97	2.70	-.05	**
Drug/substance Use is Sinful	620	5.16	3.03	-.29***	956	4.61	3.09	-.24***	***
Vengefulness	623	3.93	2.37	.05	961	3.23	2.28	-.08**	***

Notes: Age relationship expressed as Pearson rank correlation.
* < .10 ** < .05 *** < .01.

Table 4: Factor Analysis of Early Religious Rearing and Practices Inventory

	How important is it in your family to do each of the following?	Loading
1	To learn religious stories	85
2	To give money to religious organizations,	83
3	To read religious texts (e.g. Bible, Koran, Torah) or other religious materials	83
4	To go to church, synagogue or other religious services	82
5	To talk about religion and spiritual concepts	80
6	To say private prayers	73
7	To say grace or the blessing at meal times	70
8	To understand the meaning of religious holidays	68
9	To observe religious holidays (such as Easter, Passover, Christmas, Hannukah etc.)	61
10	To volunteer your time	51
11	To give money to charities not related to religious organizations	40

Notes: Single Common Factor Solution, N = 1022.

Table 4 gives loadings on a single common factor of maternal responses to the RRPI. There is strong support for a general factor of "religious rearing" loading most highly on educational practices that are more explicitly religious. There is some evidence of a weak, correlated second factor that loads more highly on the more secular items (volunteerism, giving to non-religious charities) but the number of salient items is small and, ideally, will be larger in future attempts to separate secular altruism from explicitly religious concerns. Given the strong support for a single factor of "religious rearing" a scale score was derived for each twin pair as the unweighted sum of mothers' responses to the 11 RAPI items.

Table 5 gives the polychoric correlations for every RAPI item in each of the five twin types: male or female monozygotic, male or female dizygotic, and opposite-sex twins. The table also includes two additional items, included in the KQ but not in the RAPI: "How often do you attend religious services or meetings (church, temple, etc.)?" and "How important is religion in your life?" numbered R1 and R2 respectively. The mean and standard deviation (s.d.) of the correlations over all 45 items are also tabulated for each of the five twin groups.

The impression is that the individual twin correlations are quite large but variable. The large twin correlations indicate a substantial influence of family factors, genetic or social, on adolescent religious belief and practice. Some of the twin correlations, such as that for church attendance and the perceived importance of religion are very large and comparable to those obtained for anthropometric measures such as stature in MZ twins (.8–.9). Other correlations such as many of those on the RAPI are comparable to the MZ correlations for physiological measures such as diastolic blood pressure (.6). A handful of items, such as those relating to "thankfulness and

Table 5: Twin Correlations and Contributions of Genes (h^2) and Shared Environment (c^2) to Religious Attitudes and Practices

		Twin Pair Correlations					Source of Variance				
Item #	RAPI Items	MZM	MZF	DZM	DZF	DZMF	h^2_M	h^2_F	C^2_M	c^2_F	r_{MF}
R1	How often do you attend religious services or meetings (church, etc.)?	.91	.90	.79	.87	.79	.23	.06	.69	.84	.94
R2	How important is religion in your life?	.80	.78	.55	.66	.58	.49	.24	.33	.54	.96
1	I feel like I can always count on God.	.70	.69	.64	.76	.59	.12	-.14	.59	.83	.85
2	My faith in God helps me through hard times.	.77	.66	.70	.62	.60	.15	.07	.74	.59	.90
3	I feel thankful to God for my life.	.75	.60	.69	.56	.50	.12	.06	.78	.53	.81
4	I believe in God.	.81	.55	.74	.65	.67	.14	-.20	.93	.75	.97
5	I ask God to help me make important decisions.	.62	.64	.72	.56	.55	-.20	.15	.80	.49	.86
6	I feel that without God there would be no purpose in life.	.64	.77	.68	.54	.58	-.08	.45	.60	.32	.96
7	Every day I see evidence that God is active in the world.	.64	.66	.59	.56	.63	.10	.20	.52	.46	1.10
8	I try to live how God wants me to live.	.69	.74	.69	.69	.57	.00	.11	.64	.63	.83
9	I think of God as a real person.	.56	.60	.68	.49	.43	-.24	.23	.76	.37	.74
10	My faith in God shapes how I think and act every day.	.66	.78	.66	.61	.43	.00	.33	.54	.44	.68
11	I believe the Bible (Torah, Koran etc.) is the absolute truth and should be taken literally.	.79	.71	.75	.66	.65	.08	.11	.78	.60	.93
12	My life is committed to God.	.76	.77	.68	.61	.65	.15	.31	.60	.45	1.01
13	I believe that God sometimes punished people who commit a sin.	.36	.44	.63	.25	.49	-.55	.36	.83	.07	1.22
14	Spiritual experiences are important to me.	.64	.71	.75	.56	.53	-.21	.30	.79	.41	.82
15	I take time for periods of private prayer or meditation.	.78	.62	.68	.43	.35	.20	.37	.74	.25	.64
16	I often count my blessings.	.67	.50	.48	.35	.49	.38	.30	.46	.20	1.20
17	I often see my mother (female guardian) going to church or doing other religious things.	.88	.85	.79	.76	.80	.18	.17	.73	.67	1.04
18	I often attend religious activities such as Bible study, choir practice or youth group.	.73	.84	.72	.76	.72	.02	.17	.60	.67	.98
19	I often see my father (or male guardian) going to church, praying or doing other religious things.	.82	.85	.85	.86	.84	-.06	-.01	.84	.86	.98
20	I go to Sunday school often.	.84	.85	.81	.86	.77	.06	-.02	.76	.88	.92

21	I think my mother (or female guardian) is very religious.	.86	.79	.75	.74	.60	.21	.09	.71	.70	.80
22	I like to worship and pray with others.	.71	.74	.60	.66	.55	.23	.17	.46	.57	.88
23	I think my father (or male guardian) is very religious.	.83	.74	.79	.82	.69	.07	-.16	.85	.90	.86
24	I help others with their religious questions and struggles.	.69	.60	.51	.60	.40	.36	.01	.42	.59	.72
25	My friends and I often talk about religious matters.	.62	.70	.60	.50	.34	.05	.39	.50	.31	.63
26	I know I can count on people at my church when I need help.	.74	.69	.60	.71	.52	.29	-.05	.51	.74	.79
27	Being with other people who share my religious views is important to me.	.70	.71	.56	.63	.44	.28	.17	.40	.55	.75
28	I seek out opportunities to help me grow spiritually.	.48	.67	.67	.58	.44	-.36	.17	.66	.50	.71
29	Most of my best friends are religious.	.64	.67	.37	.50	.21	.55	.34	.07	.33	.50
30	I consider myself to be a very spiritual person.	.61	.69	.68	.43	.41	-.14	.51	.67	.18	.75
31	Most of my best friends go to church or other religious services.	.67	.61	.37	.70	.29	.60	-.17	.13	.79	.57
32	I am grateful for what other people have done for me.	.45	.31	.27	.54	.38	.36	-.46	.23	.77	.98
33	I have a lot to be thankful for.	.35	.59	.63	.39	.42	-.56	.40	.67	.19	.86
34	When people in my family hurt me, they let me know they are sorry	.55	.53	.31	.38	.19	.48	.31	.08	.22	.55
35	When people do nice things for me, I try to let know that I appreciate it.	.51	.35	.39	.31	.12	.23	.08	.43	.27	.33
36	When I hurt people in my family they eventually forgive me.	.30	.27	.56	.19	.28	-.52	.16	.85	.10	.88
37	In our family, we don't carry grudges against each other.	.30	.26	.34	.51	.15	-.07	-.50	.42	.76	.37
38	I believe smoking cigarettes is a sin.	.57	.48	.63	.51	.46	-.13	-.07	.78	.54	.82
39	I believe drinking alcohol is a sin.	.71	.66	.61	.66	.41	.20	.02	.55	.65	.65
40	I believe smoking marijuana is a sin.	.42	.54	.54	.68	.38	-.24	-.27	.54	.81	.62
41	I believe that if someone hurts me, it is alright to get back at them.	.51	.50	.26	.49	.12	.49	.01	.02	.49	.34
42	If a person hurts me on purpose, I deserve to get revenge.	.40	.33	.27	.23	.17	.27	.21	.20	.13	.69
43	I would enjoy hearing that someone I dislike had gotten into trouble.	.54	.32	.13	.41	.15	.82	-.17	-.07	.49	.66
Mean		.64	.64	.63	.59	.57	.10	.10	.11	.56	.52
s.d.		.16	.16	.16	.17	.17	.30	.30	.23	.25	.23

Notes: r_{MF} is the estimated correlation between causes of family resemblance between boys and girls.

forgiveness" show the lower correlations typical of personality measures and suggest that these are influenced more by twin-specific and occasion-specific environmental factors. The variation in correlation among items may point to heterogeneity in the overall contribution of genetic and social factors to different aspects of religious behavior.

The overall picture of adolescent family influence can be inferred from the mean correlations across the 45 items for the five types of twin pair (see Table 5). The correlations for like-sex MZ and DZ twin pairs, are about .6 on average, comparable to those found for social attitude scales in adults. The average correlation for opposite-sex DZ twins is about .47, about .10 smaller than the correlation for like-sex DZ twins. This finding of a modest reduction in the opposite-sex correlation relative to that for like-sex pairs indicates that somewhat different factors, sex-limited genetic differences or sex-dependent environmental factors, create variation in males and females. The extreme case, in which the DZMF correlation is zero while the DZM and DZF correlations are large, implies that entirely different genes and/or social influences were responsible for sibling resemblance among boys and girls. Although the DZMF correlation is somewhat lower, the general impression of the table is one of boys and girls being influenced by the same genetic and/or social influences in this age range.

The average correlations for DZ twins are modestly lower than those for MZs suggesting that there may be a small influence of genetic factors on differences in adolescent religiosity. However, the overwhelming trend is one of large MZ correlations with close to equally large DZ correlations in both sexes, a finding consistent with a large impact of the shared social environment (including familial upbringing) on religious attitudes of adolescents.

If genetic factors play any role, it would be foolish to assume that there is "a" gene "for" any religious behavior. Indeed, the pathway from DNA to behavior of any kind is expected to be long and tortuous, involving many steps some of which occur at the level of cells and organs within the person and others that involve the interplay between the organism and the environment (Eaves 1977; Scarr and McCartney 1983; Silberg and Rutter 2001). Each of these steps may be, partly, under genetic control. Thus, the final expression of behavior, the behavioral "phenotype," (Johannsen 1911) may be influenced by a very large number of genes, each following the laws of Mendelian inheritance and each contributing cumulatively to the final continuous complex phenotype. This appears to be case even for those traits which are apparently under little social influence such as breast cancer. The classical statement of this "polygenic" model for family resemblance is due to Ronald Fisher (1918). Fisher's model has been extended in numerous ways over the intervening years to incorporate many features that are critical in the analysis of family resemblance for

human behavioral traits, including non-genetic inheritance (Cavalli-Sforza and Feldman 1981; Cloninger, Rice and Reich 1979) and developmental change in gene expression (Eaves, Long and Heath 1986).

Twin data alone cannot provide a definitive model for the roles of genes and the environment, but under some simplifying assumptions it is possible to estimate meaningful parameters from twin correlations, and offer a starting point to look further, as is common practice (Neale and Cardon 1992). The simplest model assumes that twin resemblance is due to two independent influences: the "additive genetic" variance component, h^2, and the "shared environmental" component, c^2. This model ignores three potentially important issues: (1. the effects of genes interacting with each other (non-additive genetic effects); (2. the effects of genes and environment are independent (individuals with "religious" genes do not receive more than their fair share of "religious" environments); (3. the effects of genes and environment do not interact (i.e. "religious" genes do not make children more or less sensitive to the impact of the environment). The implications of these assumptions, and approaches to testing them, have been widely considered (see Heath et al. 1985; Jinks and Fulker 1970; Rao, Morton, and Yee 1976). If these assumptions hold, then the expected correlations between MZ and DZ twins may be expressed in terms of the additive genetic component, h^2, and the shared environmental component, c^2, thus:

$$r_{MZ} = h^2 + c^2$$
and
$$r_{DZ} = \tfrac{1}{2} h^2 + c^2 .$$

The coefficient of .5 for the additive genetic component in r_{DZ} depends on the precise laws of Mendelian inheritance sometimes expressed in the (not absolutely precise) statement that "siblings (DZ twins) share half their genes in common." Strictly, the coefficient depends on the further (and often untenable) assumption that people choose their mates at random for the trait under analysis. Assortative mating (i.e., a positive correlation between mates for a given trait), will tend to increase the genetic similarity of DZ twins and inflate estimates of the shared environment if the effects of assortment are ignored (Martin et al. 1986). In any case, no matter what the mating system, genetic influences will always ensure that $r_{MZ} > r_{DZ}$.

The two equations for the expected correlations may be solved for any specific data to yield estimates of the genetic and shared environmental components: $h^2 = 2(r_{MZ} - r_{DZ})$ and $c^2 = 2r_{DZ} - r_{MZ}$ (Holzinger 1929). The equations may be solved separately for male and female twins to estimate the contributions of genetic differences to variation within males and females.

Typically h^2 and c^2 do not account for all the variance in a given trait. There are differences within pairs of identical twins even when they are

raised in the same family because they experience their own unique environmental differences within the family, e^2. The contribution of these residual environmental effects can be estimated from:

$$e^2 = 1 - h^2 - c^2 = 1 - r_{MZ}.$$

Fulker and Eysenck (1979) illustrate an application of this basic approach to the analysis of twin resemblance in social traits. The statistical method has been elaborated in a variety of ways to improve and quantify the precision of estimates and test the consistency of the data with the overall model (see Neale and Cardon 1992). Our simple approach reveals the broad features of family resemblance. The above algebra may be used to obtain separate estimates of the parameters from male and female like-sex twins. However, the same genes and environments may not contribute to family resemblance in both sexes. A simple statistic may be computed to summarize the extent to which the same genes and shared environments affect males and females:

$$r_{MF} = r_{DZMF}(r_{DZM}r_{DZF})^{-2}$$

The statistic r_{MF} may be conceptualized as the correlation between the sexes in the causes of family resemblance. The above calculations were performed for each of the sets of twin correlations in Table 5 and the estimates are also tabulated in Table 5.

Although there is considerable variability in the estimates across items, values of r_{MF} are generally large and positive. Occasional estimates greater than 1 arise because the "correlation" is itself a function of correlations based on separate samples and is not constrained to be positioned between -1 and +1. The large values of r_{MF} reflect large overlap between the causes of religious differences within the sexes – the same genes and/or environments that affect boys at this age, also influence girls.

Estimates of the shared environmental component, c^2, are mostly large relative to estimates of h^2. Thus, the effects of the social environment on adolescent religiosity are consistently large. The effects of the shared environment in this case include any significant trends with age. Although some of the age correlations are significant (see Table 5) they are mostly small and contribute relatively little (1-2 percent of the variance) to the similarity within twin pairs. Estimates of the genetic contribution are much smaller than those of the shared environment. Negative estimates arise by chance in relatively small samples when the contribution of genetic factors is small.

The items relating to church attendance and the perceived importance of religion are worthy of more consideration in their own right. Although the effects of the shared environment are large, there is a suggestion

that the genetic component is larger for differences in the "importance of religion" in both sexes than for "church attendance." This is consistent with a greater role for temperamental factors in personal religious belief than external religious practice, which in this age group is understandably still under parental control. The correlation between effects across sexes, r_{MF} is very large for both items (.94 for church attendance, .96 for the importance attached to religion) suggesting that almost all the factors that create sibling resemblance are shared by boys and girls.

The average of the estimates across all items leaves a striking impression that is remarkably consistent across boys and girls. On average, the estimated contribution of genetic influences is quite small, of the order of 10 percent of the total variance. By contrast, the shared environment of the family accounts for more than 50 percent of the variance, on average, leaving some 40 percent of the variance due to the unique environmental experiences of individuals within the family (e^2) and measurement error. Once again, the cross-sex correlation between family influences is .8 on average, pointing to a very high degree of similarity between the causes of family resemblance in boys and girls.

The above analysis of individual items provides a unique picture of the effects of genes and environment on specific features of adolescent religion. However, it is difficult to arrive at any sense of whether the relative effects of the familial background and genetic heritability reflect any systematic differences related to item content. For this purpose we consider the patterns of twin resemblance for the scale scores derived from the factor analysis of the RAPI.

Table 6 supplies the twin correlations for RAPI scale scores on each of the five primary factors. All the correlations are corrected for any linear trend with age. Two sets of correlations are presented for each twin group. The first raw correlations are those for the factor scores of twins (T1-T2) prior to adjustment for effects of measured family religious practice (RRPI). The correlations between the single assessment of family religious rearing practices (derived from the maternal RRPI) and RAPI factor scores are tabulated for each twin type for each of the five RAPI factors. The final correlations (labeled "partial" in the table) are the residual partial correlations between twins after the measured effects of religious rearing (RRPI) have been removed. The correlations between religious rearing on juvenile religious attitudes and practice are large, indeed extremely so for the two major factors of religious belief and religious observance and accounting for as much as 20-40 percent of the raw variation in these two dimensions. These effects, that contribute to c^2 in the simple model, are removed from the twin correlations prior to subsequent statistical analysis so further comparisons account for residual effects of genes and the shared environment.

Table 6: Age-corrected Twin Correlations for Five Primary Factors

			Correlation			
			Raw			Partial
Factor	Twin type	N (pr)	RRPI-T1	RRPI-T2	T1-T2	T1-T2
Religious Faith	MZM	84	.50	.44	.75	.68
	MZF	135	.59	.55	.79	.69
	DZM	66	.65	.64	.69	.47
	DZF	102	.43	.39	.58	.49
	DZMF	129	.47	.51	.61	.49
Religious Observance	MZM	90	.65	.63	.82	.69
	MZF	150	.71	.73	.83	.65
	DZM	67	.66	.70	.70	.45
	DZF	100	.61	.57	.79	.68
	DZMF	129	.60	.57	.61	.41
Thankful and Forgiving	MZM	91	.38	.28	.52	.46
	MZF	155	.15	.21	.41	.40
	DZM	72	.33	.25	.48	.45
	DZF	113	.23	.36	.49	.45
	DZMF	139	.16	.24	.21	.19
Believes Drug-Use is Sinful	MZM	92	.35	.28	.50	.45
	MZF	159	.28	.31	.57	.53
	DZM	69	.24	.41	.63	.60
	DZF	112	.28	.14	.55	.54
	DZMF	141	.30	.19	.40	.37
Vengefulness	MZM	93	-.43	-.42	.51	.40
	MZF	160	-.06	-.12	.47	.47
	DZM	73	-.01	-.04	.20	.20
	DZF	115	-.27	-.19	.34	.31
	DZMF	140	-.13	-.22	.20	.17

Table 7 shows the estimated contribution of genes and the shared environment to twin similarity for the factors after the effects of family religious rearing have been removed. The estimates are derived from the partial correlations in the same way as those in Table 5. A superficial examination of the table suggests that the contributions of genes and shared environment differ across scales. Differences between families in the "religious faith" factor appear to be caused by the same genetic and social influences in boys and girls (r_{MF}=1.014). However, the cross-sex correlations for family influences are numerically smaller for the other factors suggesting that the sexes differ in which genetic and environmental influences transmit individual differences. The "Thankful and forgiving" scale and the "Believes drug use is sinful" factors show no apparent genetic effects (h^2 estimates are close to zero or even somewhat negative due to sampling effects). Sibling resemblance for these two factors seems to depend entirely on the effects

Table 7: Genetic and Shared Environmental Contributions After Effects of Familial Religious Rearing Practices Removed

Scale	h^2_M	h^2_F	c^2_M	c^2_F	r_{MF}
1 Religious Faith	.42	.40	.25	.29	1.01
2 Religious Observance	.47	-.05	.25	.70	.74
3 Thankful and Forgiving	.05	-.11	.48	.50	.42
4 Believes Drug-Use Sinful	-.31	-.01	.68	.54	.65
5 Vengefulness	.40	.32	-.07	.15	.71

Notes: (h^2) represents genes, (c^2) shared environment and (r_{MF}) is the estimated correlation between causes of family resemblance between boys and girls.

of the home environment and not all on genetic influences. The pattern is reversed for the "Vengefulness" scale for which the genetic contribution is larger and that of the home environment is virtually zero.

A simple test of significance of the principal features of the data is provided by chi-square tests for each of a series of contrasts between the correlations that test particular comparisons (Table 8). After fitting a parameter for the overall correlation between twins (contrast *m*), the contrast H compares both MZ correlations with the two like-sex DZ correlations and is, thus, a test of the average effect of genes on boys and girls. The contrast S compares (like-sex) twin resemblance for all male and female twins and is a general test of sex-differences in family resemblance. The contrast L is zero of the correlation of opposite-sex twins equal to the mean of the like-sex DZ twins. If the opposite-sex correlation is substantially reduced, contrast L will be significant and provide strong evidence that some of the causes of family resemblance are sex-specific. The contrast HxS assesses the dependence of the size of the genetic effect on sex (genotype x sex interaction).

The contrasts may be estimated and their significance tested by weighted least squares applied to the normalized (z-transformed) correlations using their degrees of freedom (d.f.) as weights. The procedure is summarized by Eaves and Jinks (1972) and suffices to test some of the simple hypotheses associated with twin resemblance. While more statistically precise methods are often employed for genetic analyses in the genetics literature such as maximum likelihood or Monte Carlo Markov Chain (see Neale and Cardon 1992), much of this material is largely unfamiliar to researchers in the social sciences and therefore less transparent. Rather, we followed the example of Alford, Funk and Hibbing's (2005) *American Political Science Review* article, presenting the basic conceptual and analytical ideas using methods more commonly found in the leading social science journals. We do this confident that further attention to statistical precision would only marginally alter the results. In taking this step, we relied on work by Hatemi et al (2007b) that showed the additional level of

Table 8: Significance Tests ($\chi^2_{(1)}$)

		Test of significance: $\chi^2_{(1)}$				
Scale	**Statistic**	**M**	**H**	**S**	**HxS**	**L**
Religious Faith	Z	203.16	11.53	.06	.00	2.12
Religious Observance	Z	222.59	6.35	1.57	3.79	8.43
Thankful and Forgiving	Z	89.72	.82	.11	.24	8.16
Believes Drug-Use Sinful	Z	150.66	.10	.00	1.08	4.17
Vengefulness	Z	56.64	7.25	1.03	.03	3.61
Church Attendance	R	4424.57	13.89	1.36	2.56	2.33
Importance of Religion	R	743.22	17.65	.59	1.32	3.44

Notes: Tests based on estimates and sampling variances from a weighted least squares analysis of polychoric twin correlations (r) or z-transforms of Spearman rank correlations (z). Significance levels for $\chi^2_{(1)}$:: 3.84 (P = 5%); 6.63 (P = 1%)

analytical virtuosity in complex social behaviors did not, in simple cases like ours, lead to substantive changes in the conclusions.

The procedure was implemented in the SAS "IML" system. If *d* is the estimate of the contrast and v its variance estimated from the inverse of the information matrix, then we compute $\chi^2_{(1)} = d^2/s$ the statistic to test the significance of the contrast. The chi-square tests of significance are shown for all five factors in Table 8. In addition, we report approximate tests of the same contrasts, applied to the untransformed polychoric correlations for church attendance and the perceived importance of religion using the inverse of the asymptotic variance of each correlation as weight.

As is expected, the average twin correlation is highly significant for all the measures as the corresponding chi-square values for *m* are extremely large. Tests of the genetic component, H, are not significant for either thankfulness or beliefs about the sinfulness of substance use. This finding supports the conclusion based on inspection of the estimates in Table 6. Thus any family resemblance for these traits is purely environmental in origin. By contrast, genetic effects are significant for the "vengefulness," "religious faith" and "religious observance" scales and for the individual items relating to "church attendance" and the "importance of religion." At least by the chi-square criterion, there is somewhat stronger support for genetic effects on "religious faith" and the "importance of religion" than for the "religious observance" factor and "church attendance" item. It might be argued that these findings are consistent with a more temperamental understanding of religious faith and a more social model for religious observance, although it is important not to read too much into the results of only one study. None of the variables show a significant effect of sex on overall twin correlations (S does not differ significantly from zero), nor is there any evidence that the contribution of genes differs between

sexes (the H x S contrasts do not differ significantly from zero) except possibly in the case of religious observance for which $\chi^2_{(1)} = 3.79$ borders on significance at the .05 level. However, there is statistically significant evidence that different genetic and/or environmental influences affect boys and girls for religious observance, thankfulness and the belief that drug use is sinful.

Summary and Discussion

The results are contingent on the model for twin resemblance outlined above. Estimates of the genetic contribution will be inflated if there are non-additive genetic effects. Estimates of the family environment will be inflated if there is substantial assortative mating. While neither is tested here, the estimates of genetic influences would have to be much larger for assortment to play a major role in genetic resemblance between relatives (Fisher 1918). The results are also contingent on the assumption that any increased similarity in the environments of MZ twins would not affect the traits under analysis. This assumption is tested, and its implications evaluated in numerous publications (see Kendler and Gardner 1998; Lykken et al. 1990). In these analyses there are no indications that DZ twins would be raised any differently if they were MZ twins and vice versa for religious behaviors.

Given the assumptions, our initial analysis of religious attitudes and practices in a large population-based sample of adolescent twins and their mothers allows us to characterize the contributions of genes and the family environment to the attitudes and behaviors at a critical stage of adolescents' religious development. The data suggest that the impact of familial social influences is overwhelming for a wide range of specific items of religious value, experience and observance. However, although there is some evidence for a small but statistically significant genetic component to individual differences, the estimates of the genetic contribution pale in substantive significance against the much larger non-genetic contributions of the family. In the present study, genetic factors are estimated to contribute, on average, only about 10 percent of the total variability in the likelihood of endorsing individual items whereas the shared (family and social) environment accounts for the majority of variance, greater than 50 percent. Almost equally important is the adolescents' own personal experiences, accounting for the remaining 40 percent of the variance.

The high correlation between twins' religious attitudes and family religious training confirms that religion in the home is a major factor in the social acquisition of adolescent religious values. Our results for aspects of religious behavior are remarkably consistent with those reported for teen religiosity utilizing an adoption-based study (Abrahamson, Baker and Caspi

2002). The results also show that some of the effects of genes and family environment are sex-specific. That is, to some extent, individual differences are caused by different environments and/or genes in boys and girls.

The current analysis is only a first step and focuses on the roles of genes and the family environment on religious behavior and beliefs in themselves and says nothing about how these differences contribute to, correlate with or interact with other socially important outcomes such as social behavior, substance use, temperament, psychological health, parent-child interaction, peer-selection, political attitudes and educational attainment. Adolescents who practice religiously differ significantly from those who do not on a host of risk behaviors (Smith and Denton 2005); they are less likely to smoke, drink, use marijuana, cut class, be suspended or expelled from school, and are more likely to get good grades, engage in service or volunteer activities, and less likely to accept that cheating, lying and stealing are permissible (but not necessarily less likely to actually engage in such behaviors). Thus, we have still to address the question of whether religious upbringing protects against the expression of otherwise high-risk genetic predisposition to these and other socially and individually damaging outcomes. All of these analyses are possible and would yield significant insight into the role of religious background on adaptive behavior in adolescence.

The contribution of genetic and social factors change with age. Similar to social attitudes, genetic differences on religious behaviors are only expressed after children leave home, at which point the effects of the home environment decay rapidly. Thus two scenarios emerge: (1. the adolescent scenario, where the genetic component is latent and behavior is largely a function of the family and social environment combined with personal experience, and (2. the adult scenario where familial socialization and environmental roles are reduced and behavior is largely a function of genetic constitution and individual experience.

The adolescent data examined here provide very little support for variation in genes that affect religious predisposition as a factor in adolescent religious differences. The simple fact is that there may not be much genetic variation underlying juvenile religious differences since most of the effects appear to be social in this age group. The possibility that genetic differences in the religious phenotype cannot be expressed while children live with their parents provides strong support that Hamer's (2004) "God Genes" may only be expressed when children leave home and the constraints of the home environment. This also does not necessarily undermine the evolutionary importance of religion since highly adaptive traits are expected to show smaller genetic variability in some circumstances (Falconer 1981; Fisher 1930).

Contrary to prevailing thought, recent scholarship suggests education has little impact on the decline in religious behavior in early adulthood. Rather,

non-marital cohabitation and drug and alcohol use contribute significantly to reduced religious participation in young adults (Uecker, Regnerus and Vaaler 2007). It is remarkable that many of the adolescent correlates of religiosity such as drug and alcohol use show the same pattern of developmental change in the roles of genes and environment. As with religious behavior, so with substance use; the influence of the family environment is predominant in adolescence, where as those with genes are greater in adulthood. The shifting trajectory from social to genetic influences on religious behavior from adolescence to adulthood implies a mechanism in which genetic differences gradually mediate the selection of adult behaviors from those presented by the adolescent social environment. The results are consistent with an evolutionary model for extended parental care in which there is ultimately a switch from a parental-based model of behavior to an individual-based model of behavior. Such a model has broad implications for how we conceive of the roles of genes and social environment in social behavior and evolution. It appears that if parents hope to have a lasting influence with their offspring, their efforts cannot stop after their children leave home.

Accepting the overwhelming empirical support for the role of genes in general, the real world is more complex than explained by one discipline or method; behavior-genetic, evolutionary theory and social science is left with some explaining to do, because for religious beliefs, the role of the social environment is overwhelming in juveniles, but minimal in adults. Such a finding opens the door to a more synthetic and developmental theory for the roles of genes and culture, which is consistent with the large human investment in parental care and education. In general, regarding social attitudes and political values, significant genetic variability exists in adults but fails to do so in adolescence, but offspring still maintain similar values to their parents after they leave home (Miller and Glass 1989; Vollebergh, Iedema and Raaijmakers 2001). This paradox offers a reason to provide an alternative explanation to a socially learned or genetically driven model. We propose that the primary influence of family background, and all that goes with it, is not the transmission of specific behaviors but the transmission of the information, or "paradigm acquisition," (the knowledge of good and evil) about behavioral options (Lumsden and Wilson 2005), out of which adult social actions will be forged or "paradigm application."

Additionally, while traditional biometric studies utilize twin and family models as a means to identify genetic influence, these type of analyses also provide a means to empirically verify the importance of continued parental influence and the environment unique to the individual. The inclusion of both offspring self reports and measures of socialization and family background supplied by one of the parents provides a more complete understanding of the social environment. The immediate contribution of this examination provides evidence that the environment accounts for 90 percent of the

variation of religious experience and practice during adolescence, but the methodological and theoretical contribution may be equally important. Genetic designs need not only be used to explore genetic influence; rather, they can also be used to show the importance of the familial environment, and the potential for it to mitigate potential genetic predilections, particularly in adolescence. The findings also provide a means to gain insight into the reduced impact of family background on values after children leave home by offering a plausible and empirically testable model.

Genetic influences on social behavior are not boundless and social influences are far from irrelevant to the transmission of important social behavior. However, an integrated theory requires that any analysis of the roles of genes and environment be embedded within a developmental framework that allows for the extended human investment in parental care and education. In such a framework, there is scope for the roles of genes and the social environment to change during development in ways that are consistent with the changing roles of parents and the individual in the acquisition and application of social values and behavior. Specifically, we show for the case of religious attitudes and behavior, there is virtually no evidence for the role of genetic factors during adolescence but a substantial impact of the environment shared by family members shaped, in part, by parents. This finding limits the widely publicized claim that genetic factors play a significant role in religious behavior (Hamer 2004) and provides the impetus for a more nuanced, if still indistinct, integration of the life and social sciences.

Note

1. See the National Institute of Health Genes, Environment, and Development Initiative at http://grants.nih.gov/grants/guide/rfa-files/RFA-DA-07-012.html.

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