UNIVERSITY OF ALBERTA

RE-EXAMINING UDRY'S (1988) BIOSOCIAL MODEL

OF ADOLESCENT MALE SEXUALITY

by

RAINER FRANZ STRATKOTTER ©

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Dedicated to

my parents William and Hildegard,

my sisters Maryetta and Lorraine,

my nieces Sonya, Alexandra, and Victoria,

my nephew Derrick,

and my other relatives and friends.

"My faith is my only courage, as I just push on through"

(from the song "No Woman No Cry" written by Bob Marley).

ABSTRACT

Udry's (1988) biosocial model of adolescent male sexuality describes how testosterone (T), sex hormone-binding globulin (SHBG), age, pubertal development, and church attendance combine to produce variability in sexual behaviors and thoughts. A re-examination of Udry's model and analytic approach, using his data and a series of LISREL structural equation models (SEMs), shows the following: (1) Models with multiple indicators of sexuality failed to fit the data, whereas models using single indicators of sexuality did fit. Udry's factor analysis implies strict proportionality constraints among the covariances for the multiple indicators; these constraints did not match the data, which suggests that sexuality's indicators have non-identical determinants; (2) Udry's model of T and SHBG effects was slightly different than a model using Free-Testosterone (Free-T); (3) Udry's specification of zero measurement error affects his coefficient estimates but not his model fit; and (4) Udry's claim that T and SHBG are crucial components of adolescent male sexuality is upheld.

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D.N.A. and experience helped construct my curiosity.

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AFTC = Apparent Free Testosterone Concentration
AGFI = Adjusted Goodness of Fit Index
approx. = approximately
C = Coitus
Church A. = Church Attendance
d.f. = degrees of freedom
DHT = dihydrotestosterone
Exp. = Experience
Free-T = Free-Testosterone
GLS = Generalized Least Squares
HIV = Human Immune-Deficiency Virus
M = Masturbation
max. = maximum
min. = minimum
ML = Maximum Likelihood
N = number of cases
non-stan. = non-standardized
OLS = Ordinary Least Squares
p = probability
Pub. D. = Pubertal Development
Pubertal D. = Pubertal Development
RIA = radioimmunoassay
s.d. = standard deviation
SEX. = Sexuality (except in Table 9, where SEX. = Sexual)
SHBG = Sex Hormone-Binding Globulin
stan. = standardized
STD = Sexually Transmitted Disease
T = Testosterone
Total-T = total testosterone
WLS = Weighted Least Squares

Chapter One

Introduction

Human behavior and thought are commonly theorized to be influenced by both biological and social factors (e.g., Gould, 1976; Barash, 1978; Boulding, 1978; van den Berghe, 1978; Wilson, 1978; Parsons, 1980; Frayser, 1985; Udry, 1988; Eysenck, 1991; Rossi, 1994). Despite this belief, most empirical models of behavior and thought focus exclusively on either biological or social factors; a practise which can lead to incomplete explanations (Wrong, 1961; Jung, 1985).[1] One of the rare exceptions to the separation of the biological and the social are J. Richard Udry's biosocial models of behavior and thought (Rossi, 1994, p. X).

One of the clearest of Udry's models is his biosocial model of adolescent male sexuality (1988, p. 718, Figure 2), which presented regression estimates of the effects of Testosterone (T), Sex Hormone-Binding Globulin (SHBG), Age, Pubertal Development, and Church Attendance on Udry's Sexuality indicator.[2,3] Udry found that his biosocial model explained more of the variance in Sexuality than did his separate biological or sociological models. Testosterone dominated the model, while Age and Pubertal Development showed no significant impact on Sexuality. This suggested that Age had effects in the purely sociological model because T increases with Age, rather than because of Age related social controls. Similarly, Pubertal Development might have had effects in the sociological model not because it stands for attractiveness, or even social maturity, but because T causes both Pubertal Development and Sexuality. Udry concluded that since about half of the variance in Sexuality was explained by the effects of Testosterone, "it seems pointless for any social-science researcher to attempt to explain male adolescent sexual behavior unless the research design includes measures of testosterone effects" (p. 719). Udry's conclusion is strong, perhaps too strong, as Udry's analysis can be subjected to a variety of criticisms, as will be discussed below.

Before we embark on that discussion, however, I would like to impress upon the reader that the following criticisms are tempered by Udry's acknowledgement that his analysis is a "preliminary exploration rather than a definitive and well-specified test of a general theory" (p. 718). That is, Udry's initial exploration should not be condemned, but rather applauded; with the criticisms here intended to help us determine the best ways to further investigate and develop Udry's biosocial model of adolescent male sexuality. One strong critic of Udry's biosocial model is Udry himself. He acknowledges that his results are based on cross-sectional data, and hence they are "only suggestive of causal relationships". He further warns us that "the small sample size" (N = 102) might result in real relationships being deemed to be statistically non-significant at this sample size. Udry also acknowledges that his model is "rudimentary", and excludes "variables that have been shown to be important" by other research (pp. 718-719). To these criticisms, I add the following: Udry did not adjust for measurement error; nor did he provide an overall test of the fit of his model. Furthermore, he used a scale to measure Sexuality, and the use of scales in models has been questioned (Hayduk, 1987, pp. 212-218; 1996, pp. 50-53).

Given that Udry's model seemed both central to debates about combining social and biological factors (e.g., Jung, 1985; Rossi, 1994; Udry, 1995), and potentially suspect for a variety of methodological reasons (as noted above), this thesis re-examines his model.[4]

The re-examination of Udry's model began by checking Udry's article, questionnaire, and data for any obvious sources of invalidity. One challenge to the validity of Udry's results is that the data were influenced to some unknown degree by the reactive process of a female nurse/interviewer administering a sexuality oriented interview/questionnaire to the male adolescent respondent (Bandura, 1969).[5] Udry was attentive to this reactivity, and hence made reasonable efforts to minimize it. For instance, most of the questionnaire was self-administered. This allowed the adolescent to write his response without having to verbalize it to the nurse/interviewer, thereby reducing reactivity. The specification of measurement errors later in this thesis provides a way of adjusting for any remaining distortions due to reactivity, and other potential biases (see Campbell and Stanley, 1966).

Confident that Udry's data had sufficient integrity to proceed with the re-examination of Udry's model, the first structural equation model in this thesis, called Model 1, was developed to as closely as possible approximate Udry's model. The comparison of Model 1's maximum likelihood estimates with Udry's ordinary least squares regression estimates indicated both that there were no serious disagreements between this thesis's calculations and Udry's calculations, and also that Model 1 did indeed closely approximate Udry's model.[6] Model 1 also promoted this thesis's first extension beyond Udry's analysis by its provision of a $\chi 2$ (chi-square) test of the overall model fit, which Model 1 passed.

Following verification of the consistency between Udry's model and Model 1, additional structural equation models were developed to address various methodological issues which might challenge Udry's model. The first of these issues was measurement error. Udry's analysis assumed a perfect epistemic correlation between his theoretical latent concepts and their manifest indicators. This methodological deficiency was addressed in thesis Model 2, in which specific amounts of measurement error were specified while maintaining the basic form of Udry's model.

The next thesis model, Model 3, examines one of the biological details in Udry's model, namely whether the net effects of the indicators of T and SHBG in Udry's model can be equated with Model 3's Free-Testosterone (Free-T) effects. It was anticipated, and a comparison of Udry's model with Model 3 confirmed, that non-equivalent results can result from modeling T and SHBG versus Free-T.

Since Model 3 did not include any measurement error, the next step was to check Model 3's sensitivity to measurement error by using Model 3 as a template to which measurement error was added. This resulted in thesis Model 4. The results for thesis Models 3 and 4 were then compared to Udry's model, as an extension of the measurement error issues addressed earlier.

After having attempted to fine-tune Udry's theory in terms of measurement error and hormonal effects, the focus shifts to Udry's Sexuality scale which served as a dependent variable in Udry's model. Udry mentioned that his Sexuality scale might contain "components that are quite disparate in actual behavior" (p. 716). That is, his scale might be forcing a set of variables with diverse causal linkages into an unrealistic unitary causal position. Udry justified his scale by doing factor analysis, but stronger tests are possible for discerning realistic causal linkages (Hayduk, 1996, p. 17). A common factor such as Udry's Sexuality concept implies proportionalities among the covariances for all its indicators, and these proportionalities must also appear in the data if the model is to fit. The failure of the Sexuality scale might partially, or completely, threaten the connections to Sexuality in Udry's model, depending on the details of the failure. It was hypothesized that a model with multiple indicators of a supposed common Sexuality factor would fail to fit the data as a result of not meeting covariance proportionality requirements. It was also hypothesized that models using those same Sexuality indicators individually would fit the data.

Three styles of models were ultimately developed to explore the hypotheses regarding the Sexuality concept. The first of these models, thesis Model 5, used five of the seven components of Udry's Sexuality scale, along with two very close approximations of this scale's other two components, as multiple (seven) indicators of Sexuality. Model 5 failed to fit the data, as had been anticipated. Model 5 was then used as the template for thesis Models 6 to 12, each of which used a different one of Model 5's seven indicators as its sole indicator of Sexuality. Models 6 to 12 all had very good fits to the data. The next model, thesis Model 13, used four of Model 5's Sexuality indicators, along with six new Sexuality indicators, to check if there might be three separate dimensions of Sexuality (Interpersonal, Intrapersonal, and Cognitive Sexuality). This is contrary to Udry's modeling of Sexuality as a single causal entity, but it is more parsimonious than the seven entities required by the seven fitting models. Model 13 failed to fit the data. A comparison of the results for the above three styles of models (Models 5 to 13), along with a check of the fit of the covariance proportionalities implied by the common factors in Models 5 and 13, suggested that Udry's Sexuality scale had indeed forced an unrealistic causal concatenation into his singular Sexuality variable.

Finally, this thesis considers Udry's findings (subsequent to his reversal of his model's causal arrow from Church Attendance to Sexuality) of a "significant" negative effect of Sexuality on Church Attendance, which implies that androgens indirectly increase sexuality by leading to a reduction in church attendance (1988, p. 717). Udry claimed that, "Far more complicated research designs will be necessary to identify the causal direction" of the effect between Church Attendance and Sexuality (p. 717). This thesis shows that causal directions among these variables can be discerned, even though Udry's basic model does not contain a variable having sufficiently strong and asymmetrical effects to identify the possible reciprocal effects between these variables. Thesis models 14 and 15 contained specific fixed effects from Sexuality to Church Attendance, and the results of these two models strongly suggest that there is, contrary to Udry, no effect of Sexuality on Church Attendance.

Overall, the results of this thesis's models support Udry's claim that there are "additive effects of biological and sociological effects" on adolescent male Sexuality, along with "indirect effects of hormones through social control variables", and that some of the supposed sociological effects on Sexuality appear to be spurious when Testosterone and Sex Hormone-Binding Globulin are added into the model (1988, pp. 717-718). Ultimately, this thesis ends up agreeing with Udry that models of adolescent male sexuality can be improved by including measures of Testosterone and Sex Hormone-Binding Globulin effects.

The remaining chapters of this thesis are organized as follows. Chapter 2 presents Udry's basic model and places this in the context of several other bodies of literature, including Hirschi's (1969) social control theory and Jessor and Jessor's (1977) problem-behavior theory. Chapter 3 presents the details of the data set and some basics of LISREL modeling. Chapter 4 presents the details of all the models that have been outlined above. Chapter 5 summarizes the results and considers the limitations on this research as well as future research directions.

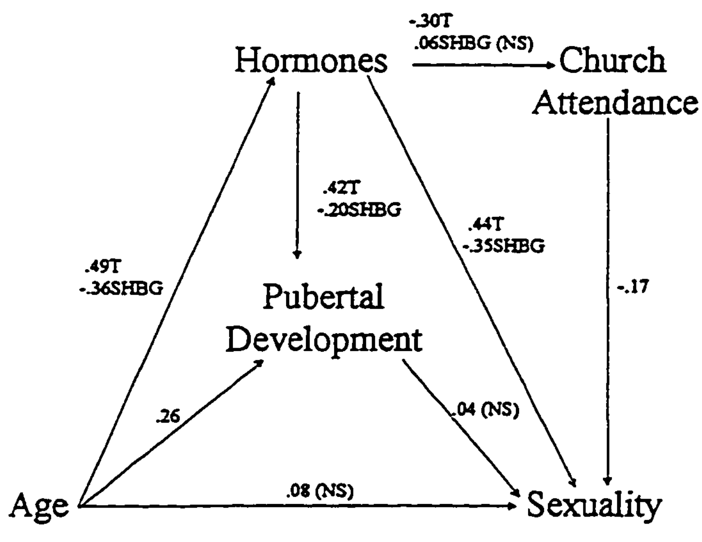
Chapter Two

Description of Udry's Model

Udry's diagram of his model (1988, p. 718, Figure 2) is re-created below as Figure 1.[7] The arrows in Figure 1 represent Udry's directional specification of the effects of the indicators of Testosterone (T), Sex Hormone-Binding Globulin (SHBG)[8], Age, Pubertal Development, and Church Attendance in producing the adolescents' scores on Udry's Sexuality scale.

Figure 1*

Udry's Model



*Only standardized coefficients are shown - They are significant at .05 except as noted (NS).

Udry's Sexuality scale measured the frequency of a variety of sexual behaviors and thoughts (i.e., "coitus, masturbation, sexual outlet in last month, noncoital sexual experience, intentions for sex in the future, thinking about sex, and a turn-on scale measuring reported sexual responses to environmental stimuli", p. 714). Udry's (1988) biosocial theory, as represented by his model, asserts that T and SHBG cause variations in individual predispositions towards Sexuality, while Age, Pubertal Development, and Church Attendance represent social constraints or opportunities for the individuals to engage in Sexuality.

Udry's ideas on individual predispositions towards Sexuality, and on social constraints or opportunities affecting Sexuality, are elaborated on in the following two sections:

Udry's Concept of Individual Predispositions Towards Sexuality

The biological component of Udry's model represents the view that androgenic hormones "increase the predisposition to engage in sexual behavior." (1988, p. 710). This increased predisposition towards sexual behavior is believed to be linked with hormonally effected changes in the patterning (frequency, intensity, and duration) of sexual thoughts (e.g., sexual interests, motivations, attitudes, and fantasies). To acknowledge these links, Udry's Sexuality scale included a variety of sexual behaviors and thoughts.

The view that there is a hormonal basis for sexual behavior and thoughts is supported by "ample evidence" (Frayser, 1985, p. 12; see also Robbins, 1996), including evidence obtained from male adolescents (Udry, Billy, Morris, Groff, and Raj, 1985). Testosterone, which is an androgenic hormone, generally appears to be a dominant factor in male sexual libido and ejaculation, while erectile mechanisms can function despite abnormally low levels of T (Bancroft, 1984; Buvat, Lemaire, and Ratajczyk, 1996).

Although it is not certain what levels of the various androgens produce maximum effects on the various aspects of Sexuality, studies which provide T to hypogonadal men suggest that above a certain threshold, increased T levels have no further effects (Sherwin, 1988). Since normal adult males' androgen levels are above the threshold, adult males are poor subjects for investigating the effects of androgens on sexuality (Udry, 1988, p. 711). In this regard, adolescent males are good subjects, as early adolescents can be considered to be analogous to hypogonadal adult males, except that normal pubertal development of the adolescents will remedy their androgen deficit (p. 711).

According to Udry, T is the "most behaviorally potent" androgen (Udry, 1990, p. 2; see also Udry, 1988, p. 713); although it is generally accepted that T's androgenic potency results from its conversion (by the 5α-reductase enzyme) to dihydrotestosterone (DHT) (Gower, 1995, p. 269; see also Norman and Litwack, 1987, p. 492; Demers, 1995, p. 28). Many of T's other actions depend on its metabolism, by an aromatase enzyme, to estradiol (Collaer and Hines, 1995, p. 57).[9]

Although Udry's data set used here does not include measures of the male adolescents' DHT, the adolescents with higher levels of T will generally also have higher levels of DHT.[10] Therefore, both Udry's model and my thesis models which include T subsume DHT effects within the effect arrows used to depict T's direct effects. In these models, T's direct effect arrows should be thought of as representing a series of effects, of which T is but one component (This series of effects might have serial, parallel, and feedback linkages involving both linear and non-linear effects, along with random and non-random perturbances).

Of the total circulating T (Total-T) in normal men, "less than 4% is free (not protein bound), 1% to 2% is bound to cortisol binding globulin, about 40% is loosely bound to albumin, and the remainder is bound with high affinity to the β-globulin, SHBG" (Winters, 1995, p. 1050; this report conflicts with Udry's assertion that "Nine-tenths or more of T is so bound [to SHBG]", 1990, p. 3). Although "the function of SHBG remains controversial" (Winters, 1995, p. 1050)[11], T effects should be interpreted in conjunction with SHBG effects, and should be opposite in sign (Udry, 1988). The T that is unbound to SHBG is commonly termed Free-Testosterone (Free-T), and is believed to be the portion of the total amount of T able to act on receptor cites (directly or via T's metabolites, such as DHT and estradiol), thereby influencing behaviors and thoughts (Nieschlag, 1979; Udry, 1988). The Free-T level has been reported to be between about 1 and 2.5 or 3 percent of Total-T's level (Winters, 1995, p. 1051; see also Schurmeyer and Nieschlag, 1984); although higher percentages have been reported (e.g., Hammond, Nisker, Jones, and Siiteri, 1980, estimated that Free-T comprises 2 to 8 percent of Total-T).

There is a mixed use of the "Free-T" terminology in the literature. Some researchers make a clear distinction between "Free-T" and "bioavailable (non-SHBG bound) T" (e.g., Buvat, Lemaire, and Ratajczyk, 1996), while others do not (e.g., Udry, 1990; Christiansen and Winkler, 1992); and the term "Apparent Free Testosterone Concentration (AFTC)" also appears (e.g., Hjalmarsen, Aasebo, Aakvaag, and Jorde, 1996). The Free-T plus the albumin-bound T have been referred to as the non-SHBG-bound T (e.g., Gower, 1995, p. 337; Winters, 1995, p. 1051).

The albumin-bound T, because of the low-affinity binding constant, is thought to be as readily available to target tissues as is Free-T, hence "bioavailable testosterone is calculated by subtracting the SHBG bound testosterone from the total testosterone level" (Winters, 1995, p. 1051). (Udry does not provide information as to how, or if, he dealt with the influence of albumin-bound T in his analysis.)

The Free-T index, which is calculated either as the Total-T / SHBG ratio, or as (Total-T)(SHBG) / (mean normal SHBG level), are ways "to correct the total testosterone value for variations in SHBG concentrations in plasma" (Winters, 1995, p. 1051). The Free-T index is believed to be a good indicator of measured Free-T; and is considered to be a better indicator of androgenicity than Total-T (Halpern, Udry, Campbell, Suchindran, and Mason, 1994, p. 221). Although Udry did not use a Free-T index in his model, some of this thesis's models include a Free-T index so that comparisons can be made between models whose hormonal component is Free-T versus models which use T and SHBG instead of Free-T.

Udry's Concept of Social Constraints or Opportunities Affecting Sexuality

Certain elements of adolescent sexuality, such as coitus and masturbation, are generally viewed by Americans as being borderline-deviant behavior (Reiss, 1970), and are subject to even stronger social control forces than are non-deviant behaviors. In Udry's modeling of the social constraints and opportunities for Sexuality, Church Attendance was viewed as a constraint on Sexuality, Age as either a constraint or opportunity depending on Age specific norms, and Pubertal Development status as either a constraint or opportunity depending on social attractiveness and self-views.

The social forces in Udry's model were partly derived from Hirschi (1969). Although Hirschi did not specifically deal with adolescent sexuality, his concepts of social control are commonly found in theories of adolescent sexuality (e.g., Hogan and Kitagawa, 1985; Thornton and Camburn, 1987; Udry and Billy, 1987). Instead of attempting to predict the motivation of deviant acts, Hirschi focused on social controls that either inhibit or disinhibit deviant acts. Hirschi asserts that deviant acts result when an individual's bond to society is weak or broken. The elements of this bond include emotional attachment to, and involvement with, conventional institutions, and commitment to conventional behavior and beliefs (Hirschi, 1969).

In developing his model, Udry determined that his Church Attendance variable seemed to operate as his data set's best indicator of an adolescent's bond to conventionality, and of Hirschi's social control construct in general. Udry's decision in this regard is supported by previous studies which have also used church attendance as a measure of a social control which inhibits adolescent sexuality (Reiss, 1967; McCabe and Collins, 1983; Thornton and Camburn, 1987).

Age is in the model not only because of Hirschi's theory, but also because Udry adds elements of the "problem-behavior theory" of Jessor and Jessor (1977), which asserts that adolescent sexual behavior belongs in a class of inter-related age-graded norm violations (i.e., the various sexual behaviors become more normative as the adolescent ages). This means that, depending on age, some or all of an adolescent's sexual behaviors might not be viewed as deviant.

Along with Age, Udry's model also includes Pubertal Development as a social characteristic that might lead to sexual opportunities. The adolescent's advancing degree of pubertal development might be a factor in his attracting a sexual partner, and advancing pubertal development may increase the adolescent's sexual confidence and willingness to be sexually active, along with buttressing the adolescent's self-referential view that he is capable of adult styles of sexuality. Furthermore, lack of complete pubertal development might not prevent sexuality, but merely divert the adolescent to different styles of sexual involvement.

Since Udry used Hirschi's (1969) social control theory as a template for the specification of the social forces component of his model, I sought to determine if Hirschi's social control theory could be more fully implemented and tested using Udry's data. Hirschi (1969) does not specifically deal with adolescents, whereas Udry's model does, so I began by locating a recent rendition of Hirschi's argument which focuses on adolescents, namely Gottfredson and Hirschi (1994). Gottfredson and Hirschi argue that low self-control is the common factor leading to a variety of adolescent "problem" behaviors, including sexual behaviors such as coitus. Since Udry's data set had indicators of key concepts used by Gottfredson and Hirschi (1994), I looked to see if self-control functions as a common factor effecting some of Gottfredson and Hirschi's listed behaviors, including coitus. This check was made by transforming Gottfredson and Hirschi's verbalization of the links between adolescent coitus, self-control, and other factors (e.g., parental sanctions of sexual behavior) into a structural equation model which was estimated using LISREL (Joreskog and Sorbom, 1989).

This fuller version of Gottfredson and Hirschi's (1994) perspective did not fit the data (χ^2 = 148.51 with 32 d.f., p = .000, AGFI = .536) (see Appendix A: Figure A1, Tables A1 and A2, and accompanying discussion, for further details of this model). Having developed and tested a model which suggests that Gottfredson and Hirschi's (1994) adolescent version of Hirschi's (1969) social control theory might not be consistent with Udry's data more generally, I conclude that it would be inappropriate to stress Udry's dependence on Hirschi's theoretical framework.

Despite having used elements of Hirschi's theory, Udry himself provides reasons for not relying on Hirschi's theory: There is often "no victim" during a sexuality experience, and hence sexual behavior may be different from behaviors assumed to be subject to Hirschi's social control processes (Udry, 1988, p. 710); and social controls of sexual behavior have no import if there is "motivation without opportunity or opportunity without motivation" (p. 710).

Overall, this placed a barrier to any attempt to extend Udry's model by making it more fully representative of Hirschi's control-theory ideas. I would have liked to be able to expand Udry's model in a compatible theoretical way, but expanding it in a way that would likely end with a failing model seemed not well advised. Consequently, I returned to focusing on Udry's basic model, and treated Udry's control arguments as focused on specific effects and not as being indicative of any commitment to a broader range of application.

We are now ready to turn to Chapter 3 which describes the data on which Udry's model and this thesis's models are based, along with the methodology employed in constructing my thesis models.

Chapter Three

Description of the Participants and the Data

This thesis uses the same data set as used by Udry (1988). The data set with all machine-readable files and paper documentation is titled as "The Study of Adolescent Sexual Behavior, Tallahassee: Hormone Supplement (Data Set I1)", and cited as Udry (1992). The user's guide component of the above documentation was produced by Aaron S. Kaplan, Eric L. Lang, and Josefina J. Card (1992). The complete data set and documentation was from the Sociometrics Corporation's "Data Archive on Adolescent Pregnancy and Pregnancy Prevention".[12]

The data set includes a representative sample of 102 male adolescents aged between 13 and 18 years, racially identified by the nurse/interviewer as "White" (rather than "Black/Afro American" or "Other")[13], and enrolled in the eighth through tenth grades (the gradewise N = 34, 32, and 36 respectively) among nine schools in the Tallahassee/Leon County School system, which is a school district of the public school system in Tallahassee, Florida (U.S.A.).[14] The ninth and tenth grade adolescents' portion of the data set was partly derived from a two wave panel study "The Study of Adolescent Sexual Behavior", conducted between January 1980 and August 1982 (by the Carolina Population Center, with Udry as principal investigator). That is, ninth and tenth grade adolescents who had earlier provided interview/questionnaire responses (for the first and second waves of "The Study of Adolescent Sexual Behavior") were recontacted and asked to provide blood and saliva samples for hormone and SHBG analysis. There was an "an average of three and a half months" duration between their interview/questionnaire and biological sampling (Udry, 1988, p. 713); with their later biological data being combined with their data from the second wave of the earlier study.

Around the time of the ninth and tenth grade adolescents' biological sampling, a sample of eighth grade adolescents was obtained and asked to provide blood and saliva samples, along with a same day completion of an abbreviated form of the earlier interview/questionnaire given to the ninth and tenth grade adolescents.

For all the adolescents, the questionnaire was largely self-administered with a "forced response" (i.e., it did not provide the adolescent with a response option in the manner of "I refuse to answer") close-ended design (with the exception of the final question which asked if the adolescent had any additional comments), and the nurse/interviewer and parent(s) also provided information.[15] The questionnaire focused on sexuality, and covered such topics as the adolescent's pubertal development, sexual history, and attitudes concerning sexual matters (further details of the instrument are provided in Sociometric's "A User's Guide To the Machine-Readable Files and Documentation", cited as Kaplan, Lang, and Card, 1992).

For the blood sampling, done in the adolescents' homes between 3 and 7 P.M., the nurse/interviewer used a catheter which remained in place for about 30 minutes. Due to the possibility of short-term pulsatile releases of hormones, three 5 millilitre samples were collected at 15 minute intervals, and "an average hormone level over a 30-minute period" was calculated (Udry, 1988, p. 713).[16] Blood samples were allowed to clot, the clot was then removed, the remaining blood was centrifuged, and serum was stored at -20 degrees Celsius until assay. Radioimmunoassay was used to measure T and SHBG, along with other biological variables not included in Udry's model (e.g., androstenedione, dehydroepiandrosterone, dehydroepiandrosterone sulphate, luteinizing hormone). Also, although Udry obtained hormone data from the adolescents' saliva samples, he did not use that data in his model.[17]

Concepts and their Indicators

The concepts and indicators used in this thesis were derived from Udry's (1988) article in conjunction with Udry's questionnaire and data set documentation. I recoded some of the indicators' values, so that the signs (positive or negative) of the effects in my thesis models would be consistent with Udry's model. In one instance, my recoding forced a substantive change (i.e., I modified Udry's Future Sex by giving the "I Don't Know" response a value between a "Yes" and a "No" response, whereas Udry had given the former a greater value than the latter two responses; further details are provided below in my discussion of Motivation for

Sex in the Next Year). Also, since Udry did not specify which of two masturbation items (i.e., "frequency of masturbation induced ejaculation last month" or "frequency of masturbation without ejaculation last month") he used as part of his Outlet variable, I used both of those masturbation items to create the new variable Coitus plus Masturbation Last Month, which is described in more detail below. A comparison of the original codes and recodes is provided in Appendix B, Table B1. The concepts and indicators used in Udry's model and my thesis models are described below. The descriptive statistics for these variables are given in Table 1 at the end of this listing.

Age was obtained by subtracting the adolescent's "reported birthdate" from the "interview date", with the result reported in years. The distribution of the age values approximates a "bell-shaped" distribution, with approximately two thirds of the cases being within one standard deviation of the mean.

Testosterone was measured by radioimmunoassay of the testosterone concentration (reported in ng/ml) in the adolescent's blood samples. The T indicator's values are distributed with some degree of positive skewness along with noticeable outliers on both ends of the distribution. At the upper end, the T levels for six of Udry's adolescents, ranging from 9.975 to 12.725 ng/ml, are beyond the maximum value reported in Lee's (1995) summary of adolescent androgen research: For the most advanced stage of pubertal development (e.g., genitalia within the adult range in size, hair growth extending toward the umbilicus) the average T level (reported in ng/dl) was 611 ng/dl with a range of 285 to 980 ng/dl (pp. 828-829). The abnormally high T values for these six adolescents might have resulted from a variety of disease conditions which produce dramatic increases in T production (see Becker, 1995; Redmond, 1995). Extremely high T values can also represent the intake of "anabolic-androgenic steroids" (i.e., chemically modified analogues of T), which is a relatively common activity among adolescent males (Matsumoto, 1995, p. 1118). It is also possible that these six outliers are not "abnormal", but rather there was a sampling bias in the studies summarized by Lee (1995).

Looking at the lower end of the T values distribution, only one of Udry's adolescents has a T level within the pre-pubertal ("Stage 1") T range reported by Lee (p. 829), while his age of 14.5 years is above the age range normally associated with the start of pubertal "Stage 2" (genital growth) (p. 828). I checked if he had a high pubertal development score accompanying his low T level, which might indicate the existence of a disease causing lowered T production (Becker, 1995; Redmond, 1995), and/or exogenous steroid consumption which can lead, via negative feedback, to a decrease in endogenous T levels (Mitchell, personal communication, 1996). I found that he had a low pubertal development score, and hence I tentatively concluded that this outlier is not representative of a systematic bias due to either disease or steroid consumption.

Overall, 23 of Udry's adolescents had serum T levels below the normal adult male range (300 - 1000 ng/dl, Horton, 1995, p. 1042), 75 were within the adult range, and 4 were above the range.

Sex Hormone-Binding Globulin was indicated by radioimmunoassay of Testosterone Binding Globulin (TBG) concentration (in nmols/l) in the adolescent's blood samples. The SHBG values distribution is almost perfectly normal.

Free-T is represented by Udry's Free-T Index = [T (ng/dl) / SHBG (nmol/l)] X 100 (Kaplan, Lang, and Card, 1992, p. 43).[18] Although Udry's T assay is reported in ng/ml (1988, p. 713), he uses the ng/dl value for T in his Free-T Index formula.

Pubertal Development is an index created from self-report items, including a set of Tanner-type drawings representing the degree of pubic hair and genital development (Tanner, 1962). Udry factor analyzed these items and extracted a single factor, and then assigned factor scores to the adolescents on the basis of the factor weightings of the items. Although there are about an equal number of values on either side of the mean, the Pubertal Development values distribution has a large negative skew mainly due to eleven adolescents whose low pubertal development scores have absolute values greater than those of all the other adolescents.

Church Attendance arose from the interviewer asking: "How often have you gone to church services in the last year?", along with her describing four possible responses to the adolescent. The possible responses, their code values, and the percent of adolescents selecting each value are as follows: "Less than once a month." = 1 (35% of the adolescents), "About once a month." = 2 (13%), "About once a week." = 3 (41%), and "More than once a week." = 4 (11%).

In a closely related panel study by Halpern, Udry, Campbell, Suchindran, and Mason, 54 percent of their male adolescent sample reported their attendance at "church or synagogue services" as once a month or less (1994, p. 221), compared to 48 percent in Udry's sample. Part of the difference may be due to sampling fluctuations, and another part might reflect the mean age being higher for Udry's adolescents. Older adolescents may attend church less frequently than younger adolescents (Halpern et al., 1994).

Sexuality is represented by a factor score derived from a factor analysis containing the following seven indicators: coitus, masturbation, outlet, sexual experience, turn on, think about sex, and future sex (Udry, 1988, p. 719). So as to better match the questionnaire wording, Udry's "sexual experience", "turn-on", and "think about sex" are renamed in this thesis as, respectively, "non-coital sexual experience", "sexual turn on", and "sexual thoughts". For some specific analyses, and in an attempt at conceptual improvement, I modified Udry's "outlet" and "future sex" (as will be discussed below), with the modified variables being called "coitus plus masturbation last month", and "motivation for sex next year".

The distribution of the Sexuality indicator's values is in general evenly distributed, although there is somewhat of a negative skew along with a very large peak at the positive end representing about one quarter of the adolescents. Since each adolescent's Sexuality score represents his unique experience with various Sexuality dimensions, equal or similar Sexuality scores among the adolescents do not necessarily represent equal or similar degrees of experience with the various Sexuality dimensions.

Coitus was indicated by the adolescent's response to his reading of: "To have sex (sexual intercourse) is to put the male penis into the female vagina. This is sometimes called "screwing" or "getting laid" Please mark an x in the box that best tells about you." The listed responses and their codings were: "I have never had sex with a girl." = 0, "I have had sex with a girl 1 or 2 times in my life." = 1, "I have had sex with a girl more than 2 times in my life." = 1.

Almost one third of Udry's male adolescents reported coital experience, which is reasonably similar to other samples. For instance, in the metropolitan United States areas in 1988, about one third of the 15-year-old males, about one half of the 16-year-old males, and about two thirds of the 17-year-old males reported coital experience (Nevid, Fichner-Rathus, and Rathus, 1995, p. 406).

Masturbation was indicated by the adolescent's response to his reading of: "Boys sometimes play with their penis until it gets hard. Have you ever played with your penis until it was hard (masturbated)?". Listed responses and my recodings were: "No." = 0 , "Yes." = 1. Almost one third of the adolescents reported masturbation experience, which is a lower proportion than other samples with approximate temporal and spatial congruence with Udry (1988). For example, in the Coles and Stokes (1985) national American survey, about half of the male adolescents reported masturbating, with 11 years and 8 months being the average age of first masturbation. In an older American study by Kinsey, Pomeroy, and Martin (1948) about 82 percent of males had masturbated to orgasm by age 15. Although Udry's masturbation results are quite different from the above other studies, I was unable to discern why this difference exists, especially given that Udry's collection of masturbation reports does not appear to be methodologically deficient compared to the aforementioned studies. It is possible that Udry's sample was collected in an area with stronger than normal cultural taboos against masturbation and/or reporting masturbation.

Coitus plus Masturbation last Month is almost identical to Udry's Outlet which had been calculated by summing the adolescent's responses to his reading of two questions: one pertaining to frequency of masturbation last month, and the other to frequency of coitus last month. Since Udry (1988) did not indicate which one of the two masturbation questions below was used in his Outlet, this thesis sums both to produce the new variable Coitus plus Masturbation Last Month: (1) "Since this time last month, about how many times have you played with your penis until you had thick, white liquid shoot out the end of your penis while you were playing with it?" Responses ranged from zero to ten, and were likewise coded; (2) "Since this time last month, about how many times have you played with your penis without having thick, white liquid shoot out the end of it?" Responses ranged from zero to four, and were likewise coded. Frequency of coitus last month was determined by the adolescent's response to his reading of the question: "How many times did you have sex in the last month?" Responses ranged from zero to three, and were thusly coded.

The distribution of the Coitus plus Masturbation Last Month indicator's values shows a very evident positive skew, with 68.8 valid percent of the males scoring zero. This approximates Udry's report that for his Outlet variable, 65 percent of the males scored zero (1988, p. 714). Hass's (1979) text on American adolescent sexuality, which used information having both temporal and spatial similarity to Udry's study, reports that, on the average, male adolescents masturbate two to three times a week. This suggests that the values for Coitus plus Masturbation Last Month might reflect a substantial under-reporting of masturbation by a portion of Udry's adolescents.

Non-Coital Sexual Experience was indicated by the adolescent's response to his reading of questions regarding eleven different heterosexual behaviors, ranging in "sexual intimacy" from holding hands to directly touching the unclothed sex organs of the opposite sex. For each behavior, participants were asked whether they had never, once or twice, or more than twice experienced the behavior. Udry factored these responses by principal components, and the first unrotated factor was used to construct a factor score (1988, p. 719). Udry also reports that the factor scores for all the cases have a mean of zero and a standard deviation of one (p. 719), however, there is no "sexuality" variable with this mean and standard deviation in the Sociometric's version of the data set. Hence, I used Udry's description of the items comprising his variable Sexual Experience (p. 719), to locate the most appropriate indicator of my concept Non-Coital Sexual Experience, which I found to be Udry's variable "Sexual Experience Index - Count" (labeled here as SEXEXP). The distribution of this indicator's values is negatively skewed, with just over forty percent of the males having the highest index score. However, one cannot know from this score the exact relative contributions of each of the eleven items in the index for each adolescent, which means that adolescents can have similar scores while having had dissimilar sexual experiences. That is, this summative score results in a loss of causally important information. I deal further with this issue later in this thesis by disaggregating the indicators of this concept.

Sexual Turn On was indicated by the adolescent's responses to his reading of questions referring to eleven "potentially sexually arousing stimuli" (Udry, 1988, p. 719): "Are you turned on sexually by ...? "Women without clothes on", "Sexy pictures", "Movies", "TV", "Nude Art", "Reading", "Looking at your own body", "Dancing", "Music", "Dreaming while asleep", "Men without clothes on". Listed responses and their codings were: "often", "sometimes", "never"; and the scores were summed (Udry's questionnaire codes "often" = 1, "sometimes" = 2, and "never" = 3; neither Udry 1988 nor the data set documentation describes any recodes of these values prior to their summation, although I assume they were recoded). The distribution of the values for Sexual Turn On's indicator is approximately normal.

Sexual Thoughts was indicated by the adolescent's response to his reading of the question: "How often do you think about sex?". Listed responses and their codings were "never" = 1, "1 time a month" = 2 , "1 time a week" = 3, "once every 2 or 3 days" = 4, "1 or 2 times a day" = 5, "about 5 times a day" = 6, "10 or more times a day" = 7. The distribution of the Sexual Thoughts indicator values is negatively skewed, with 24.6 valid percent of the males having the lowest frequencies, from never to one time a week; 49 percent were in roughly the middle range of the frequencies, once every 2 or 3 days to 1 or 2 times a day; and 26.4 percent were in the highest range of frequencies, about 5 times a day to 10 or more times a day.

Motivation for Sex in the Next Year is my recoded version of Udry's Future Sex which was indicated by the adolescent's responses to his reading of three questions below which were "assumed to be tapping the same underlying motivation for sex and were summed to create an additive index" (Udry, 1988, p. 719). Due to a conceptual change induced by my recoding of 0 to 2 in the third question below, Udry's Future Sex is generally replaced in this thesis (except for when Udry's Sexuality scale score is used) by Motivation for Sex in the Next Year.

(1) "How likely is it that you will have sex in the next year?" Listed responses and my recodings were: "Would happen for sure" = 4, "Probably would happen" = 3, "Even chance (50-50) it would happen" = 2, "Probably wouldn't happen" = 1, "Sure it wouldn't happen" = 0.

(2) "How much do you think you would like to have sex in the next year?" Listed responses and my recodings were: "Like very much" = 4, "Like a little" = 3, "Neither like nor dislike" = 2, "Dislike a little" = 1, "Dislike very much" = 0.

(3) "Do you intend to have sex during the next year?". Listed responses and my recodings were: "Yes, I intend to have sex during the next year." = 4, "No, I intend not to have sex during the next year." = 0, "I don't know." = 2: Udry's coding scored the "No" response higher than the "I don't know response", while my recoding asserts that the latter response is conceptually closer to a "Yes" response than the "No" response. The distribution of the Motivation for Sex in the Next Year indicator's values is negatively skewed, with 26.8 percent of the males in the lowest range of values, 1 to 5; 38.1 percent in the next highest range of values, 6 to 8; and 35.1 percent in the highest range of values, 9 to 10.

Touching a Girl's/or Girls' Sex Organs was indicated by the adolescent's response to "Here are some things you may have done with a girl. Please mark an X in the box that tells how often you have done that thing ... Felt the sex organs (private parts) of a girl under her clothes or with no clothes on." Listed responses and my recodings were "I have never done this." = 0, "I have done this only 1 or 2 times in my life." = 1, "I have done this more than 2 times in my life." = 2. (For the indicator of Touching a Girl's/or Girls' Sex Organs, 40.4 valid percent of the adolescents scored 0, while 21.2 and 38.4 percent scored, respectively, 1 and 2. This distribution is similar to the "heterosexual masturbation of a partner" distribution in

Schuster, Bell, and Kanouse's (1996) survey of a sample of American urban adolescents in the ninth through twelfth grades.

A Girl/or Girls Felt My Penis was indicated by the adolescent's response to "Here are some things you may have done with a girl. Please mark an X in the box that tells how often you have done that thing: Had a girl feel my penis under my clothes or with no clothes on." Listed responses and my recodings were "I have never done this." = 0, "I have done this only 1 or 2 times in my life." = 1, "I have done this more than 2 times in my life." = 2. Fifty-six point four percent of the adolescents scored 0, while 15.8 and 27.7 percent scored, respectively, 1 and 2. Schuster et al. (1996) report a similar distribution for the values of their "heterosexual masturbation from a partner" variable.

Necking with a Girl/or Girls was indicated by the adolescent's response to "Here are some things you may have done with a girl. Please mark an X in the box that tells how often you have done that thing: Necked (hugged and kissed a girl for a long time)." Possible responses and my recodings were "I have never done this." = 0, "I have done this only 1 or 2 times in my life." = 1, "I have done this more than 2 times in my life." = 2. Twenty-four point eight percent of the adolescents scored 0, while 13.9 and 61.4 percent scored, respectively, 1 and 2. This distribution concurs with Coles and Stokes's (1985) results.

Masturbation with Ejaculation Last Month (which is also a component of the above described Coitus plus Masturbation Last Month concept) was indicated by the adolescent's response to his reading of the question: "Since this time last month, about how many times have you played with your penis until you had thick, white liquid shoot out the end of your penis while you were playing with it?" The reported frequencies ranged from 0 to 10, and were likewise coded. The distribution of this variable's values is very positively skewed, with 80.2 valid percent of the adolescents scoring 0.

Masturbation without Ejaculation Last Month (which is part of the Coitus plus Masturbation Last Month concept depicted above) was indicated by the adolescent's response to his reading of the question: "Since this time last month, about how many times have you played with your penis without having thick, white liquid shoot out the end of it?". The response was indicated in the space preceding the word "Times". The reported frequencies ranged from 0 to 4, and were likewise coded. This variable's values distribution is very positively skewed, with 90.5 valid percent of the adolescents scoring 0.

Sexual Turn On Thoughts arose from the adolescent's response to the question: "Do you ever have dreams or fantasies that turn you on sexually?". (Since dreams and fantasies might not be equivalent items for all respondents, it is unfortunate that Udry combines these terms in the above question.) I used the response to the above question as an indicator of Sexual Turn On Thoughts, wherein "dreams or fantasies" were equated as thoughts. Possible responses and my recodings were "No" = 0, "Yes" = 1. Forty-one point eight valid percent of the adolescents responded "No", while 58.2 percent responded "Yes".

For the aforementioned variables, their thesis labels, data set labels, minimum and maximum values, means, standard deviations, and valid N are presented in Table 1 below.

Table 1

Descriptive Statistics and Labels for the Indicators

Indicator (listed in approx. order of first appearance in this thesis)	Thesis label	Data Set label	Min. - Max. Value (level of measurement)	Mean	S.D.	N
Age	AGEMALE	AGSI1203	13.38 - 16.91 years	14.946	.798	102
Testosterone	TESTOSTE	BFSI1702	0.190 - 12.725 ng/ml	4.980	2.560	102
Sex Hormone-Binding Globulin	GLOBULIN	BFSI1703	14.08 - 81.26 nmols/l	46.754	13.703	102
Free-Testosterone	FREETEST	BFSI1006	0.9 - 137.9 T/SHBG ratio	41.825	26.667	102
Pubertal Development	PUBERTAL	BFSI1004	-2.533 - 1.357 factor score	.000	.881	99
Church Attendance in the Last Year	CHURCHGO	RLBI1106	1 - 4 (ordinal)	2.280	1.064	100
Sexuality Score	SEXSCORE	BFSI1005	-1.481 - 1.185 factor score	.000	.977	99
Coitus (C)	COITUS	SXHI1357	0 - 1 (nominal)	.303	.462	99
Masturbation (M)	SELFPLAY	SXHI1384	0 - 1 (nominal)	.320	.469	100
C + M Last Month	OUTLET	•	0 - 10 summative score	1.129	2.213	93
Non-Coital Sexual Experience	SEXEXP	SXHI1537	0 - 11 summative score	7.961	3.354	102

(continued)

Table 1 (continued)

Descriptive Statistics and Labels for the Indicators

Indicator (listed in approx. order of first appearance in this thesis)	Thesis label	Data Set label	Min. - Max. Value (level of measurement)	Mean	S.D.	N
Sexual Turn On	TURNON	SXBI1601	0 - 10 summative score	5.363	2.193	102
Sexual Thoughts	THINKSEX	SXCI1599	1 - 7 (ordinal)	4.520	1.603	102
Motivation for Sex in the Next Year	FUTURSEX	••	1 - 10 summative score	7.103	2.307	97
Touching Girl's/Girls' Sex Organs	IFELTHER	SXHI1268	0 - 2 (ordinal)	.980	.892	99
Girl/Girls Felt My Penis	SHEFELT	SXHI1266	0 - 2 (ordinal)	.713	.876	101
Necking with Girl/Girls	IMADEOT	SXHI1262	0 - 2 (ordinal)	1.366	.857	101
M with Ejaculation Last Month	SHOOT	SXBI1435	0 - 10 (ratio)	.740	1.932	96
M without Ejaculation Last Month	NOSHOOT	SXBI1436	0 - 4 (ratio)	.242	.795	95
Sexual Thoughts Turn On	FANTASYS	SXHI1548	0 - 1 (nominal)	.582	.496	98

• OUTLET = SHOOT + NOSHOOT + SEXMONTH (Udry's SXBI1546); with all -998 values recoded as 0.

•• FUTURSEX = LIKELYDO (Udry's SXCI1539, recoded 1=4, 2=3, 3=2, 4=1, 5=0) + LIKESEX (Udry's SXAI1540, recoded 1=4, 2=3, 3=2, 4=1, 5=0) + INTENDTO (Udry's SXII1541, recoded 1=4, 2=0, 3=2).

Udry states that for his model, "the distribution of the independent and dependent variables is similar to that obtained from other populations, [although] no claim to representativeness of a broad population is justified" (1988, p. 718).

Methodology

This section describes the key components of how the data from the adolescents was used to gain estimates for the coefficients in my thesis models. The basic steps I followed were to create a covariance matrix for the necessary variables, and then use that matrix along with a specification of the model, to obtain estimates of the model coefficients and other testing and diagnostic information. To achieve the above, I used the following two computer programs: PRELIS® 1.20 (Joreskog and Sorbom, 1990) helped me create the covariance matrix, and LISREL® (linear structural relations) 7.2 (Joreskog and Sorbom, 1989) was used for estimating, testing, and diagnosing the models. These procedures are further described below.

The variance-covariance matrix of the variables

The basic data required for input into LISREL is a covariance matrix for the indicators of all the concepts in the model which is to be estimated. PRELIS was used to calculate the covariance matrix using pairwise deletion of missing values (See Appendix C, Table C1). The pairwise deletion resulted in the model N possibly changing whenever the set of variables changes. The N specified for each model was the mean number of cases available for the covariances for that model's variables, as recommended by Joreskog and Sorbom (1989, p. 53). Hayduk reported, about a decade ago, that, "The costs involved in violating the assumption of a listwise matrix are unknown ... [and] the response of χ^2, standard errors, and other program output to pairwise matrices is [also] unknown" (1987, pp. 326-327). Since then, the literature has remained silent on listwise versus pairwise result comparisons. To help overcome this deficiency, I provide a listwise versus pairwise result comparison for thesis Model 1, which is depicted and discussed in Appendix F, Table F1.

The variance-covariance matrix provided by PRELIS is called S and is used in estimating and testing the thesis models (as is described below).[19] S is provided in Appendix C. Joreskog and Sorbom recommend that, "When some or all observed variables are continuous, i.e., measured on interval scales, it is best to analyze the covariance matrix S rather than the correlation matrix R" (1989, p. 204) because this provides a more accurate model χ^2 (chi-square) test.

Using LISREL to obtain estimates of the coefficients in the model, measures of model fit, and model diagnostics

LISREL was used to obtain maximum likelihood (ML) estimates of the coefficients in my thesis models. LISREL's ML estimation procedure is a "full information" method, in that it simultaneously estimates all the coefficients among both the structural and measurement components of a model. The structural component of the model specifies the theorized causal relationships among the latent (unobserved) variables, while the measurement component of the model specifies how the latent variables produce, and are indicated by, the observed variables. The measurement component also includes the setting of a scale for each latent variable, as well as the measurement errors (This aspect of my thesis models will be addressed in the next chapter). (For more detailed information on the general LISREL model, see Hayduk, 1987, 1996; and Joreskog and Sorbom, 1989).

When a specific set of numerical values are attached to each of the coefficients in a model, this implies a specific covariance matrix should be observed for the indicators (observed variables) in that model. The ML estimates attempt to make the model's implied covariance matrix, Σ (Sigma), match the observed covariance matrix, S, as closely as possible. The coefficients comprising any model are usually placed in eight parameter matrices:

(1) B (beta) contains the coefficients of the direct effects among latent endogenous concepts, η's (Eta's);

(2) Γ (gamma) comprises the coefficients of the direct effects of latent exogenous concepts, ξ's (xi's, pronounced "ksi's"), on the η's;

(3) Φ (phi) is a symmetric variance-covariance matrix of the ξ's;

(4) Ψ (psi) is a symmetric variance-covariance matrix of the "errors" in the η's in the conceptual component of the model, with ζ (zeta) being the vector of these errors;

(5) Λ_y (lambda y) is a regression matrix of the observed endogenous indicators on the η's;

(6) Λ_x (lambda x) is a regression matrix of the observed exogenous indicators on the ξ's;

(7) Θ_δ (theta delta); and

(8) Θ_ε (theta epsilon); are symmetric variance-covariance matrices of the "errors" in, respectively, the exogenous, and endogenous measurement components of the model. To increase the diagnostic information obtainable from LISREL, my thesis models' concepts were programmed as LISREL η's (Hayduk, 1987, pp. 209-212), so only four of these eight matrices are used.

Maximum likelihood estimation makes the model implied covariance matrix Σ as similar to the real covariance matrix S as possible, but the constraints implied by a model's specification of effects might make it impossible for that model to imply covariances that closely match with the data covariances. LISREL's comparison of the "optimal" Σ for a specific model with S leads to a χ^2 test of model fit, the Adjusted Goodness of Fit Index (AGFI), and other model diagnostics, such as the standardized residuals; as is discussed below.

The χ^2 test is an omnibus test of all a model's constraints. That is, χ^2 tests whether a model's variance-covariance implications are significantly different than the data (i.e., the observed covariance matrix S). The probability (p) value associated with a particular χ^2 value (and its degrees of freedom) describes the probability of finding a sample with a covariance matrix S as a random sampling fluctuation, if the model implied covariance matrix Σ was the true population covariance matrix.

The model fits well if it has a small value of χ^2 and a p value close to 1.0. There is no single convention for deciding which combinations of the above values represent a particular degree of fit, such as "very good", "good", "okay", or "poor" fit.

A potential problem with the χ^2 statistic is that both its value, and its accompanying p value, are dependent on the sample size (N). With large enough samples almost any model could be rejected according to the χ^2 test. This issue is further examined in my thesis Note 20.

The AGFI is a goodness of fit index (GFI) which has been adjusted for the model's degrees of freedom. The degrees of freedom for χ^2 indicate the degree of parsimony in a model. The location of any poor fit is indicated by the residual covariances, which are the differences between the corresponding observed covariances (in S) and the model-implied covariances (in Σ). The standardized form of these residuals are a primary model diagnostic.

However, using a large residual to locate a model's problems can be difficult, given that any specific residual might arise from numerous model misspecifications (e.g., see Hayduk, 1987, p. 170.) The standardized residuals are obtained by dividing each fitted residual by its asymptotic standard error (Joreskog and Sorbom, 1989, p. 31); and can be defined as the "estimates of the number of standard deviations the observed residuals are away from the zero residuals that would be provided by a perfectly fitting model" (Hayduk, 1987, p. 170).

The accuracy of the prediction of any specific dependent variable is suggested by LISREL's calculation of the corresponding R^2 (squared multiple correlation), which is a measure of the strength of a linear relationship between that variable and its predictors (Joreskog and Sorbom, 1989, p. 42).

Having described Udry's data and the basic methodology used in this thesis, we are now ready to turn to my thesis models, all of which approximate Udry's model.

Chapter Four

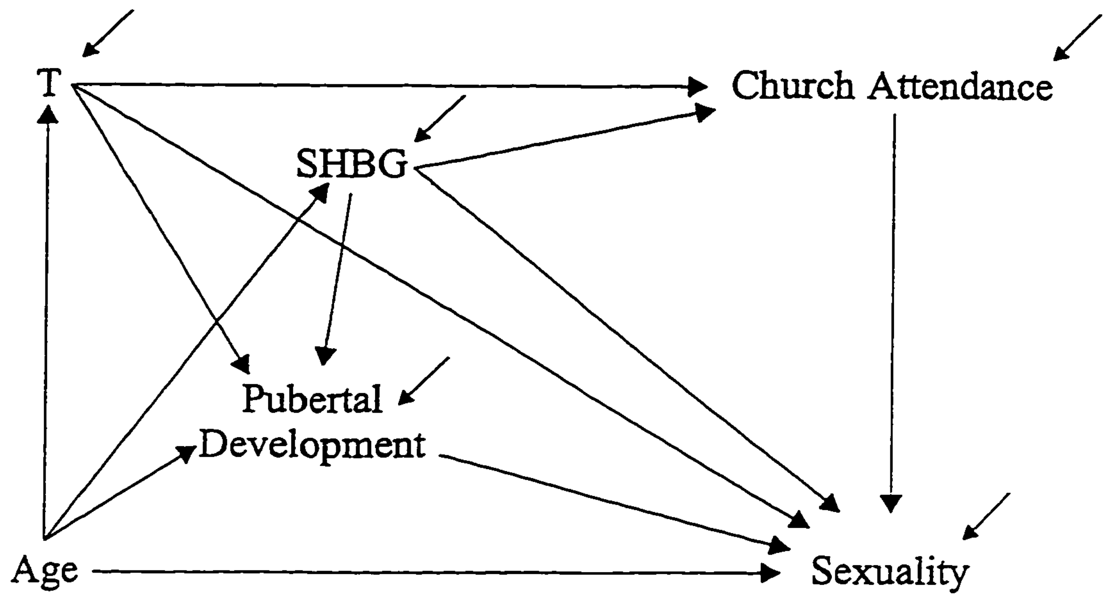
Model 1: This thesis's closest approximation of Udry's model (Zero Measurement Error and Udry's Sexuality variable)

The first thesis model, Model 1, attempts to closely approximate Udry's model. The comparison of Model 1 with Udry's model serves to corroborate Udry's calculations and to guarantee that the measurement procedures used in this thesis have not substantially interfered with this reanalysis.

Although Udry obtained estimates of the effects of T and SHBG, Udry's model diagram (Figure 1 above) is unclear in an important way. It uses the single concept Hormones to represent the causally separate concepts of T and SHBG. Udry's depiction of his model includes a single arrow to display the T and SHBG effects. However, Udry estimated these variables as having separate effects. A clearer depiction of Udry's model is provided in Figure 2 below, which constitutes this thesis's Model 1.

Figure 2

Model 1



In trying to make Model 1 closely approximate Udry's model, some uncertainty was encountered in determining which of the data set's Sexuality indicators had been used in Udry's calculations. The variable called "Factor Score: Sexual Experience" (labeled here as SEXSCORE) was considered to be the most likely candidate since its name was congruent with Udry's statement that the sexuality variable's values were factor scores derived from a factor analysis (1988, p.719).

However, the above did not dispel all the uncertainty, since neither Udry (1988) nor the Sociometrics data set guide clearly stated which sexuality indicator had been used. To verify that "Factor Score: Sexual Experience" (SEXSCORE) had been used in Udry's model, I estimated Model 1 using SEXSCORE as the Sexuality indicator, and then compared the results to both Model 1B, whose Sexuality indicator was the weighted variable "Standard Sexual Experience Score" (labeled here as WEIGHTED), and Model 1C, which measured Sexuality with the summative variable "Sexual Experience Index - Count" (which I termed SEXEXP). It was assumed that the correct indicator would provide the closest match to Udry's estimates.

However, it was difficult to discern which indicator was closest to Udry. For instance, Models 1, 1B, and 1C are equally similar to Udry's model on seven of their twelve effects, with Model 1 closest to Udry on T to Sexuality, Model 1B is most similar to Udry on Pubertal Development to Sexuality, SHBG to Sexuality, Church Attendance to Sexuality, and Model 1C is nearest to Udry on Age to Sexuality (a more detailed presentation of the results for the three different indicators is provided in Appendix D, Table D1). These results still left me uncertain as to which indicator Udry had used, so I next tried finding a solution by looking at the results obtained when the three indicators in question are separately placed in models which use Free-T rather than T plus SHBG, namely Model 3 (SEXSCORE), Model 3B (WEIGHTED), and Model 3C (SEXEXP). Model 3 (SEXSCORE) has the closest match to Udry on Pubertal Development to Sexuality and also on Church Attendance to Sexuality; and its Free-T to Sexuality effect is closer than the other two models to Udry's T to Sexuality effect (additional details of Models 3, 3B, and 3C are presented in Appendix E, Table E1). SEXSCORE now appears as the most likely indicator of Udry's Sexuality, especially since we can rule out SEXEXP due to it not including a clear indicator of Coitus (i.e., its most intimate Sexual item was "feeling unclothed sex organs of the opposite sex", Udry, 1988, p. 719) which was a stated component of Udry's Sexuality score; and we can also rule out WEIGHTED as the models using SEXSCORE had Sexuality R^2 values which most closely resembled the male Sexuality R^2 value provided by Udry for one of his biosocial models (as described in 1988, p. 716, "Table 4. Biosocial Models Predicting Sexuality"), which is likely similar to the Sexuality R^2 value for Udry's model re-examined here (unfortunately there is no Sexuality R^2 value clearly attached to Udry's model in his 1988 article).

Model 1 matches Udry's specification of no measurement error (i.e., 1.0 epistemic correlations between Udry's concepts and their indicators), by using fixed 1.0 Λs (lambdas) and fixed zero Θ_εs (theta epsilons) in LISREL. Both Udry's estimates and Model 1's estimates with the SEXSCORE indicator of Sexuality appear in Table 2 below. Model 1's estimates were located without signs of estimation problems, and they also passed the non-statistical test of being reasonably similar to Udry's results.

Table 2

Comparison of Udry's model and Model 1

Effects Among the Concepts:	Udry's model standardized	Model 1 standardized	Model 1 *(non-stan.)* •
Age to T	.49 *	.494 *	*(1.584)* *
Age to SHBG	-.36 *	-.362 *	*(-6.221)* *
Age to Pubertal D.	.26 *	.245 *	*(.269)* *
Age to Sexuality	.08	.156	*(.190)*
T to Pubertal D.	.42 *	.412 *	*(.141)* *
SHBG to Pubertal D	-.20 *	-.203 *	*(-.013)* *
Pubertal D. to Sexuality	.04	-.012	*(-.013)*
T to Church Attendance	-.30 *	-.280 *	*(-.116)* *
SHBG to Church A.	.06	.039	*(.003)*
T to Sexuality	.44 *	.331 *	*(.125)* *
SHBG to Sexuality	-.35 *	-.176	*(-.012)*
Church A. to Sexuality	-.17 *	-.129	*(-.118)*
Sexuality R^2	not available ••	.299	
χ^2 probability	not available	1.60 (3 d.f., p = .660)	
AGFI	not available	.963	
Number of cases	approx. 102 •••	100	

* = LISREL T value > 2.00 ("Parameters whose t-values are larger than two in magnitude are normally judged to be different from zero", Joreskog and Sorbom, 1989, p. 89).
• Udry (1988) only depicted standardized coefficients, therefore this thesis reverses the usual coefficient presentation convention by bracketing the non-standardized coefficients.
•• "not available" indicates information and/or procedures not provided in Udry (1988).
••• Udry (1988) does not provide the N for Udry's model (p. 718, Figure 2). Although the max. N available for analysis is 102, Udry's model might be based on 97 cases, as is suggested by his description of his other biosocial models (see p. 716, Table 4, and p. 717, Table 5).

Model 1's χ^2 is 1.60 with 3 d.f., p = .660, and the AGFI = .963.[20] This χ^2 value tells us that Model 1's residual covariances are small and insignificant, and the p value of .660 indicates that if Model 1 was the true model, then data like Udry's would be observed in about two thirds of the random samples taken. The AGFI value, .963, also suggests that Model 1 fits the data well. However, these results do not require us to "accept" Model 1, as some other model(s) may also be consistent with the same set of data (Duncan, 1975, p. 20). That is, a good fit does not guarantee that we have the "right" model in any absolute sense (p. 101). The effect estimates found in Model 1 are conditional on the model being at least a reasonable approximation to the real world, and these fit statistics provide no strong indication of an inappropriate model.

LISREL's estimations and diagnostics were examined for indications of how Model 1 might be made to fit even better than it did. LISREL had no problems fitting the covariance as indicated by all the standardized residuals having absolute values less than 2. A standardized residual is considered "large" if its absolute value is greater than 2.58 (Joreskog and Sorbom, 1989, p. 32). That is, Model 1 fit the data well in terms of a close match between each of the observed and the model-implied covariances. This indicates that χ^2 was not hiding a big covariance bad-fit problem in a forest of non-problems.[21]

An examination of the correlations of estimates did not locate any indications of colinearity problems. The largest correlation between two estimates was .468. Also, since none of the modification indices exceeded 4.0, there were no coefficients that could be added to the model which would significantly improve the model fit (Joreskog and Sorbom, 1989, p. 111). Since this thesis attempts to approximate Udry's model, it would have been inappropriate to use the modification indices to alter Model 1. Any change to the model would represent a new theory, and hence would have compromised my ability to focus on Udry's theory.

Although LISREL's χ^2 test provides an indication of acceptable statistical fit between S and Σ, we should also assess the substantive fit of the model (Hayduk, 1987, see especially pp. 172-173). To provide a more substantive look at Model 1, I attempt below to explain some of the differences in the estimates between Model 1 and Udry's model. There are two locations where Model 1 shows non-significant effects rather than the significant effects shown in Udry's model. Model 1's non-significant effect of SHBG on Sexuality is about half as strong as the significant effect of SHBG on Sexuality in Udry's model, and Model 1's non-significant effect of Church Attendance to Sexuality is about three-quarters as strong as the significant effect of Church Attendance to Sexuality in Udry's model. I believed these differences might be partly or wholly due to the estimation strategy used. To examine this possibility, Model 1 was re-estimated using Generalized Least Squares (GLS) coefficient estimation. (GLS estimation is described in Joreskog and Sorbom, 1989.) Eight of the twelve unstandardized GLS estimates of the effects among the concepts were identical to their counterpart ML estimates depicted in Table 2 above, while four of the unstandardized GLS estimates were very slightly different from their ML counterparts. For the standardized GLS estimates, five of the twelve estimates were the same as their counterpart ML estimates, while the remaining seven were minimally different (the standardized differences ranged from .002 to .006).

Though slight, these discrepancies in results for Model 1, depending on whether ML or GLS estimation had been used, suggests that some of the differences in results between Model 1 and Udry's model might be due to these two models having not used the same estimation strategies. Although GLS coefficient estimation is similar to the Ordinary Least Squares (OLS) coefficient estimation used by Udry, I would have preferred to have used Udry's exact estimation strategy to examine the above issue. Unfortuneately, LISREL 7.2 is not programmed for OLS estimation. (In retrospect, I could have used the OLS estimation program in SPSS for Windows 6.1, © SPSS Inc.)

Another potential reason for the differences in results between Udry's model and Model 1 is that Udry and I might have specified different error covariances. Udry's OLS methodology might have allowed any pair of errors to covary, however, since I did not know for which, if any, error pairs Udry had done this, I specified fixed-zero error covariances in Model 1 (I could not free all the error covariances as the model would become under-identified). To partially explore how Model 1's fixed-zero error covariances might be associated with the discrepancies between Udry's model and Model 1, I modified Model 1 by allowing LISREL to estimate the covariance for the errors on T and SHBG (this new model is Model 1X). Although Model 1X (χ^2 = .15 with 2 d.f., p = .928, AGFI = .995) was more closely matched with the data than Model 1, Model 1X's standardized coefficient estimates among the η's (Eta's) were generally less close than their Model 1 mates to their accompanying estimates in Udry's model. For instance, of the seven statistically significant effects among the η's in Model 1 and Model 1X, Model 1 was slightly closer than Model 1X to Udry's model on three counts (Age to Pubertal Development, T to Pubertal Development, T to Sexuality), slightly less close for one effect (SHBG to Pubertal Development), and equal on the rest (Age to T, Age to SHBG, T to Church Attendance). Since different results were obtained depending on how I treated the covariance between the errors on T and SHBG, I suspect that some portion of the discrepancies between Udry's model and my Models 1 and 1X are due to Udry's procedure differing from mine in its specification of error covariances

Further possible contributors to the discrepancy between Udry's model and Model 1 are random data "gremlins" (such as those discussed in my Note 18), and Udry might have used listwise rather than pairwise deletion which would likely add to the discrepancies between his model and my Model 1 (as suggested by my listwise versus pairwise result comparison for Model 1, see Appendix F, Table F1).

Model 2: Modifies Model 1 by Entering Non-Zero Measurement Error

Model 2 addresses the problem that Udry's model and Model 1 specified no (zero) measurement error. Models without measurement error are surely unrealistic, as some degree of measurement error will always be present (Blalock, 1964). In this regard, Duncan states that since "all observation is fallible ... we never measure exactly the true variables discussed in our theories ... [therefore] all (true) variables are "unobserved"." (1975, p. 113). Furthermore, some degree of measurement error might be due not only to measurement imprecision (e.g., slips of the pencil, inaccurately calibrated machines), but also to the effects of variables not currently in the model.

It is seemingly impossible to judge, with certainty, the magnitudes of errors. Nonetheless, including some reasonable degree of error should increase a model's validity. By specifying reasonable measurement errors, a model can adjust for the assessed degree of measurement problems, thereby potentially improving the estimates for the substantive parts of the model (Hayduk, 1996, p. xix).

Model 2 used Model 1 as its template, but each indicator's error variance was fixed at a non-zero value (i.e., theta epsilon values were fixed at non-zero values in LISREL) to acknowledge measurement error. Values of the theta epsilons were chosen to reflect my knowledge of the data collection procedures. That is, I specified particular measurement reliabilities (as recommended by Hayduk, 1987, p. 119). Fixing the theta epsilons also enabled me to help determine the concepts' meanings (Hayduk, 1987, p. 120; 1996, pp. 25-28, describes how a theta epsilon value affects a concept's meaning). A concept's meaning is also partly determined by its links to other concepts (Hayduk, 1987, pp. 178-179), so Udry's theory also has some control over the meanings of the concepts in Model 2 since Model 2 continues to use the connections between the concepts specified by Udry.

Model 2's fixed theta epsilons (which are depicted in Table 3 below) are justified as follows (with the percentage of each indicator's variance attributed as error shown within brackets after the indicator's name):

Age (1%) - Reported age level should closely match actual age level, as there seems to be no readily apparent reason for Udry's adolescents to misreport their birthdate, and also no apparent benefit for doing so. Hence, the 1% measurement error (fixed theta epsilon) allows for an occasional inaccuracy by the interviewer, the school, the parent(s) and/or the adolescent. (In Hayduk's model of adult smoking behavior and antismoking acts, "5% error variance was considered an absolute upper bound on [reported age] errors", 1987, p. 120. I asserted less than 5% here as I believed Udry's adolescents would generally have less tendency to misreport their ages than Hayduk's adults.)

Testosterone (20%) - Barnard, Read, and Collins (1995) assert that radioimmunoassays (RIAs) for the measurement of hormones "can never provide an absolute measurement" (p. 210). In this regard, Halpern and Udry (1992) report that their RIA results varied across six laboratories during a three year longitudinal study of male adolescents. Although correlation coefficients across the labs for RIA results for T from plasma samples were generally high, the strength of relationships between T and pubertal development, and also between T and several behavior dimensions, varied by lab. Udry (1988) does not state whether or not a single lab had been used for all the adolescents' hormonal measures in his 1988 data set. However, even if a single lab had been used, the hormonal measures might still have been subject to fluctuations due to intra-laboratory factors.

Furthermore, for the grade nine and ten adolescents, there was an average delay of about three and a half months between their earlier interview/questionnaire responses and their provision of blood samples. This raises the possibility of an increasing mismatch between the levels of T at the time of its effects, and T at the time of measurement for about two thirds of Udry's sample. Also, for all the adolescents, we have no way of knowing whether the measured T levels were exactly the same as the T levels that might have been causally operative at the time of their reported behaviors and thoughts. In light of the above, 20% measurement error seems more reasonable than no measurement error. A substantially higher error percentage would be unreasonable since most adolescents' T values are not likely to have changed in a way which altered the adolescents' relative T values during the time spans implicit in the measures of the various behaviors and thoughts.[22]

SHBG (20%) - The justification for this amount of error parallels the justification for T just above.

Pubertal Development (25%) - Udry (1988) does not tell us if the adolescents were able to directly compare themselves to the Tanner-type drawings provided by Udry, as was recommended by Morris and Udry (1980): "In subsequent utilization of the self-rating items, if the methodology called for contacts in the student's home the student could be sent to a private room where he/she could examine himself/herself in order to provide greater accuracy in his/her answers" (p. 280). Even if the adolescents had directly compared themselves, there might still be measurement error due to both over-reports and under-reports, with over-reports perhaps being more common among adolescents embarrassed and/or concerned about being "late bloomers".

The self-measurement of Pubertal Development level in other research has been checked for validity. Morris and Udry (1980) had pediatricians rate adolescents on a battery of items that were nearly identical to the items on which Udry's (1988) adolescents had rated themselves. Factor scores from the pediatricians' ratings correlated r = .74 for male adolescents. This non-perfect correlation is supportive of my assertion here of a non-perfect epistemic correlation between the concept pubertal development and its indicator.

Church Attendance (5%) - Only a small degree of measurement error for church attendance was asserted as the self-report nature of the questionnaire should have minimized "pressures to both over- or underreport attendance" (Hayduk, 1987, p. 121). Also, the adolescents should have had no or few problems accurately locating themselves in one of four distinctive categories (i.e., less than once a month, about once a month, about once a week, and more than once a week).

Sexuality (25%) - Errors in measuring sexuality can arise at all of Levine's (1992) "five layers" of errors: (1) secrets from ourselves [including inaccurate recall], (2) secrets from others about ourselves [which can involve social desirability bias], (3) privacy among the participants [hence those willing to disclose might represent selection bias and motivation bias, with the context and setting playing a possible role], (4) societal rules for discussing sexuality [e.g., "masculine ideology" can affect male adolescents' styles of sexuality discourse; Pleck, Sonenstein, and Ku (1993)], and (5) the almost universal sexual language limitations of individuals.

Despite the consensus that measurement error is likely ubiquitous in sexuality research, only a "few investigators" have considered differentiating inaccurate from accurate adolescent respondents (Alexander, Somerfield, Ensminger, Johnson, and Young, 1993, p. 456). In one study which does address the issue of accuracy, about seven percent of the adolescents admitted to not having told the truth about sexual intercourse in a prior survey (Newcomer and Udry, 1988). Given that sexual intercourse level is but one component of Udry's Sexuality, and assuming that the other components also have some smaller amount of measurement error (e.g., Catania, McDermott, and Pollack, 1986, report that non-response bias commonly affects masturbation items in self-administered questionnaires), a relatively large (25%) measurement error for Sexuality seems reasonable.

Having determined a reasonable (though not necessarily exactly correct) percent error for each indicator, we can calculate the error variances as (assessed % error)(total variance of indicator) = error variance (see Table 3 below).

Table 3

Model 2's Fixed Theta Epsilons

Concept	Assessed Error in the Indicator	Fixed Theta Epsilon Value
Age	1%	.00636
Testosterone	20%	1.3102
SHBG	20%	37.553
Pubertal Development	25%	.19425
Church Attendance	5%	.05665
Sexuality	25%	.2385

When these values are entered in place of the zero measurement errors for Model 1, we obtain thesis Model 2 which had nearly the same fit (χ^2 = 1.50 with 3 d.f., p = .681, AGFI = .965) as Model 1 (χ^2 = 1.60 with 3 d.f., p = .660, AGFI = .963). Overall, adjusting for measurement error led to slightly stronger effects in the model and hence a slightly larger proportion of explained variance in Sexuality. A few of the effects' estimates declined slightly, and one, the effect of Age on Pubertal Development dropped below statistical significance. There seems little point to debating about the details of the specific percentage of error variance used since using error variances that were half or double those in Table 3 led to essentially the same results.[23] This is expected, because the models are "statistically equivalent", even though the values at which the theta epsilons are fixed provide for estimate and interpretation differences (Hayduk, 1997, personal communication). Table 4 below presents the estimates for Model 2 along with the estimates for Udry's model and Model 1.

Table 4

Comparison of Udry's model, Model 1, and Model 2

Effects Among the Concepts:	Udry's model standardized	Model 1 stan.	Model 1 *(non-stan.)*	Model 2 stan.	Model 2 *(non-stan.)*
Age to T	.49 *	.494 *	*(1.584)* *	.555 *	*(1.601)* *
Age to SHBG	-.36 *	-.362 *	*(-6.221)* *	-.408 *	*(-6.295)* *
Age to Pubertal D.	.26 *	.245 *	*(.269)* *	.178	*(.170)*
Age to Sexuality	.08	.156	*(.190)*	.126	*(.134)*
T to Pubertal D.	.42 *	.412 *	*(.141)* *	.575 *	*(.190)* *
SHBG to Pubertal D.	-.20 *	-.203 *	*(-.013)* *	-.272 *	*(-.017)* *
Pubertal D. to Sexuality	.04	-.012	*(-.013)*	-.206	*(-.229)*
T to Church A.	-.30 *	-.280 *	*(-.116)* *	-.318 *	*(-.144)* *
SHBG to Church A.	.06	.039	*(.003)*	.031	*(.003)*
T to Sexuality	.44 *	.331 *	*(.125)* *	.583 *	*(.214)* *
SHBG to Sexuality	-.35 *	-.176	*(-.012)*	-.290	*(-.020)*
Church A. to Sexuality	-.17 *	-.129	*(-.118)*	-.122	*(-.099)*
Sexuality R^2	not available	.299		.467	
χ^2 probability	not available	1.60 (3 d.f., p = .660)		1.50 (3 d.f., p = .681)	
AGFI	not available	.963		.965	
Number of cases	approx. 102	100		100	

* = LISREL T value > 2.00 ("Parameters whose t-values are larger than two in magnitude are normally judged to be different from zero", Joreskog and Sorbom, 1989, p. 89).

Model 3: Using Free-T instead of T and SHBG

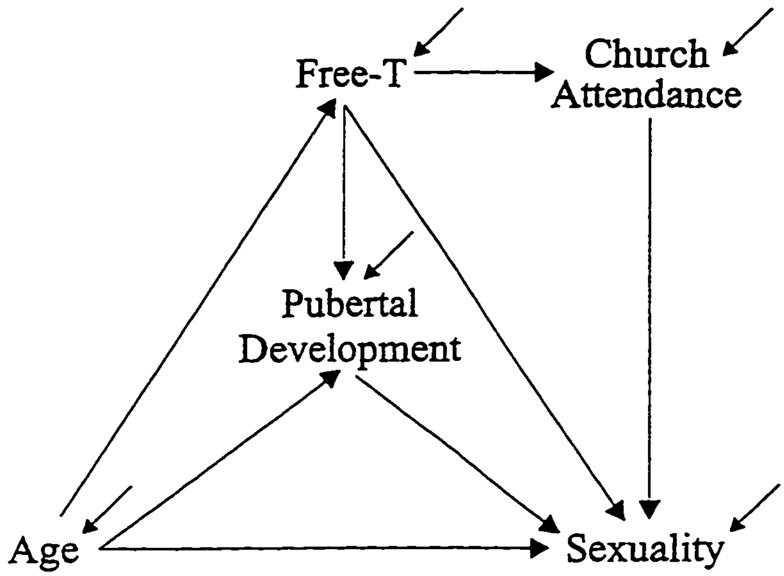
Model 3 shifts the focus from measurement error issues to Udry's specification of hormone and SHBG effects. Specifically, this section considers whether a Free-Testosterone index, calculated as T divided by SHBG, provides the same results as using T and SHBG separately. SHBG binds T and hence reduces its activity, but SHBG may also bind other hormones that could conceivably influence Sexuality. For instance, in the sample used here, three of the adolescents had nearly the same T values (about 2 ng/dl), whereas their SHBG values were 39, 58, and 24 (nmol/l) respectively. Therefore, the adolescent who had the SHBG value of 58 might have had more SHBG available to bind to non-T hormones, with a possible result being a greater reduction of these non-T hormones' effects on components of Sexuality than for the adolescents with the SHBG values of 39 and 24.

Similar results may or may not be obtained using Free-T instead of T and SHBG. In Udry's research with a different sample than that used here, using Total-T with SHBG produced "similar results" as using a Free-T index (Halpern, Udry, Campbell, Suchindran, and Mason, 1994, p. 221).

To investigate the possibility of different results due to using T and SHBG versus Free-T, Model 3 replaces T and SHBG with Free-T, while following the basic form of Udry's model and Model 1 (along with zero measurement error). Model 3 is depicted below and fit the data well (χ^2 = .29 with 2 d.f., p = .863, and the AGFI = .991). In general, this model produced results similar to Udry's use of T and SHBG.

Figure 3

Model 3



Both Model 3's Free-T, and Udry's T, had significant effects on Pubertal Development, Church Attendance, and Sexuality; with Free-T having slightly weaker effects for each of these, most notably for Sexuality (see Table 5 below). The slight reduction in Free-T's effect on Sexuality and the loss of SHBG's previously small effect on Sexuality combine to produce a slight reduction in the proportion of explained variance for Sexuality but this decline is minimal. These small differences in results might be partly due to the proportion of Free-T to Total-T being higher for lower levels of Total-T (Couwenbergs, Knussmann, and Christiansen, 1986).

Table 5

Comparison of Udry's model, Model 1, and Model 3

Effects Among the Concepts:	Udry's Model standardized	Model 1 stan.	Model 1 *(non-stan.)*	Model 3 stan.	Model 3 *(non-stan.)*
Age to T	.49 *	.494 *	*(1.584)* *	not in model	
Age to Free-T	not in model	not in model		.562 *	*(18.773)* *
Age to SHBG	-.36 *	-.362 *	*(-6.221)* *	not in model	
Age to Pubertal D.	.26 *	.245 *	*(.269)* *	.294 *	*(.325)* *
Age to Sexuality	.08	.156	*(.190)*	.167	*(.204)*
T to Pubertal D.	.42 *	.412 *	*(.141)* *	not in model	
Free-T to Pubertal D.	not in model	not in model		.399 *	*(.013)* *
SHBG to Pubertal D.	-.20 *	-.203 *	*(-.013)* *	not in model	
Pubertal D. to Sexuality	.04	-.012	*(-.013)*	.075	*(.083)*
T to Church A.	-.30 *	-.280 *	*(-.116)* *	not in model	
Free-T to Church A.	not in model	not in model		-.273 *	*(-.011)* *
SHBG to Church A.	.06	.039	*(.003)*	not in model	
T to Sexuality	.44 *	.331 *	*(.125)* *	not in model	
Free-T to Sexuality	not in model	not in model		.296 *	*(.011)* *
SHBG to Sexuality	-.35 *	-.176	*(-.012)*	not in model	
Church A. to Sexuality	-.17 *	-.129	*(-.118)*	-.145	*(-.133)*
Sexuality R^2	not available	.299		.269	
χ^2 probability	not available	1.60 (3 d.f., p = .660)		.29 (2 d.f., p = .863)	
AGFI	not available	.963		.991	
Number of cases	approx. 102	100		100	

* = LISREL T value > 2.00 ("Parameters whose t-values are larger than two in magnitude are normally judged to be different from zero", Joreskog and Sorbom, 1989, p. 89).

Model 3 did not include measurement error, therefore my next step was to specify what I thought was a reasonable amount of measurement error for each of Model 3's indicators, thereby forming Model 4, as is discussed below.

Model 4: Adding Non-Zero Measurement Error to Model 3

Model 4 is the same as Model 3, except that measurement errors are added (fixed theta epsilons in LISREL). Model 4's measurement error values for the indicators of Age, Pubertal Development, Church Attendance, and Sexuality are the same as those previously justified and used in Model 2 (see Table 3 above). Since the indicator of Free-T was the T / SHBG ratio, it was assigned 20% measurement error variance, in congruence with the 20% previously assigned to the indicators of both T and SHBG. (This resulted in a fixed theta epsilon value of 142.2288 for the indicator of Free-T.)

Model 4 fit the data somewhat better than Model 3 (see Table 6), and also had slightly stronger effects in general, just as Model 2, which included measurement error, tended to have stronger effects than Model 1 which had no measurement error. This resulted in an increase of 13% in the explained variance in Sexuality. However, just as the Free-T Model 3 with zero measurement error variance had lower explained Sexuality variance than the T and SHBG Model 1 with zero measurement error, the Free-T Model 4 which included measurement error variances provided less explained variance in Sexuality than did the T and SHBG Model 2 which contained measurement error variance.

Overall, the use of Free-T instead of T and SHBG seems to produce the same patterns of effects but with a minor reduction in the magnitude of T effects. The loss of the SHBG variable implies some reduction in explained variance for whatever variables SHBG originally influenced, in addition to the minor reduction due to the slightly weaker effects of Free-T compared to T in models with both T and SHBG.

Table 6

Comparison of Udry's model, Model 3, and Model 4

Effects Among the Concepts:	Udry's Model	Model 3 stan. *(non-stan.)*	Model 4 stan. *(non-stan.)*
Age to T	.49 *	not in model	not in model
Age to Free-T	not in model	.562 * *(18.773)* *	.630 * *(18.942)* *
Age to SHBG	-.36 *	not in model	not in model
Age to Pubertal D.	.26 *	.294 * *(.325)* *	.236 *(.227)*
Age to Sexuality	.08	.167 *(.204)*	.126 *(.134)*
T to Pubertal D.	.42 *	not in model	not in model
Free-T to Pubertal D.	not in model	.399 * *(.013)* *	.579 * *(.019)* *
SHBG to Pubertal D.	-.20 *	not in model	not in model
Pubertal D. to Sexuality	.04	.075 *(.083)*	.029 *(.032)*
T to Church A.	-.30 *	not in model	not in model
Free-T to Church A.	not in model	-.273 * *(-.011)* *	-.312 * *(-.014)* *
SHBG to Church A.	.06	not in model	not in model
T to Sexuality	.44 *	not in model	not in model
Free T to Sexuality	not in model	.296 * *(.011)* *	.461 * *(.016)* *
SHBG to Sexuality	-.35 *	not in model	not in model
Church A. to Sexuality	-.17 *	-.145 *(-.133)*	-.146 *(-.119)*
Sexuality R^2	not available	.269	.399
χ^2 probability	not available	.29 (2 d.f., p = .863)	.01 (2 d.f., p = .993)
AGFI	not available	.991	1.000
Number of cases	approx. 102	100	100

* = LISREL T value > 2.00 ("Parameters whose t-values are larger than two in magnitude are normally judged to be different from zero", Joreskog and Sorbom, 1989, p. 89).

Having thus far focused on the issues of measurement error, and the use of T plus SHBG or Free-T, we now turn to a series of models which investigate the Sexuality variable.

Model 5: Replacing Udry's Sexuality Scale with Multiple Indicators of Sexuality

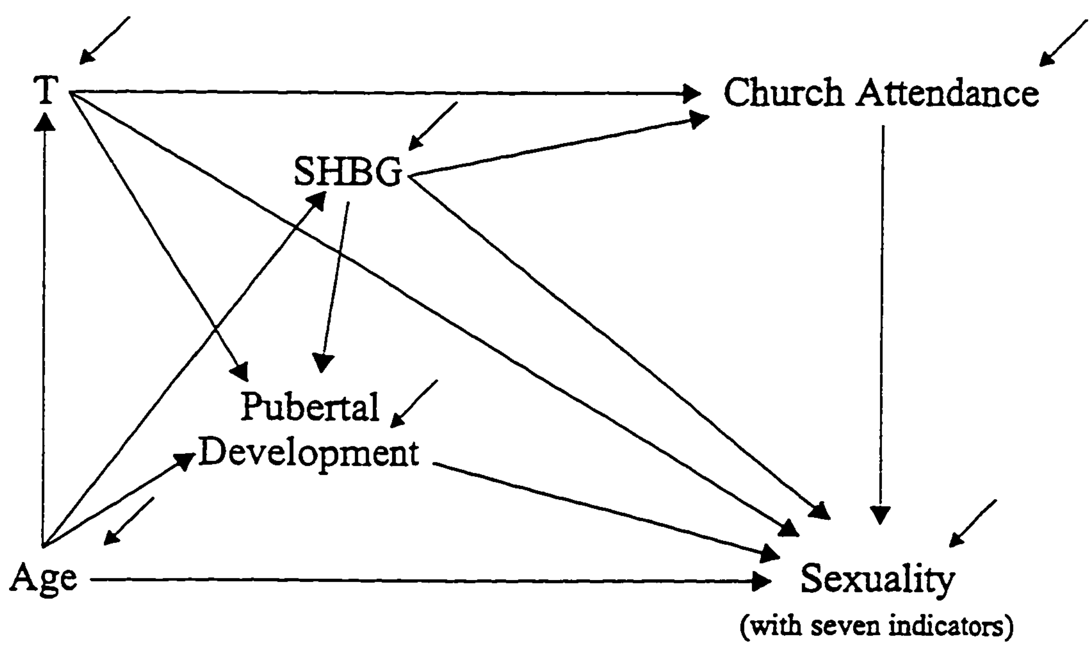
Model 5 focuses on the dependent variable Sexuality. Recall that Udry had factor analyzed seven items and subsequently created a Sexuality scale by summing responses to the items which loaded on the common factor. Model 5 explores the implications of Udry's use of a Sexuality scale by re-inserting a factor analytic segment into Udry's basic model. Model 5 (which is depicted in Figure 4) makes Sexuality a common factor underlying seven indicators of sexuality. Thus no Sexuality scale score is used but the variables from which a scale could be constructed are used. Consequently the covariances for all the indicators with each other and with the indicators of the other concepts in the model are included in the data matrix S and are available for diagnostic and testing purposes. Model 5 recombines into a single model two steps that Udry had investigated independently - namely the dependence of the multiple sexuality indicators on a single source (the Sexuality concept) and the inclusion of that concept in Udry's overall model. Inclusion of the multiple Sexuality indicators eliminates any need for the intermediate step of constructing a Sexuality scale. Model 5 directly connects the Sexuality construct to its several indicators, rather than connecting Sexuality to a single Sexuality scale that had been constructed from the multiple indicators.

Five of the seven components of Udry's Sexuality scale were located in the data set and very close approximations were made for the remaining two components. The five identical items are Coitus (COITUS), Masturbation (SELFPLAY), Non-Coital Sexual Experience (SEXEXP), Sexual Turn On (TURNON), Sexual Thoughts (THINKSEX), and the two near but not perfectly identical items are Coitus plus Masturbation Last Month (OUTLET) and Motivation for Sex in the Next Year (FUTURSEX) as discussed in Chapter 2.

In terms of measurement error, Model 5 matches Udry's modeling of zero measurement errors for the indicators of Age, T, SHBG, Pubertal Development, and Church Attendance. The theta epsilons for the seven indicators of Sexuality were estimated by LISREL since this parallels what was done in Udry's factor analysis of these items.

Figure 4

Model 5



Although Model 5's estimates of the effects among the concepts closely matched Udry's model (as is seen in Table 7 below), Model 5 did not fit the data (χ^2 = 154.98 with 47 d.f., p = .000, and AGFI = .664). (An attempt to salvage Model 5 by allowing LISREL to estimate the covariance for the errors on T and SHBG was unsuccessful: χ^2 = 153.54 with 46 d.f., p = .000, and AGFI = .659; although I did discover that this estimated covariance implies an "error" correlation of 015, which suggests that the unknown sources of T and SHBG concentrations are relatively dissimilar.) To locate possible sources of Model 5's failure, LISREL's estimates and model diagnostics were examined. The largest standardized residuals occurred among the multiple indicators of Sexuality. For instance, the largest (6.881) was for the indicators labeled SELFPLAY and OUTLET, the second largest (4.927) was for TURNON and THINKSEX, the third largest (3.690) was for COITUS and SEXEXP, and the fourth largest (3.146) was for COITUS and FUTURSEX. These large residuals were not focused on the two indicators that were close approximations to Udry's indicators, but were equally inditing of the five identical indicators. So the failure cannot be dismissed as attributable to inexact replication procedures.

The above large residuals suggest that Model 5 did not fit the data because it tried to force seven different indicators of Sexuality to respond to a single causal source. A common factor model implies proportionality constraints among the covariances of the common factor's indicators, and if these model implied proportionality constraints are not similarily proportional in the data, then the model will not fit the data (Hayduk, 1996). Therefore, Model 5 appears to have failed, as do many multiple indicator models, "because of the stringency of [its] proportionality demands" (p. 17). For instance, in Model 5, the effects of Age on the Sexuality indicators all involve the effect of Age to Sexuality, and hence all the covariances between Age and the Sexuality indicators must reflect or respect the magnitude of the Age to Sexuality effect which can be strengthened or weakened by the loadings of the indicators on the Sexuality concept. The crucial point is that these same loadings of the Sexuality indicators on the Sexuality concept must (if the model is correct) similarly divide up the effects of T, SHBG, Free-T, Pubertal Development, and Church Attendance on Sexuality's indicators. That is, the same relative strengthenings and weakenings that the loadings make to the effect of Age on the Sexuality indicators are applied to the effects of T on the Sexuality indicators, the effects of SHBG on the Sexuality indicators, and so on. If there is no single set of loadings that can appropriately modify all the effects that come into the Sexuality concept for distribution to the Sexuality indicators, and at the same time match with the degree of correlation among the indicators themselves, then the model will fail, just as it did. The model was unsuccessful because the data suggest that the indicators have somewhat different causal sources and causal connections. Udry anticipated this problem when he stated that, "The dependent variable

Sexuality, although statistically capturing the intuitive global meaning of the term, contains components that are quite disparate in actual behavior ... therefore our composite Sexuality is an inappropriate dependent variable" (1988, p. 716). Model 5 demonstrates that this is not an empty caution and is in fact sufficient to create a major model failure.

Table 7

Comparison of Udry's Model and Model 5

Effects Among the Concepts:	Udry's model standardized	Model 5 standardized	*(non-stan.)*
Age to T	.49 *	.494 *	*(1.584)* *
Age to SHBG	-.36 *	-.362 *	*(-6.221)* *
Age to Pubertal D.	.26 *	.245 *	*(.269)* *
Age to Sexuality	.08	.097	*(.097)*
T to Pubertal D.	.42 *	.412 *	*(.141)* *
SHBG to Pubertal D.	-.20 *	-.203 *	*(-.013)* *
Pubertal D. to Sexuality	.04	.045	*(.041)*
T to Church Attendance	-.30 *	-.280 *	*(-.116)* *
SHBG to Church A.	.06	.039	*(.003)*
T to Sexuality	.44 *	.363 *	*(.114)* *
SHBG to Sexuality	-.35 *	-.362 *	*(-.021)* *
Church A. to Sexuality	-.17 *	-.237 *	*(-.178)* *
Sexuality R^2	not available	.549	
χ^2 probability	not available	154.98 (47 d.f., p = .000)	
AGFI	not available	.664	
Number of cases	approx. 102	99	

* = LISREL T value > 2.00 ("Parameters whose t-values are larger than two in magnitude are normally judged to be different from zero", Joreskog and Sorbom, 1989, p. 89).

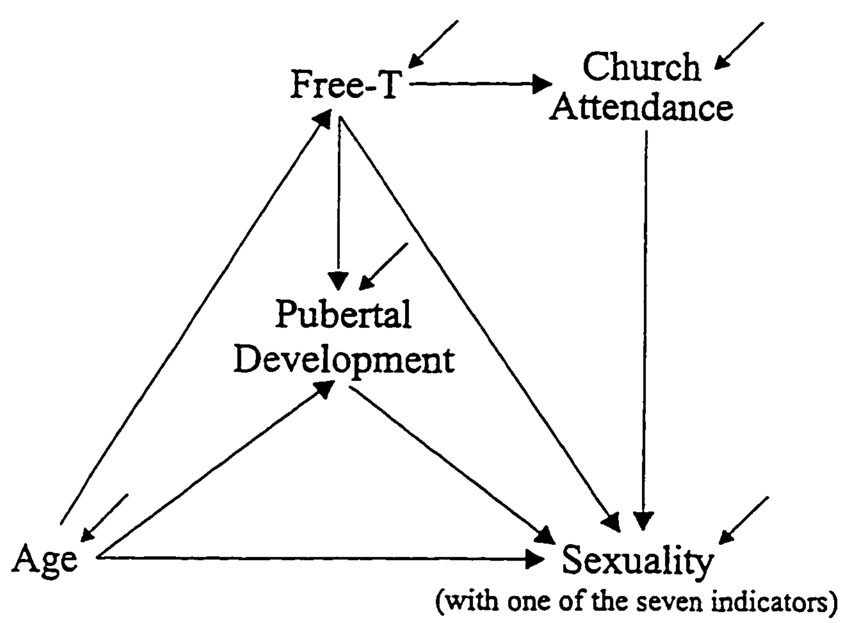
Having found that Model 5 did not fit the data as a result of its multiple indicators of Sexuality having different causal connections than those implied by their attachment to the common factor Sexuality, I developed a series of models (Models 6 to 12) which investigated how each of Model 5's Sexuality indicators behaved if placed as the single indicator of Sexuality within Udry's model's framework.

Models 6 to 12: Single Indicators of Sexuality, Free-T, and Fixed Measurement Error

Models 6 to 12 check how the seven variables used as Model 5's multiple indicators of Sexuality might have non-identical causal determinants. This check was performed by successively specifying each of the seven Sexuality components as the single Sexuality indicator in Models 6 to 12. As is seen in Figure 5, Models 6 to 12 include the same effects as Udry's model (but use Free-T rather than T and SHBG so that I could more readily focus on the above issue), while adding measurement error (as discussed below).

Figure 5

Models 6 to 12



For Models 6 through 12, the measurement error (theta epsilon value) for each of the single indicators of Sexuality was fixed at 15 percent of each indicator's variance (as indicated in Table 8). 15 percent is less than the 25 percent chosen for the composite indicator of Sexuality, thereby acknowledging that single disaggregated indicators can impart their own individual slant to the meaning of the Sexuality concept, and hence the concept is likely to be more similar to that indicator than to a scale score to which the indicator was one of many contributors.

Table 8
Models 6 to 12 - Fixed Theta Epsilons

Concept	Assessed Error in the Indicator	Fixed Theta Epsilon Value
Coitus (C) (Model 6)	15%	.03195
Masturbation (M) (Model 7)	15%	.033
C + M Last Month (Model 8)	15%	.7344
Non-Coital Sexual Exp. (Model 9)	15%	1.6869
Sexual Turn On (Model 10)	15%	.7212
Sexual Thoughts (Model 11)	15%	.38535
Motivation for Sex ... (Model 12)	15%	.79845

Models 6 to 12 all fit the data well (see Table 9), but the strengths of certain of the effects among the concepts vary according to which dependent variable was specified (see Table 9). For instance, Free-T had statistically significant (positive) effects on only two of the seven dependent Sexuality concepts, Masturbation and Coitus plus Masturbation Last Month. Since these two concepts are indicated by variables which include orgasm, the results here are congruent with other researchers' findings of significant positive correlations between Free-T and frequency of orgasms in "healthy young men" aged 19 to 31 years (Knussmann, Christiansen, and Couwenbergs, 1986). One possible explanation for Free-T only having significant effects on Masturbation and Coitus plus Masturbation Last Month is that Masturbation might be the concept that is the least constrained by other concepts in the model, and hence there would be reduced barriers to Free-T having effects on Masturbation. However, a check of the data indicated that eight of the males reported that they had at least one coital experience "last month", while reporting having never masturbated. Hence, for those eight males, the indicator of Coitus plus Masturbation Last Month is bereft of masturbation. It seems to be unrealistic that as many as eight males out of the sample of 102 experienced coitus without ever having experienced masturbation (Nevid, Fichner-Rathus, and Rathus, 1995).

I also considered the lack of Free-T effects on Sexual Turn On and Sexual Thoughts (Table 9). One might argue that Free-T did not effect the above two sexual thought concepts because the adolescents lacked the social stimuli, such as certain visual cues (e.g., erotic images), which invoke sexual thoughts (Bancroft, 1984). This is likely a poor explanation, given the prevalence of erotic stimuli (potentially from real people, movies, television, billboards, fetish objects) in the adolescents' culture.

Another unexpected result was that Model 12 was the only model from among Models 6 to 12 to agree with Udry's finding of a statistically significant negative effect of the social control concept Church Attendance on the dependent Sexuality concept. Part of the explanation for this may be the stronger Free-T to Sexuality effects which provide a stronger negative covariance contribution to the Church Attendance - Sexuality correlation due to the negative effect of Free-T on Church Attendance. This difference in results might also be partly attributable to the weighting of items which occurred in Udry's Sexuality scale. That is, weighting procedures might have artificially given emphasis to items more susceptible to the effects of Church Attendance than other items in the scale. Hence, in Udry's model Church Attendance would show effects on the Sexuality scale as a whole, while in Models 6 to 12 the individual Sexuality indicators might each have been resistant to effects from Church Attendance. (Although Church Attendance's positive effects on Coitus plus Masturbation Last

Month and Sexual Turn On were deemed here to be statistically non-significant, these effects are not necessarily a sampling artifact, and might be suggestive of Church Attendance providing increased coital opportunity due to the meeting of coital partners at church, and also increased Sexual Turn On via the stimuli of sexually attractive individuals at church.) Regardless of the true explanations for these results, the differential effects on the dependent Sexuality items across Models 6 to 12 clearly suggest that Udry's model does not equally apply to all the disparate components of Sexuality.

Table 9

Comparison of Models 6 to 12

Model:	6	7	8	9	10	11	12
Eta 5:	Coitus (C)	Mastur -bation (M)	C + M Last Month	Non-Coital Sex. Exp.	Sexual Turn On	Sexual Thoughts	Motivation for Sex ... Next Year
Effects Among the Concepts:	standardized *(non-stan.)*	standardized *(non-stan.)*	standardized *(non-stan.)*	standardized *(non-stan.)*	standardized *(non-stan.)*	standardized *(non-stan.)*	standardized *(non-stan.)*
Age to	.630*	.630*	.630*	.630*	.630*	.630*	.630*
Free-T	*(18.942)**	*(18.942)**	*(18.942)**	*(18.942)**	*(18.942)**	*(18.942)**	*(18.942)**
Age to	.236	.236	.236	.236	.236	.236	.236
Pub. D.	*(.227)*	*(.227)*	*(.227)*	*(.227)*	*(.227)*	*(.227)*	*(.227)*
Age to	-.088	.040	.000	-.010	.040	.075	.003
Eta 5	*(-.047)*	*(.022)*	*(-.001)*	*(-.041)*	*(.101)*	*(.140)*	*(.008)*
Free-T to	.579*	.579*	.579*	.579*	.579*	.579*	.579*
Pub. D.	*(.019)**	*(.019)**	*(.019)**	*(.019)**	*(.019)**	*(.019)**	*(.019)**
Pub. D. to	.037	-.415	-.446	.162	.079	.061	.371
Eta 5	*(.021)*	*(-.235)*	*(-1.193)*	*(.655)*	*(.211)*	*(.117)*	*(1.034)*
Free-T to	-.312*	-.312*	-.312*	-.312*	-.312*	-.312*	-.312*
Church A.	*(-.014)**	*(-.014)**	*(-.014)**	*(-.014)**	*(-.014)**	*(-.014)**	*(-.014)**
Free-T to	.436	.674*	.739*	.350	.388	.332	.017
Eta 5	*(.008)*	*(.012)**	*(.063)**	*(.045)*	*(.033)*	*(.021)*	*(.002)*
Church A.	-.037	-.049	.055	-.192	.116	-.178	-.358*
to Eta 5	*(-.015)*	*(-.020)*	*(.108)*	*(-.572)*	*(.226)*	*(-.254)*	*(-.734)**
Eta 5 R^2	.181	.249	.254	.316	.206	.265	.342
χ^2	.01 (2 d.f.,	.01 (2 d.f.,	.01 (2 d.f.,	.01 (2 d.f.,	.01 (2 d.f.,	.01 (2 d.f.,	.01 (2 d.f.,
probability	p = .993)	p = .993)	p = .993)	p = .993)	p = .993)	p = .993)	p = .993)
AGFI	1.000	1.000	1.000	1.000	1.000	1.000	1.000
N	100	100	99	101	101	100	100

* = LISREL T value > 2.00 ("Parameters whose t-values are larger than two in magnitude are normally judged to be different from zero", Joreskog and Sorbom, 1989, p. 89).

Having found that the above Models 6 to 12 fit the data, whereas Model 5 with its multiple indicators of Sexuality failed to do so, I developed a model (Model 13), whose number of Sexuality concepts was intermediate between that of Models 6 to 12 (seven separate Sexuality concepts with one indicator each) and Model 5 (which had one Sexuality concept with seven indicators).

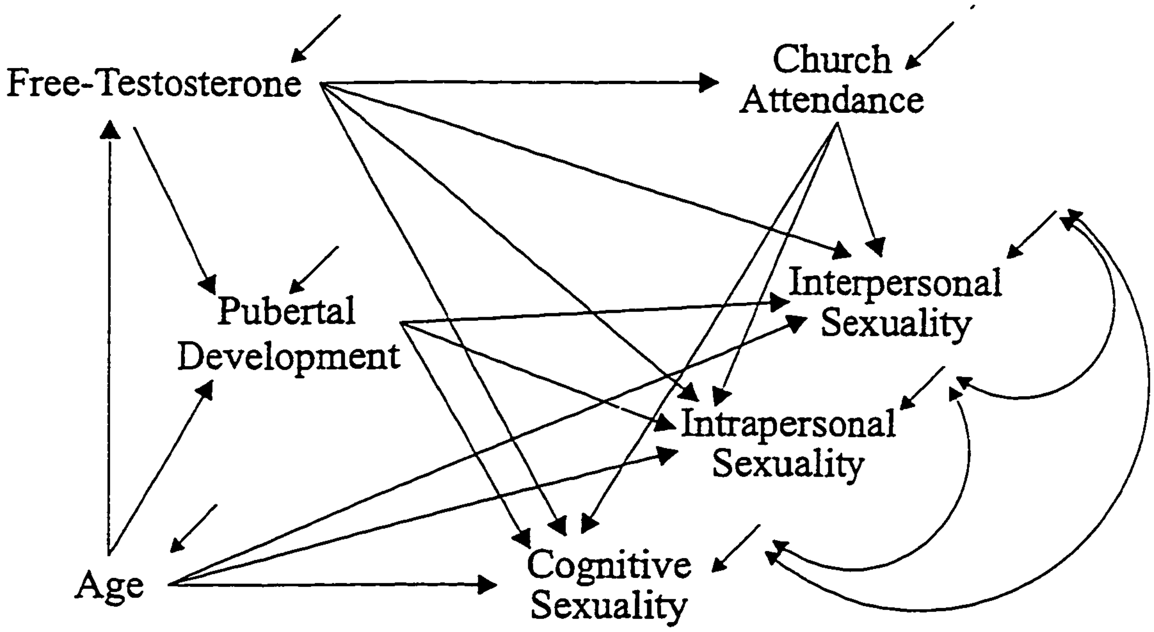
Model 13: Three Sexuality Factors: Interpersonal, Intrapersonal, and Cognitive

Model 13 proposed a more parsimonious number of Sexuality factors then the seven separate Sexuality concepts used in the Model 6 to 12 series, while at the same time it specified these factors as being less causally aggregrated than the single dimension that comprised Udry's Sexuality scale. In Model 13, Sexuality was specified as having three factors: (1) Interpersonal Sexuality (i.e., sexuality involving physical interaction with others), which was indicated by the variables labelled as COITUS, IFELTHER, SHEFELT, and IMADEOUT; (2) Intrapersonal Sexuality (defined as solo masturbation), indicated by the variables SELFPLAY, SHOOT, and NOSHOOT; and (3) Cognitive Sexuality (represented by cognitive components which do not require solo or non-solo physical sexuality), indicated by THINKSEX, TURNON, and FANTASYS. Each of these ten indicators was chosen based on its face validity along with its resemblance to one or more of Udry's Sexuality components: COITUS, SELFPLAY, THINKSEX, TURNON, IFELTHER, SHEFELT, and IMADEOUT are actual components of Udry's Sexuality; SHOOT and NOSHOOT are components of my variable Coitus plus Masturbation Last Month which very closely approximates the "Outlet" component of Udry's Sexuality; and FANTASYS is conceptually similar to the "Turn On", "Think About Sex", and "Future Sex" components of Udry's Sexuality (1988, p. 719). These indicators, with the exception of FANTASYS, have appeared in earlier thesis models.

Model 13's effect directionalities are generally congruent with Udry's model (see Figure 6). Each of the three Sexuality factors is linked with the non-Sexuality concepts in the same manner as Udry's Sexuality Scale. (Recall that Udry's model made no distinction between concepts and indicators, whereas this model does.) Additionally, correlated errors were specified among the three Sexuality factors. This permits these variables to have common sources beyond those explicitly included in the model.[24]

Figure 6

Model 13



Model 13 also included fixed measurement error for its indicators, the amounts of which have been previously justified and described (see Tables 3 and 8 above) except for the variables labelled IFELTHER, SHEFELT, IMADEOUT, FANTASYS. These four variables were specified as having 15% measurement error, given their resemblance to other variables having previously been assigned this amount of measurement error. (Model 13's fixed theta epsilon values are depicted in Table 10 below.) The lambda estimates for Model 13 are for Interpersonal Sexuality: 1.0 (COITUS), 2.295 (IFELTHER), 2.144 (SHEFELT), and 1.892 (IMADEOUT); for Intrapersonal Sexuality: 1.0 (SELFPLAY), 3.389 (SHOOT), and 1.197

(NOSHOOT); and for Cognitive Sexuality: 1.0 (THINKSEX), 1.425 (TURNON), and .273 (FANTASYS).

Table 10

Model 13's Fixed Theta Epsilons

Concept	Assessed Error in the Indicator	Theta Epsilon Value
Age	1%	.00636
Free Testosterone	20%	142.2288
Pubertal Development	25%	.19425
Church Attendance	5%	.05665
Coitus	15%	.03195
Touching a Girl's Sex Organs	15%	.1194
Girl Touching My Penis	15%	.11505
Necking with a Girl	15%	.1101
Masturbation (M)	15%	.033
M with Ejaculation	15%	.55965
M without Ejaculation	15%	.0948
Sexual Thoughts	15%	.38535
Sexual Turn On	15%	.7212
Sexual Turn On Thoughts	15%	.0369

Model 13 did not fit the data (χ^2 = 865.87 with 72 d.f., p = .000, and AGFI = .199). Of the fifteen non-zero modification indices (whose values ranged from .001 to .013) for effects among the concepts, eleven involved the Sexuality concepts' links with non-Sexuality concepts. Had these modification indices been large they would have been suggestive that Model 13's primary defect might be a faulty specification of the connections between Sexuality and non-Sexuality concepts. Even more challenging were the numerous substantial (i.e., values greater than 4) modification indices for the fixed measurement errors for the Sexuality indicators, which rendered it very difficult to discern which culprits were the most guilty of contributing to the model's failure.[25] Although freeing coefficients with large modification indices would likely have led to the model's χ^2 being reduced, the corresponding loss of degrees of freedon (one for each coefficient freed) would partially offset the χ^2 and p improvement. Also, because of the potential complexity of the true concatenations among the concepts, following the largest modification indices might not lead to the best model, as the most potent causal factors might be hidden among the numerous smaller modification indices. Given these problems, I did not follow the suggestions of the modification indices, but left Model 13 as is.

Model 13's failure to fit the data appears to be due to the model's implied covariance proportionality constraints (among the covariances of the Sexuality factors' multiple indicators) not matching the actual covariances in the data. This is a repeat of the kind of problem that caused the failure of the earlier multiple indicator Model 5. This suggests that while Model 13 permits three general types of Sexuality, the various Sexuality indicators are sufficiently unique that even this degree of clustering confounds their unique causal determinants. The indicators are more uniquely determined than even three modes of Sexuality permit.

Now that I have discussed all three of my main criticisms of Udry's modeling methodology (i.e., he did not adjust for measurement error, nor did he perform an overall test of the fit of his model, and he aggregrated causally diverse Sexuality components into a Sexuality scale having a singular causal location in his model), I present Models 14 and 15 below which investigate the issue of reciprocal effects between Sexuality and Church Attendance.

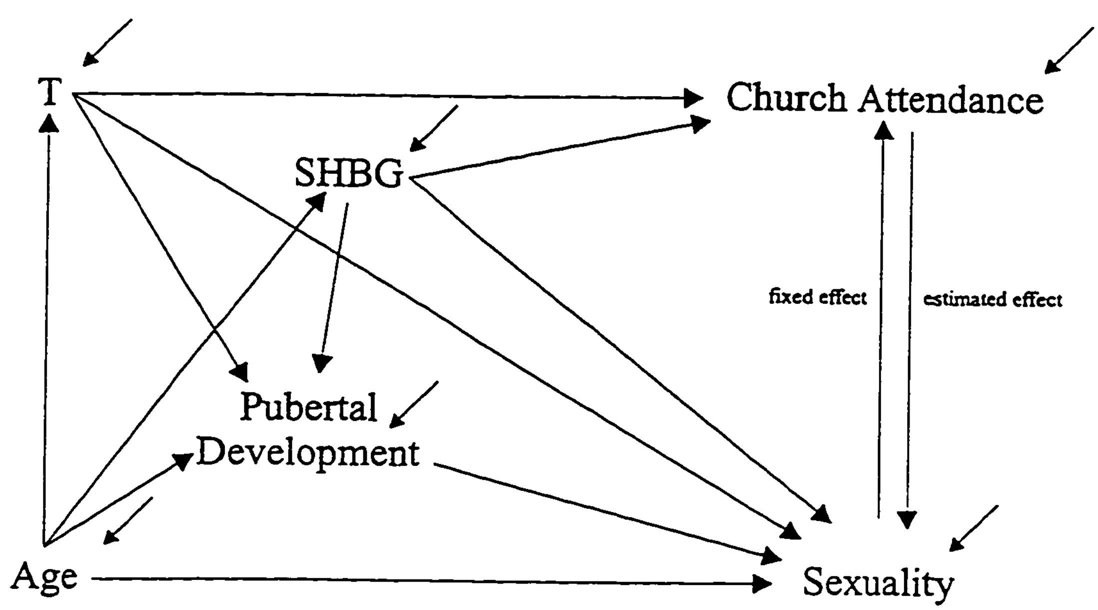
Models 14 and 15: Fixed Effect of Sexuality to Church Attendance

The models in this section turn to a different kind of issue in Udry's model. Udry raised the possibility of a reciprocal effect between Church Attendance and Sexuality when he considered reversing "the causal arrow from church attendance to sexuality" (1988, p. 717). This would imply that androgens could increase sexuality, and subsequently (indirectly) reduce church attendance in addition to the direct reduction modeled as direct T and SHBG effects on Church Attendance. Udry felt that, "Far more complicated research designs will be necessary to identify the causal direction(s)" between Church Attendance and Sexuality (p. 717).

I considered two different ways to investigate the possibility of reciprocal effects between Church Attendance and Sexuality. First I tried to locate a variable in Udry's data set that might have strong enough (symmetry breaking) effects on either Church Attendance or Sexuality to permit estimating the possible reciprocal effects between these two variables. Unfortunately no theoretically sensible symmetry breaking variable could be found, so I turned to a second approach. Thesis Models 14 to 15 (see Figure 7) entered specific fixed values for the effect from Sexuality to Church Attendance, while allowing the effect from Church Attendance to Sexuality to be estimated as had been done in Udry's model.

Figure 7

Models 14 and 15



It was anticipated that if Sexuality did have an effect on Church Attendance, the effect would perhaps account for about five percent, but no more than ten percent, of the variance in Church Attendance. To examine this possibility, Model 14 specified an effect of Sexuality on Church Attendance which would account for about five percent of the variance in Church Attendance (calculated as: effect squared x Sexuality's variance = five percent of Church Attendance's variance = an unstandardized effect of -.24514). Model 15 specified that the Sexuality effect would account for ten percent of the variance in Church Attendance (calculated as: effect squared x Sexuality's variance = ten percent of Church Attendance's variance = an unstandardized effect of -.34668). These values are negative because more sexual behavior should, if anything, reduce church attendance. The -.24515 and -.34668 values were entered as fixed effects in models that otherwise resembled Model 1.

Models 14 and 15 fit about as well as did Model 1, though the estimates of the effect from Church Attendance to Sexuality differed. In Model 1 this effect (standardized) was estimated as -.129, and in Models 14 and 15 the corresponding estimates are .047 (T value = .519) and .124 (T value = 1.298). So forcing small but reasonably signed effects from Sexuality to Church Attendance changed the estimate of the Church Attendance to Sexuality effect from negative (reasonable) to positive (unreasonable). That is, to permit even a small effect from Sexuality to Church Attendance Udry would have to argue that there was either no effect or an inappropriately signed effect of Church Attendance on Sexuality. This means that the data covariances are inconsistent with entering (reasonable) effects going both ways simultaneously. So we really do face a choice of one effect or the other, as the data suggest both are not simultaneously operative. Had the estimated effect been both significant and of the wrong sign we would have had reasonably strong evidence that Sexuality does not influence the adolescents' Church Attendance. The fact that the estimates were merely of the wrong sign (but insignificant) is suggestive of the same conclusion.

If I look at the real world, instead of my models, is Church Attendance more likely to influence Sexuality or is Sexuality more likely to influence Church Attendance? If forced to choose I would have agreed with Udry that the Church Attendance to Sexuality effect is more likely. The minor sexuality (in terms of overall Sexuality scores) of the adolescents is too minor to suggest the reverse; and the pulpit condemnations of adolescent sexuality are too pervasive to ignore.

So while I can not demonstrate Udry's use of the Church Attendance to Sexuality effect is correct (or incorrect) as I had hoped I could via estimation of the reciprocal effects, it does seem that Udry's Church Attendance to Sexuality effect is the most defensible alternative from both the perspective of modeling and a general assessment of the kinds of mechanisms that might be operative in the real world.

We have now reached the end of this thesis's technical re-examination of Udry's model. The results of these models are summarized in the next - and final - chapter of this thesis, along with my conclusions, a discussion of the validity and generalizability of this thesis's results; and recommendations for future research which might help us better understand adolescent male sexuality.

CHAPTER FIVE

Summary and Conclusions

This thesis re-examines Udry's (1988) biosocial model of adolescent male sexuality which had established regression estimates of the effects of Testosterone, Sex Hormone-Binding Globulin, Age, Pubertal Development, and Church Attendance in producing variance in adolescents' scores on Udry's Sexuality scale. Udry had found that Testosterone was importantly related to Sexuality and that this hormone disentangled some of the social-biological confounding in the variables Age and Pubertal Development. These observations constitute a fundamental shift in thinking about these sociological variables. Though Udry's observations were path breaking, there remained the question of whether his results could be trusted. Udry had not adjusted for measurement error, and he had not provided an overall test of the fit of his model. Furthermore, he used a scale to measure Sexuality, and the use of scales in models has been questioned (Hayduk, 1987, pp. 212-218; 1996, pp. 50-53). These three criticisms were the main focus of this thesis's re-examination of Udry's model.

The re-examination involved creating a series of structural equation models using LISREL (Joreskog and Sorbom, 1989), which approximated Udry's model to varying degrees. The first thesis model closely approximated Udry's model. The comparison of Model 1's maximum likelihood estimates with Udry's ordinary least squares regression estimates indicated both that there were no serious disagreements between this thesis's calculations and Udry's calculations, and also that Model 1 did reasonably approximate Udry's model. Model 1 also promoted this thesis's first extension beyond Udry's analysis by providing a χ^2 (chi-square) test of the overall model fit, which Model 1 passed.

Following verification of the consistency between Udry's model and Model 1, I turned to the issue of measurement error. Udry's procedure had assumed that there was no measurement error. This is unreasonable, since there is always some degree of measurement error, but Udry was not able to adjust for any measurement errors because the OLS regression procedure he was using did not permit this. Since LISREL does permit the specification of measurement errors I was able to address this methodological deficiency by developing and testing thesis Model 2, in which I specified reasonable amounts of measurement error while maintaining the basic form of Udry's model. Model 2, Model 1, and Udry's model all provided similar results. The inclusion of measurement error in Model 2 resulted in a slightly better fit than Model 1, so Udry's inattention to this provided no substantial challenge to his conclusions. That is, while it is correct to point out that Udry failed to adjust his estimates for measurement error, it is incorrect to claim that this slanted his results in favour of his model. His biosocial model actually works slightly better when reasonable measurement errors are adjusted for.

Next I examined one of the biological details in Udry's model, namely whether the net effects of the variables T and SHBG in Udry's model could be equated with Free-Testosterone's (Free-T's) effects, as in thesis Model 3. Non-equivalent results were found, indicating that the net effects of T and SHBG are slightly different from those of Free-T, though the basic pattern of effects was little changed. Model 3's sensitivity to measurement error was tested in Model 4. This extension of the measurement error issue addressed earlier in Models 1 and 2 also found that the model with measurement error fit better then the model without measurement errors and also left the essential findings of the model unchanged.

Having attempted to fine-tune Udry's theory in terms of measurement error and hormonal effects, this thesis shifted its focus to the Sexuality scale Udry used as a dependent variable. Udry mentioned that his Sexuality scale might contain "components that are quite disparate in actual behavior" (1988, p. 716). If this is so, Udry might have been forcing a set of variables with diverse causal connnections into his Sexuality scale. Udry justified his scale by doing factor analysis, but stronger tests are possible (Hayduk, 1996, p. 17). A common factor such as Udry's Sexuality factor implies proportionalities among the covariances for all the indicators of that Sexuality factor. These proportionalities must appear in the data if the model is to fit. Udry's model did not test these proportionalities because he had combined the multiple Sexuality items into a single Sexuality scale. The failure of the multiple items to behave in a consistent way would question Udry's Sexuality scale and hence could threaten the connections between Sexuality and the other variables in Udry's model. It was hypothesized that a model with multiple indicators of Sexuality would fail to fit the data as a result of not meeting the proportionality requirements of the Sexuality factor; and it was also hypothesized that models using the same Sexuality indicators individually would fit the data, though with somewhat varying effects in the model.

Three styles of models were developed to explore these hypotheses. The first of these models, Model 5, used five of the exact seven components of Udry's Sexuality scale, along with two very close approximations of the remaining two components, as seven indicators of Sexuality. As anticipated, this model failed to fit the data and all the diagnostic signs pointed to differences among the multiple Sexuality indicators. Models 6 to 12, each of which used a different one of the seven indicators as the sole indicator of Sexuality, all had very good fits to the data. Thus the seven indicators worked well individually but not as a set. The effects among the concepts were stronger in some of the seven models, and weaker in others. It is these differences that permit the Sexuality indicators to work well individually. When combined as seven indicators of a single Sexuality concept however, the model must use a single "compromise" estimate of each of the effects. The substantial variability in the effects for different indicators means that no "acceptable compromise" value is possible and hence the multiple indicator model fails.

The next model developed, Model 13, proposed that there was more than a single Sexuality concept but fewer then seven Sexuality concepts. Model 13 suggests it might take three Sexuality concepts (Interpersonal, Intrapersonal, and Cognitive) to span a total of ten indicators, each of which had face validity as an indicator of its respective Sexuality concept. Model 13 also failed to fit the data so even this style of aggregating the Sexuality indicators did not locate concepts that were invariant in their effect connections to Testosterone, Age, and the other concepts. A comparison of the results from Models 5 to 13 suggests that Udry's Sexuality scale had indeed forced an unrealistic causal concatenation into the singular sexuality variable, and that more than three separate Sexuality concepts would be required to span the Sexuality indicators in Udry's data set.

Having re-examined Udry's model in light of my three main criticisms of Udry's modeling methodology (i.e., he did not adjust for measurement error, nor did he perform an overall test of the fit of his model, and he aggregrated causally diverse Sexuality components into a Sexuality scale having a singular causal location in his model) I turned to one final investigation. I attempted to discern if there were reciprocal effects between Sexuality and Church Attendance. Udry had found that reversing the direction of his model's causal arrow between Church Attendance and Sexuality also led to a significant effect. Udry did not explore the possibility of reciprocal effects, as he believed that more complicated research designs would be needed to do so. However, I believed this could be done if I could locate a variable in Udry's data set that had a strong and theoretically sensible effect on either Church Attendance or Sexuality. This would have permitted LISREL to estimate the pair of reciprocal effects between Church Attendance and Sexuality. Unfortunately I was unable to find such a symmetry breaking variable in Udry's data set. The next approach taken was to develop two models, Models 14 to 15, which specified small effects from Sexuality to Church Attendance, while allowing the reciprocal effect from Church Attendance to Sexuality to be estimated, as had been done in Udry's model. The results for Models 14 to 15 suggested even a small effect from Sexuality to Church Attendance is sufficient to make the Church Attendance to Sexuality effect have the wrong sign. While this does indeed leave us with the choice of one effect or the other, the minor sexuality (in terms of overall Sexuality scores) of the adolescents and the obvious sexuality suppression of most churches leads us to agree with the direction Udry chose, namely from Church Attendance to Sexuality.

Despite the shortcomings of Udry's model, and the failure of the models with multiple indicators of Sexuality, the results of this re-examination generally support Udry's (1988) conclusion that Testosterone and Sex Hormone-Binding Globulin might play significant roles in producing variance in adolescent male Sexuality. More importantly T and SHBG modify how we think about the connections between Age, Puberty, Church Attendance, and Sexuality. T and SHBG seem to constitute intervening causal variables that make it impossible to discuss the social variables without integrating the hormonal variables into the discussion. This conclusion challenges the following excerpt from *The Blackwell Dictionary of Sociology: A User's Guide to Sociological Language*: "Although sociology cannot deny the fact that all human capabilities ultimately have a biological basis, the creative potential of human beings to shape and give meaning to their social environment is so great that the *biological factors have relatively little importance in sociological analysis*" (Johnson, 1995, p. 269, emphasis added). Due partly to allegiance to Durkheim's (1895) "injunction to seek the causes of social facts in preceeding social facts", and partly due to ignorance of behavior genetics, behavioral endocrinology, and behavioral pharmacology, many sociologists continue to develop models of human social behavior and thought which exclude biological factors (Udry, 1995, p. 1267). I believe that many of these type of models will be overthrown by the rapidly mounting evidence of ubiquitous effects of biological variables on all human social behaviors, with biological effects being at times stronger than those from social factors, as was shown in this thesis. For further examples, see Bouchard et al. (1990) and Udry (1995).

Threats to the Realism of the Models

Models are by definition unrealistic

Models in general, including the models in this thesis, are "highly oversimplified versions of the real world" (Blalock, 1964, p. 20). For instance, their "representation of biological and [social] effects is rudimentary" (Udry, 1988, pp. 718-719), and they exclude variables which have been shown to be important in other research (such as neurotransmitters; see van Haaren, 1993). Excluded variables might have produced nonrandom effects on more than one of a model's variables, thereby producing effects which are "confounded" with the modeled effects (Blalock, 1964, p. 21). If these other variables had been added to the models, the effects estimates might have been drastically altered (p. 19). Furthermore, most of the preceeding models assumed that all their "error" terms were uncorrelated with one another (with the exceptions including the errors on the concepts T and SHBG in Model 1X, and of Interpersonal, Intrapersonal, and Cognitive Sexuality in Model 13). Given the uncertainty about which factors actually produce a model's disturbance terms, "it is often impossible to provide a convincing justification for an assumption that each error term in a model is uncorrelated with all other error terms in the model" (Berry, 1984, p. 8).[26]

Research design deficiencies

Udry's cross-sectional, non-experimental research design lacked control over conditions, repeated observations, comparison groups, and full randomization (Denzin, 1978, p. 160), which renders his model's results, and mine, as "suggestive" rather than conclusive (Udry, 1988, p. 718). Even if an experimental design had been used, which would have been contrary to ethical standards and also perhaps technically unfeasible (although B.F. Skinner's fictional story "Walden Two" forebodes the possibility), the results might still be biased by the artificiality of the experimental setting.

Reactivity

Reactivity can be a serious threat to the models' causal propositions. According to Denzin, if "the investigator has failed to control his or her own reactivity, ... generalizations become impossible because the substantive-extrinsic nature of the causal proposition is now contingent on the research act, and no claim for substantive causality can be made." (1978, p. 139). I believe that there probably was some substantial degree of reactivity during Udry's data collection, although I do not know if this reactivity would have made Udry's and this thesis's results spurious.

Non-identicality of meanings

Although the uniform presentation (e.g., wording, context, and sequence) of Udry's questionnaire items to all the adolescents might not have elicited the same range of meanings among the adolescents (Denzin, 1978, p. 113-114; see also Osgood, Suci, and Tannenbaum, 1957), the questionnaire's simple words, clearly stated contexts, and sensible sequencing of items likely minimized wide ranges of meanings among the adolescents, rendering the problem of non-identicalities of meanings only a minor threat, if at all, to the results here.

Time ranges of effects

Taken at face value, the models might appear to depict a simultaneity of various effects among their variables, although in the real world there likely would not always have been a simultaneity of effects. Given that Udry's cross-sectional design makes it difficult to discern if any of the variables were operative in one instance but not in another, we cannot be sure whether any of the variables normally had no or weak effects but were exceptionally strong during the single "point" in time data collection, or the opposite.

Non-linearity

Udry's regression equations, and this thesis's structural equations, specified linear functions. However, "If behavioral processes also occur as cycles or oscillations, rather than as linear functions, then most of our research methodology is inadequate to measure these processes." (Kelly and McGrath, 1988, p. 24). And even if non-linear functions are specified, there are still mathematical constraints in describing the real world. In this regard, Formby states that, "We have seen that physical phenomena can be described by differential equations only after a process of simplication or idealization. Any physical process is essentially non-linear in character, in the sense that it cannot be described accurately by a system of linear equations, but this does not mean that it can be described accurately by a non-linear system. Such a system may be regarded as one step nearer to physical reality than a linear one." (1965, p. 108). To reduce the problem of non-linearity, Udry's model is based on adolescents, for whom effects of interest may be non-linear in the long-term (e.g., T rising then declining with age) but linear during adolescence.

Methodological constraints on knowing

If different methods lead "to different features of empirical reality, then no single method can ever completely capture all the relevant features of that reality" (Denzin, 1978, p. 15). Hence, in a paraphrase of Marshall McLuhan's "the medium is the message", one might say that the "methodology is the message".

Heterosexual bias

The sexuality measures used in Udry's model and this thesis's models had a "heterosexual bias" (Harrison, 1996, personal communication). That is, there was only one explicit non-heterosexual (i.e., homosexual or bi-sexual) item among the measures used: "Are you turned on sexually by men without clothes on?" (although the "thinking about sex" and "sexual fantasy" items might also be taken to include non-heterosexual content). This heterosexual bias would likely decrease the generalizability of results to a non-heterosexual population. Udry's data set does include scales of "Heterosexuality", "Masculine Attributes", "Femine Attributes", and items from these scales might possibly be used as indicators of non-heterosexual sexuality, but the individual items from these scales are not described in the data set.

Some consolation for Udry's lack of homosexual items comes from Schuster, Bell, and Kanouse's (1996) anonymous self-administered survey (N = 2026), in which homosexual sexual activities were rarely reported. Given that there is likely more openness to homosexual activity disclosure in the 1990's than in the early 1980's when Udry collected the data, the Schuster et al. study suggests that Udry's data might not be extremely biased by the lack of homosexual activity items.

The author himself

My experiential "Lebenswelt" (i.e., a multiplicity of factors, including personal interests, intellectual environment, and cultural milieu) might have "systematically influenced" (i.e., biased) this thesis and its models in ways that even I can not now appreciate.

Rival explanations

Udry's biosocial model attempted to integrate biological and sociological rival explanations of sexuality. Hence, Udry (1988) can be seen as straddling more extreme biological explanations on the one side, and more extreme sociological explanations on the other.

One of the more extreme biological views contends that pre-adolescent dispositions or traits, such as genetic and fetal trajectories, might be key determinants of behavior and cognition, including those that comprise adolescent sexuality. For instance, Halpern, Tucker, Udry, Campbell, Suchindran, and Mason (1994), using panel data, suggest that Testosterone might be "serving as a proxy for predispositional differences among individuals rather than reflecting direct hormonal effects on behavior" (p. 232). These predispositional differences might result to some degree from an individual's set of genetic and fetal factors which establish physical and behavioural development trajectories which fashion later relationships between pubertal biological change variables and behavioral change variables (Coe, Hayashi, and Levine, 1988). One example of a predispositional difference which might affect sexuality is temperament. Udry (1994) suggests that biologically based temperament might have a more basic role in the etiology of adolescent problem behaviors, including certain sexual behaviors, than the social factors that co-determine how temperament is manifested.

Contrary to the above extreme biological view, Bandura states that "The basic assumption of trait theories - that persons display generalized modes of behavior than can be predicted from a restricted sampling of responses - finds little empirical support" (1969, p. 14). Mischel (1968) reports that the belief in generalized response dispositions (traits) is often based on inferring behavioral consistencies from variable performances, even though there might be a high degree of specificity at the behavioral level.

Perhaps we can find a way to mediate between the above strong biological views and sociological views by following Jung's (1985) assertion that human nature is genetically underdetermined and socially co-determined.

Generalizability

In order to have some degree of generalizability beyond the unique situation described by the data, we have to assume that events can similarly re-occur and that people have some degree of "constant" attributes (Blalock, 1964, p. 7). If continual changes in reality prevents the essential exact repeatability of events and attributes (Pearson, 1957, in Blalock, 1964, p. 7), then generalizability will decline.

To the extent that the data describes a unique occurrence of reactivity among the participants, it can be argued that there is no generalizability of the models' results. Even if the issue of reactivity is not considered, there are still limitations on generalizing the results. For instance, since the models were developed and tested on white male adolescents living in a single American state, there might be no, or limited, generalization of the results to other races, females, adolescents in other regions, and to non-adolescents regardless of their region of residence.

Policy and Intervention Implications

Models of sexuality can affect policies and interventions. However, caution should be exercised, as models are based upon assumptions which are "often unstated and untestable" (Warwick and Pettigrew, 1983, p. 356, in Wallace, 1994, p. 233). These assumptions can result in misspecified models which lead to actions which "waste resources in the wrong direction" (Goldenberg, 1992, p. 74).

Although the models in this thesis are admittedly naive, simplified, heuristic representations of reality, they were tested with data collected from real people. Hence, with consideration of the aforementioned validity issues and generalizability limits, the models might be suggestive of locations in the real world where interventions might be more efficacious.

Future Directions

Integrate knowledge from evolutionary biology, behavior genetics, and behavior endocrinology into our theories of human sexuality

Given that genes are involved in the production of biological substances such as Testosterone and SHBG which seem to effect sexual behaviors and thoughts, we should integrate "knowledge from evolutionary biology, behavior genetics, and behavior endocrinology" into our theories of human sexuality (Udry, 1995, p. 1267). See also Plomin, Owen, and McGuffin (1994), who claim that genetic influences are ubiquitous on the social behaviors studied by sociologists.

Continue to investigate biosocial models and work to overcome opposition to the biosocial approach

I recommend that we continue to investigate biosocial models of human sexual behavior and cognition. Some potential barriers to the biosocial study of sexuality are: (1) traditional avoidance of interdisciplinary research; (2) entrapment within a paradigm which dismisses other perspectives; (3) fragmentation of sexuality research; and (4) cultural taboos about sexuality (Frayser, 1985, pp. 12-13). I believe these above four factors reciprocally inform one another, hence changing one might change the others.

The above factors (1) and (2) are sustained by "sociologists [who] have argued that it is not the business of sociology to explain individual differences, but to explain differences based on group membership" (Udry, 1988, p. 719). However, as Udry points out, "group membership may be a consequence of biologically based individual differences in behavioral predispositions (or even abilities) that select people into groups" (p. 719). Therefore, sociologists are theoretically remiss if they ignore individual differences (Udry, 1995). Factor (3) can be overcome if factors (1) and (2) are overthrown by a "scientific revolution" (Kuhn, 1962). Factor (4) seems to be currently decreasing in strength in North-American (e.g., the Disney corporation's televised presentation of "non-mainstream" sexuality, such as homosexuality, appears to be increasing despite resistance from the "religious right" - in particular certain Baptist organizations).

Re-examine Udry's (1988) models of female adolescent sexuality

My review of the literature suggests that Udry's (1988) models for females have not yet been re-examined. This lack of re-examination is subject to Eichler's (1991) admonition that:

> "Failing to analyze data by sex when they have been collected on both sexes may thus severely limit the utility of any findings and may, in fact, hide some of the most important aspects of a phenonemon ... the only safe course is to routinely

> analyze data by sex ... failing to do so can have not only serious theoretical consequences, but even more serious policy consequences as well" (p. 73).

Test the cross-cultural generalizability of Udry's (1988) models of sexuality

Udry (1988) built his models using data from one district in a single American state, and hence a next step is to test Udry's ideas using data obtained from other intra-American, and also non-American, cultural regions. (see Frayser, 1985, for an example of a cross-cultural research study which included sexuality items, Appendices A to E, pp. 423-493.)

Improve sexuality research methodology

With the current serious health consequences of sexual behavior (e.g., STD's such as HIV), knowledge of how sexual behavior is distributed is a critical research problem whose solution depends on achieving reliable and valid methods for conducting sexuality research (Catania, McDermott, and Pollack, 1994, p. 339). Furthermore, we continue to have "unresolved problems of participation bias and measurement error" and we do not have "the methodological precision necessary for coping with the information demands" involved in social interventions (p. 340). For instance, "a solid validity index of self-reported sexual behavior is not available" (p. 341).

Use phenomenological and ethnomethodological approaches

Complementary advances in our understanding of sexuality can be made by using phenomenological and ethnomethodological approaches. For instance, Schutz (1932) argues that the seeking of the subjective point of view might help prevent the world of social reality being replaced by a fictional non-existing world created by the observer of the subject. That is, a person's subjective experience cannot currently be accurately described by observable actions.

Given that certain observable actions might be preceded by certain styles of "spontaneous activities" (Schutz, 1932), that is, conscious and/or unconscious physiological activities (Libet, 1996), predictions of sexual behaviors and thoughts might be obtained by locating these "spontaneous" physiological correlates.

Investigate fetal hormonal effects on dimorphism of sexual behaviors and thoughts

Dimorphism of sexual behavior and thought might partially arise from fetal hormonal effects. For instance, Udry, Morris, and Kovenock (1995) report that androgen exposure in the 2nd trimester of fetal life, in conjunction with later adult androgens, explains a substantial proportion of the variance in women's gendered behavior. To further investigate this type of findings, Collaer and Hines (1995) propose that correlative human studies be done "in which repeated samples of hormones obtained during development are related to subsequent behavior" (p. 97).

Investigate the role of sensation seeking and disinhibition in sexuality

Bogaert and Fisher (1995) suggest that we should consider the role of sensation seeking and disinhibition in sexuality. They found significant correlations between the number of university men's sexual partners and sensation seeking, and their principal components analysis suggested that a common factor labeled "Disinhibition" might be partly responsible for the relationship between sensation seeking and the number of sexual partners. Kalichman and Rompa (1995) also noted a link between sensation seeking, disinhibition, and HIV risk behaviors.

Investigate the role of symbols in sexuality

Symbols can have both sensory and ideological power (Turner, 1967), and hence can be important factors in sexuality. Symbols can elicit biological responses connected to sexuality, and they can also effect the biological processes which help fashion a person's views on sexuality. If we equate symbols with environmental cues, we can assert environmental effects on sexuality. (See Jung, 1985, for a discussion of how the "template" metaphor describes environmental influence.)

Consider the role of energy processes in sexual behaviors and thoughts

In the Parson and Shils (1959) analysis of social action they assert that behavior has four characteristics: "it is goal-oriented; occurs in situations; is normally regulated; and involves an expenditure of energy." (Denzin, 1978, p. 49). The first three of these characteristics were explicitly (even if minimally) considered in Udry's model. This leaves the issue of energy un-examined by Udry. Energy is an important issue for the social sciences, especially if we consider the role of energy in the process of habitualization. In this regard, Berger and Luckmann state that "... by providing a stable background in which human activity may proceed with a minimum of decision-making most of the time, it [habitualization] frees energy for such decisions as may be necessary on certain occasions." (1967, p. 53). For sexuality, an example of the role of energy is found in Frayser's comment that, due to the swelling of the external genitalia of some female monkeys and apes, "The female conserves her energy by having males approach her, rather than seeking them out" (1985, p. 33).

The issue of energy keeps arising in social science discourse, but it remains largely un-examined. With regard to this thesis, energy processes are an essential part of a person's sexual behaviors and thoughts, given that these phenomena are emergent properties of "a physiological system in which a thermodynamically improbable state is maintained by exchanges of energy (including matter) between the various subsystems, and between the system as a whole and its environment" (Jung, 1985, p. 173). That is, these continual energy exchanges provide a continual succession of transient structural constraints which allow for (and are perhaps identical to) a person's continual succession of transient sexual behaviors and thoughts. (For a discussion of energy vis-a-vis emergent properties, see Yates, 1987.)

Notes

[1] Sociologists' views of human nature are definately incomplete if they exclude biological variables (Wrong, 1961; Jung, 1985; Udry, 1995). To help remedy this, Wrong asserts that sociologists "must start with the recognition that *in the beginning there is the body*" (1961, p. 191). Wrong adds that the concomitant prospect of "biological determinism" causes "sociologists [to] draw back in fright", a response which contributes to "disembodied", "non-materialistic", and "de-sexualized" views of human nature (p. 191). Both the embodied nature of humans and biological determinism is described by the poet William Wordsworth in the following excerpt: "The eye - it cannot choose but see; We cannot bid the ear be still; Our bodies feel, where'er they be, Against or with our will." (1958, p. 40). That is, the conscious "self" is believed to be an "embodied self" that is aware of itself via "bodily sensations", hence "*Sentio, ergo sum* - I feel, therefore I am" (Humphrey, 1992, p. 115).

Along with embodied views such as those above, disembodied views of human nature are common, and are often sustained and informed by their purveyors' conceptual loyalty to the "socially-situated mind" ontological metaphor and its concomitant modes of discourse (Jung, 1985). Disembodied views are maintained in "religious" writings such as the "Tibetan Book of the Dead" and the Judeo-Christian "Gospels"; and are also supported by the supposedly disembodied experiences of "psychics", "astral travelers", "shamans", and "exorcists".

[2] Udry states that his 1988 paper "should be set in the context" of three previous papers in the same research program: Udry et al. (1985), Udry et al. (1986), & Udry and Billy, (1987) (see Udry, 1988, p. 715, for summaries of these earlier papers).

[3] Throughout this thesis, latent concepts are capitalized to acknowledge that latent concepts have non-perfect epistemic correlations with their manifest indicators. Occasionally, both concepts and indicators may appear as capitalized, for example when Udry specified perfect epistemic correlations between his concepts and indicators.

I provide the caution that a "supposedly" distinct naming of something, such as "Concept X", does not necessarily entail that there is any real distinctiveness to the thing named (see Humphrey, 1992, pp. 31-36), as we will see for Udry's Sexuality concept.

[4] The Social Sciences and Humanities Research Council of Canada provides the directive that, "studies involving only one sex are legitimate and justifiable ... studies involving male subjects only may likewise be appropriate, as long as no claims are made that the findings apply to everybody" (Eichler and Lapointe, 1985, p. 21, paragraph C.2.2.). This thesis adheres to the above directive by not generalizing its results to females or anyone else not closely resembling the males in the sample.

The female adolescents' data was used by this author in a companion project to this thesis, which was less dependent on closely approximating Udry's model (Stratkotter, unpublished; for details please contact the author).

This thesis does not re-examine Udry's (1988) comparison of his male and female models. This author recommends that any re-examination of Udry's above comparison should consider the following three issues: (1) Udry (1988) analyzed hormonal data from postmenarcheal females only (N = 78), whereas the males cover a greater range of pubertal development; (2) although Udry obtained the female hormonal data at two temporally distinct points in the menstrual cycle, his depiction of the results of female biological and biosocial models (pp. 716-717, Tables 3 to 5) appears to combine follicular and luteal stage hormonal effects together, which might be misleading if there were temporal differences in the initiation of their effects and/or their types of effects; (3) The male hormone variables used in Udry's model had no missing cases, whereas all 26 of Udry's female hormone variables had 18 or more missing cases.

5 Bandura asserts that reactivity is inherent in social interchanges, as each person's behavior "exerts some degree of control over the actions" of the other(s) (1969, p. 46). Goldenberg describes how potential reactivity among the adolescent subject, his parent(s), and the nurse/interviewer affects how we should view the data construction: "the presence of an observer does not merely create reactivity but also reality. In this view reactivity is not a distortion of reality; it is the only kind of reality, and as such is quite unavoidable in principle and constitutes the only data to which we ever actually have access" (1992, p. 237).

One possible indicator of reactivity was the nurse/interviewer's response to the question: "Did the adolescent show signs of being upset?". Nurse 1 did not assess any of her adolescent respondents as "being upset", nor did Nurse 2 (however, her response to the above question is coded as missing for Cases 15 and 67, these two adolescents might have been "upset"); Nurse 3 assessed Case 73 as "being upset", Nurse 4 assessed cases 29, 56, and 83 as "being upset" (while her assessment of Case 86 is coded as missing), and Nurse 5 assessed Cases 23, 33, 72, and 97 as "being upset". I do not know if, when, and how often any nurse's assessment of "upset" or "not upset" accurately described the adolescent in question. There might have been some non-zero amount of reactivity involving "being upset"; however, these reactivity effects have unknown effects on the coefficients of interest in this thesis.

6 This re-examination via different estimation procedures is considered to be an essential scientific task (Popper, 1959, 1963; Lykken, 1968; Denzin, 1989).

7 T and SHBG are located in Udry's model (1988, p. 718, Figure 2) by the heading Hormones. This makes Udry's model less clear than if he had drawn separate arrows to and from T and SHBG, rather than single arrows to and from Hormones with abbreviations for T and SHBG next to these arrows. To improve on Udry's diagram, thesis Models 1, 2, 5, 14, and 15 depict both T and SHBG, and hence depict their effects separately.

8 SHBG is also referred to as testosterone binding globulin (TBG or TeBG), or as sex steroid binding protein (Winters, 1995, p. 1050; White, Pescovitz, and Cutler Jr.,

1995, p. 655); while the SHBG that is produced by the Sertoli cells of the testis is designated as testicular androgen binding protein (ABP) (Winters, 1995, p. 1050). Udry reports that "In the very newest literature, it [SHBG] is now called SHBP sometimes (sex hormone binding protein)" (1996, personal communication via e-mail).

Of the above terms, only TBG (i.e., "Male: Testosterone Binding Globulin Level") appears in the male portion of Udry's data set; whereas in the female portion, both TBG and SHBG appear (e.g., "Female Luteal Stage: TBG Level", "Female Luteal Stage: SHBGC Level", "Female Luteal Stage SHBGM level". Both I and Sociometrics are unsure as to what the "C" in SHBGC and the "M" in SHBGM represent. I was unable to locate these terms in the endocrinology texts cited in this thesis, and "Sociometrics was not able to obtain [from the original investigators] the full hormone names for these abbreviations", Kaplan, Lang, and Card, 1992, p. 11). This inconsistent use of terminology makes me suspect that different labs and/or personnel were handling the hormone measures; if this is so, there might be implications for reliability and validity.

9 There are "intracellular receptors that bind testosterone and DHT with high affinity" (Winters, 1995, p. 1053), but "it has not been possible to unequivocally determine in which tissues which steroid [T or DHT] is the primary or sole initiator" (Norman and Litwack, 1987, p. 495). Hence, there is continued debate over whether T or DHT is the effectually most potent androgen, with support for either position dependent on the biological location in question (Mitchell, 1996, personal communication).

10 It is unclear why Udry's data set provides no measures of the male adolescents' DHT levels, given that it does provide measures of the female adolescents' DHT levels.

11 Winters reports that "the finding of membrane binding sites for ABP [androgen binding protein] in the epididymis and for SHBG in testis ... suggests that these binding proteins" might be directly involved in androgen action (1995, p. 1050).

12 The National Institutes of Health provided funding for the data collection via grants to the Carolina Population Center, and funding for the preparation of the revised documentation for public distribution was provided by contract (282-91-0011) between the U.S. Office of Population Affairs and Sociometrics Corporation.

Sociometric's postal mailing address is Sociometrics Corporation, 170 State Street, Suite 260, Los Altos, California 94022-2812; and the phone number is (415) 949-3282.

13 Udry's racial identification item is worded as: "What is this person's race?", with the response choices being "White", "Black/Afro American", and "Other (Specify:________)."

14 The data set's school identification variable (labeled as MEXI1533) indicates that the male adolescents were from nine schools, with the N per school being as follows: 2,

17, 9, 3, 23, 44, 1, 1, 1; with one adolescent having a missing value for school identification. I would have liked to have stacked all the thesis models in such manner that possible school-wise effects might be detected, but considered the N too small to maintain adequate testing power.

15 There were five different nurse/interviewers used in the study, and they were apparently all female (as indicated by the User's Guide comment that "the nurse/interviewer introduced herself", p. 4). However, both Udry (1988) and the data documentation are unclear if the same nurse/interviewers were used for each of the grade nine and ten adolescents during their separate dates of interview/questionnaire responding and giving of their biological samples.

16 Butler et al. (1989) report that T levels in most male adolescents usually decrease between the morning and afternoon, with late afternoon and early evening T levels being nearly similar. Hassler and Nieschlag (1991) also report circadian rhythms in adolescents' T levels, with their study showing a "gradual [salivary] testosterone decrease from morning to evening levels" that was greater in boys who had reached puberty (indicated by "breaking of the voice") compared to boys that had not (p. 515). For all the male adolescents (N = 42), the evening (6 to 7 p.m.) salivary T mean standard deviation was about 20% lower than both the midday (12 a.m. to 1 p.m.) and morning (8 a.m. to 9 a.m.) standard deviations (p. 515, Table 5).

17 Since serum T is highly correlated with salivary T (Vittek et al., 1985), results from serum measures might generally be similar to results from saliva measures.

18 A check was made of Udry's "Male: Free Testosterone Index" (labelled as BFSI1006) by using Udry's formula to calculate a new variable CHEK1006. That is, CHEK1006 = [testosterone (ng/dl) / SHBG (nmol)] X 100. (Despite Udry's T assay being reported in ng/ml, 1988, p. 713, he uses the ng/dl value for T in his Free-T Index formula.)

The PRELIS 1.20 computer program (Joreskog and Sorbom, 1990) indicated that BFSI1006 has a mean of 41.825 (and a range of .900 to 137.900) whereas CHEK1006 has a mean of 12.164 (with the range .253 to 40.052); and Udry's values of BFSI1006 are approximately 3.5 times as large as the values of CHEK1006 (for e.g., the highest value of BFSI1006 is 137.900, while the highest value of CHEK1006 is 40.052; and the lowest value of BFSI1006 is .900, while the lowest value of CHEK1006 is .253). This discrepancy is not explained by Udry's T assay being reported in ng/ml whereas his Free-T formula uses T's ng/dl values.

The correlation between BFSI1006 and CHEK1006 is .9993. A correlation coefficient of 1 rather than .9993 was expected between BFSI1006 and CHEK1006. A scatterplot (produced by the "SPSS for Windows - Release 6.1" computer program, © by SPSS Inc.) of BFSI1006 (values on the y axis) and CHEK1006 (values on the x axis) located 2 cases which did not fall exactly on a straight line (identified as cases 66 and 74) (There may have been more cases so close to the line that they escaped visual detection).

As part of my search for the cause of the above discrepancies, I checked to see if Udry's "Male: Salivary Free Testosterone Ratio NG" (labelled as BFSI1699) would equal my new variable CHECKSAL = ["Male: Salivary Testosterone NG Level" (BFSI1700) / "Male: Testosterone Binding Globulin Level" (BFSI1703)] X 100. Udry's BFSI1699 (mean = .001, s.d. = .001, N = 101) did not equal my CHECKSAL (mean = .077, s.d. = .077, N = 101).

The above procedures did not reveal the reason why my CHEK1006 does not equal Udry's BFSI1006.

19 A check of the accuracy of the variance-covariance matrix created by PRELIS 1.20 (in SPSS 6.1) was made by comparing it to a variance-covariance matrix of the same variables created by a different SPSS computer program, "REGRESSION" in SPSS 6.1. This comparison confirmed an equality of values. A check was also made of the integrity of LISREL's entry of the PRELIS variance-covariance matrix. This check located one discrepancy in rounding: the PRELIS covariance of the variables having the thesis labels GLOBULIN and TURNON equaled -10.385; whereas LISREL reports this covariance as equaling -10.384. This discrepancy was considered to be too small too effect the substantive conclusions based on LISREL's calculations.

20 Since the χ^2 statistic and its accompanying p value are highly dependent on N, the sensitivity of Model 1's χ^2 and p to the value of N was indicated by successively re-estimating Model 1 (which has N = 100) with fictitious N's of 25, 50, 200 (a value suggested by Hoelter, 1983), 500, and 1000. Since fictitious N's were used, I caution the reader that the results (depicted below in Notes Table 1) are only suggestive of the results which would be obtained if the same covariance matrix had been observed for the various sample sizes.

Notes Table 1

N	χ^2	p
25	.39	.943
50	.79	.852
100 (real)	1.60	.660
200	3.21	.361
500	8.04	.045
1000	16.11	.001

Very large N's can lead to the rejection of nearly any model, with better models requiring larger N's to be rejected (Dabbs, 1992, p. 816). Hoelter (1983) proposed that most substantial model failures could be detected with an N of about 200. Hence this model has a "satisfactory" fit, if we consider a satisfactory fit to be around a 30% probability or better. There are ongoing debates as to what p value indicates a satisfactory fit. Hayduk recommends using a χ^2 "$p > .75$ or so, instead of the traditional .05, to acknowledge our implicit favoring of the null hypothesis" (1996, p. 69). The .66 value is well over the traditional limit, though not as good as Hayduk's conservative criterion. The tabled values are also reasonably in line with Rindskopf's suggestion that the model should fit with between five to twenty-five times the number of observed indicators in the model (1981, p. 180).

[21] The unusual occurrence of seven standardized residuals having an absolute value of 1.199 appeared to have no cause "other than that the sparsness of the model with 3 d.f. was introducing some inscrutable constraint" (Hayduk, 1997, personal communication).

[22] Here I am glossing over T's effects on the development process of the human organism (Collaer and Hines, 1995). T might have had effects on certain of the behaviors and cognitions reported by the adolescents before their T was measured by Udry's lab.

[23] The sensitivity of Model 2 to changes in its measurement error specification was investigated in a series of 12 LISREL models in which each one of Model 2's six Θ_ε values was successively and individually fixed, first at a value half and then at double its value as depicted in Table 3. (This procedure was recommended by Hayduk, 1987, p. 125; 1996, p. 28, and has been used by Hayduk, 1987, p. 125; and Germain, 1994, p. 54.) Since a theta epsilon value affects a concept's meaning, the halving and doubling procedure alters the concept's meanings. Therefore, each of these models is representative of a slightly different theory, because this institutes conceptualizations that are closer to, or further form the indicators.

11 of the 12 model runs converged and showed generally similar results to the original Model 2, with the exception being the run in which the Θ_ε for Pubertal Development's indicator had been doubled from its inital value in the original Model 2. This run failed to converge after 54 iterations, apparently because Pubertal Development and its indicator were now too "loosely" connected (this result is congruent with Hayduk's report that models having single indicators with greater than 40% to 50% error variance are prone to estimation problems, 1987, p. 122).

[24] Model 13 is likely unrealistic in that it does not specify one-way or reciprocal effects among the indicators of its three Sexuality factors; nor does it include effects among the three Sexuality factors themselves. For instance, the cognitive components of Sexuality might influence the other two modes of Sexuality. Also, it was assumed that the masturbation indicators measured private solo masturbation, rather than masturbation combined with interpersonal physical interaction.

[25] Freeing the error variances for all the indicators except the indicators used to scale the concepts resulted in a χ^2 of 163.17 with 65 d.f. and $p = .000$, so the assertion of specific error variances is not the primary source of the difficulties with this model.

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26 LISREL assumes "that the values of the disturbance are drawn from the same probability distribution for all units the population. This subsumes, in particular, the assumption of 'homoskedacity'" (Duncan, 1975, pp. 4-5). LISREL's estimates are believed to be minimally affected by the degree of homoskedacity, though the standard error of the estimates may be influenced by heteroskedacity. For instance, Harlow (1985) and Laake (1987) "suggest that standard errors of ML and GLS estimates may be systematically under- or overestimated if the distributions have heavier or lighter tails than the normal distribution" (Joreskog and Sorbom, 1989, p. 192).

Joreskog and Sorbom tested LISREL's tolerance to variables that were "far from being normally distributed" (1989, p. 206). Their results were similar to the theoretical results of Browne (1987) and Anderson and Amemiya (1985) which suggest that ML is robust against non-normality (1989, pp. 207-208). Joreskog and Sorbom's general conclusion in this regard is that, "If the variables are highly non-normal, it is still an open question whether to use ML (or GLS) or WLS with a general weight matrix" (1989, p. 205), whereas, "If the distribution of the observed variables are moderately non-normal, skewed or peaked, the ML and GLS methods may still be used to fit the model to the data and, if interpreted with caution, standard errors and χ^2 values together with other fit statistics can still be used to assess the fit of the model" (1989, p. 191).

The use of LISREL with moderately non-normally distributed variables and ordinal variables is supported by Joreskog and Sorbom's assertion that "LISREL 7 provides efficient estimates and correct asymptotic χ^2 and standard errors under non-normality of the observed variables and when some or all of the observed variables are only measured on an ordinal scale" (1989, p. ii).

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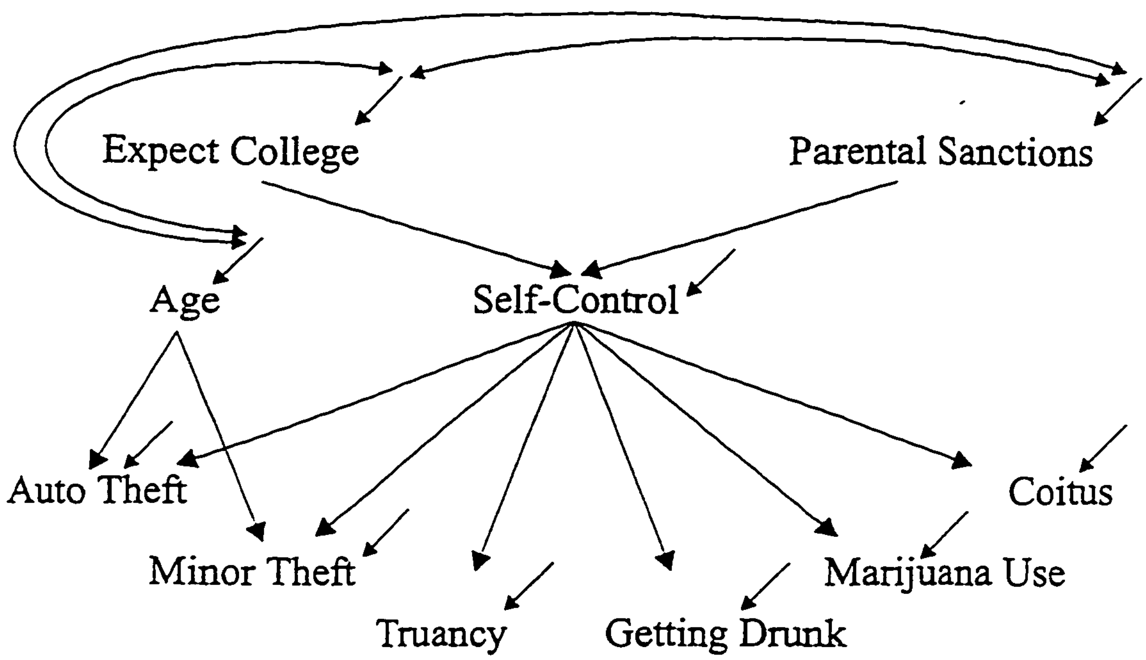
APPENDIX A

Checking if Udry's data approximate Gottfredson and Hirschi (1994)

Appendix A Figure A1



The above figure was derived as follows:

Gottfredson and Hirschi (1994) state that, "Recently, we advanced a general theory of crime and argued its applicability to a wide variety of delinquent, deviant, and reckless acts" (p. 41). This assortment of acts is characterized by the seeking of immediate benefits despite the risk of long-term cost. The general trait of individuals most likely to perform these criminal, deviant, and reckless behaviors is "low self-control" (p. 41). These behaviors have three properties: (1) they reach a peak in individuals in late adolescence or early adulthood (ages 17-22); (2) individuals who commit any one of these behaviors tend to commit others (versatility); and (3) individuals who are relatively highly involved in these behaviors at one time tend to be highly involved at later times (stability) (p. 41). The versatility of the behavioral manifestations of low self-control indicates the "illusion of specific causation" of each of these behaviors (p. 44).

Gottfredson and Hirschi (1994) also state that, "The ubiquity of the age effect led us to conclude that **age has a direct effect on crime**" (p. 46), while "**low self-control**" **is the common cause** of adolescent delinquent events and behaviors such as "**auto theft**", "**common** theft", "**truancy**", "**alcohol abuse**", "**drug taking**", and "**unrestrained sexual activity**" (1994, pp. 42,43,44,47). The sources of self-control are "generated in the early years of life, primarily through parental action" ... when "parents care about their children, monitor their actions, **sanction it negatively self-control** will become a stable characteristic of the child" (Gottfredson and Hirschi, 1994:44). The school's role in the development of **self-control** includes helping the child develop "**a commitment to the future**" (p. 44) (emphasis added above).

To test Gottfredson and Hirschi's (1994) theory, I transformed their above verbal description of their theory's causal specifications into a structural equation model, wherein their concepts were matched with indicators derived from Udry's data set. I then used LISREL to see how well my representation of Gottfredson and Hirschi (1994) fit Udry's adolescent data. (The estimates are depicted below in Appendix A, Table A1.) The model did not fit Udry's data (i.e., the χ^2 probability is 148.51 with 32 d.f., p = .000), hence I did not use Gottfredson and Hirschi (1994) as a theoretical template for my thesis. The following details are provided to permit the reader to see the process that was used in my test of Gottfredson and Hirschi (1994).

Age (my label = AGEMALE / the data set's label = AGSI1203) was indicated by subtracting the adolescent's "reported birthdate" from the "interview date", with the result reported in years.
Self-control level (SCONTROL / PETI1534) was indicated by the adolescent's total score on Udry's Self-Control scale, which he had constructed using items from the Gough Adjective Check List© (For his Self Control Scale, Udry did not save the individual item data, which had been scored as "checked" or "not checked") (Udry, 1996, personal communication).
Auto Theft level (STEALCAR / CIHI1234) was indicated by the adolescent's response to the question "Have you ever driven a car without permission?" Listed responses and my recodings were: Yes = 1, No = 0. (Note: Using dichotomous dependent variables may lead to biased estimates in LISREL, but since I did not plan to use the estimates in a tentative and suggestive way, this was tolerated in this model.)
Common Theft level (LOWTHEFT / CIHI1238) was indicated by the adolescent's response to the question: "Have you ever taken things of some value ($50 or less) that did not belong to you?" Listed responses and my recodings were Yes = 1, No =2.
Truancy level (TRUANCY / CIHI1230) was indicated by the adolescent's response to the question: "Have you ever cut school or class?" Listed responses and my recodings were Yes = 1, No = 0.
Alcohol Abuse level (GOTDRUNK / SAHI1227) was indicated by the adolescent's response to the question: "Have you ever been drunk?" Possible responses and my recodings were Yes = 1, No = 0.
Drug-taking level (MARIJUAN / SAHI1235)was indicated by the adolescent's response to the question: "Have you ever smoked marijuana?" Possible responses and my recodings were Yes = 1, No = 0.
Sexual Activity level (COITUS / SXHI1357) was indicated by the adolescent's response to his reading of: "To <u>have sex</u> (sexual intercourse) is to put the male penis into the female vagina. This is sometimes called "screwing" or "getting laid" Please mark an x in the box that best tells

about you." The listed responses and their codings were: "I have never had sex with a girl." = 0, "I have had sex with a girl 1 or 2 times in my life." = 1, "I have had sex with a girl more than 2 times in my life." = 1.

Parent(s) level of Sanctioning Deviant Behavior Negatively (PUNISHME / SXCI1645) was indicated by the adolescent's response to the question: "How likely do you think each thing would happen to you if you have sex next month with a girl you know well?: I would be punished by my parents." Possible responses and my recodings were: Would happen for sure = 5, Probably would happen = 4, Even chance (50-50) it would happen = 3, Probably wouldn't happen = 2, Sure it wouldn't happen = 1.

Commitment to the Future level (COLLEGE / EDAI1352) was indicated by the adolescent's response to the request: "Please mark an x in the box which best tells how important it is to you that you go to college." Listed responses and their codings were Box 1 (labelled as "Not Important") = 1, Boxes 2 to 5 (not labelled) = 2 to 5, and Box 6 (labelled as "Very Important") = 6.

Appendix A Table A1

Testing Gottfredson and Hirschi (1994) - Variance-Covariance Matrix to be Analyzed

	AGEMALE	PUNISHME	COLLEGE	SCONTROL	STEALCAR	LOWTHEFT
AGEMALE	.636					
PUNISHME	-.189	2.082				
COLLEGE	-.162	.372	2.049			
SCONTROL	.356	1.922	-.985	66.012		
STEALCAR	.046	-.122	.030	-.272	.239	
LOWTHEFT	.068	.016	-.092	-.416	.046	.238
TRUANCY	.087	-.060	-.182	-.337	.079	.036
GOTDRUNK	.181	-.135	-.020	-.677	.068	.041
MARIJUAN	.081	-.037	-.150	-1.075	.100	.057
COITUS	.073	-.104	-.059	-.941	.055	.030
	TRUANCY	**GOTDRUNK**	**MARIJUAN**	**COITUS**		
TRUANCY	.249					
GOTDRUNK	.089	.250				
MARIJUAN	.122	.120	.248			
COITUS	.052	.080	.105	.213		

Appendix A Table A2

Results for the Model Derived from Gottfredson and Hirschi (1994)

Effects Among the Concepts:	*(Unstandardized)*	Standardized
Parental Sanctions to Self-Control	*(1.043)*	.185
Expect College to Self-Control	*(-.670)*	-.118
Self-Control to Auto-Theft	*(-.005)*	-.075
Self-Control to Minor-Theft	*(-.007)*	-.115
Self-Control to Truancy	*(-.005)*	-.083
Self-Control to Getting Drunk	*(-.010)*	-.167
Self-Control to Marijuana Use	*(-.016)**	-.266*
Self-Control to Coitus Experience	*(-.014)**	-.251*
Age to Auto-Theft	*(.074)*	.121
Age to Minor-Theft	*(.111)*	.182
χ^2 probability	148.51 (32 d.f., p = .000)	
AGFI	.536	
Number of cases	100	

* = LISREL T value > 2.00 ("Parameters whose t-values are larger than two in magnitude are normally judged to be different from zero", Joreskog and Sorbom, 1989, p. 89).

APPENDIX B

Appendix B Table B1

Recodes and Original Codes of Variable Values for Models 1 to 15

```
numeric TESTOSTE (F8.3). compute TESTOSTE=bfsi1702.
compute GLOBULIN=bfsi1703.
compute FREETEST=bfsi1006.
compute AGEMALE=agsi1203.
numeric PUBERTAL (F8.7). compute PUBERTAL=bfsi1004.
compute CHURCHGO=rlbi1106.
numeric SEXSCORE (F8.7). compute SEXSCORE=bfsi1005.
compute COITUS=sxhi1357.
compute SELFPLAY=sxhi1384. recode SELFPLAY (1=0) (2=1).
compute SHOOT=sxbi1435. recode SHOOT (-998=0).
compute NOSHOOT=sxbi1436. recode NOSHOOT (-998=0).
compute SEXMONTH=sxbi1546. recode SEXMONTH (-998=0).
compute OUTLET=SHOOT + NOSHOOT + SEXMONTH.
compute SEXEXP=sxhi1537.
compute WEIGHTED=sxhi1538.
compute TURNON=sxbi1601.
compute THINKSEX=sxci1599.
compute LIKELYDO=sxci1539. recode LIKELYDO (1=4) (2=3) (3=2) (4=1) (5=0).
compute LIKESEX=sxai1540. recode LIKESEX (1=4) (2=3) (3=2) (4=1) (5=0).
compute INTENDTO=sxii1541. recode INTENDTO (1=4) (2=0) (3=2).
compute FUTURSEX=LIKELYDO + LIKESEX + INTENDTO.
compute FANTASYS=sxhi1548. recode FANTASYS (1=0) (2=1).
compute IFELTHER=sxhi1268. recode IFELTHER (1=0) (2=1) (3=2).
compute SHEFELT=sxhi1266. recode SHEFELT (1=0) (2=1) (3=2).
compute IMADEOUT=sxhi1262. recode IMADEOUT (1=0)(2=1)(3=2).
```

APPENDIX C

Appendix C Table C1

Variance-Covariance Matrix for Thesis Models 1 to 15

	AGEMALE	TESTOSTE	GLOBULIN	FREETEST	PUBERTAL	CHURCHGO
AGEMALE	.636					
TESTOSTE	1.008	6.551				
GLOBULIN	-3.960	-9.698	187.765			
FREETEST	11.949	54.986	-246.118	711.144		
PUBERTAL	.364	1.319	-4.865	13.259	.777	
CHURCHGO	-.155	-.792	1.696	-7.746	-.181	.133
SEXSCORE	.310	1.209	-4.444	12.256	.306	-.281
COITUS	.073	.404	-1.748	4.254	.101	-.073
SELFPLAY	.077	.410	-1.563	4.246	.037	-.077
OUTLET	.303	1.793	-7.397	19.305	.124	-.157
SEXEXP	.843	3.540	-14.321	38.431	1.072	-1.077
TURNON	.498	1.796	-10.385	20.983	.555	-.065
THINKSEX	.416	1.299	-9.635	16.896	.438	-.475
FUTURSEX	.514	2.040	-7.854	20.364	.758	-.989
IFELTHER	.282	1.041	-3.009	9.519	.290	-.195
SHEFELT	.222	.942	-3.116	9.496	.248	-.211
SHOOT	.246	1.221	-4.937	14.027	.168	-.192
NOSHOOT	.000	.115	-1.033	.429	-.169	.031
FANTASYS	.038	.179	-1.113	2.395	.019	-.112

	SEXSCORE	COITUS	SELFPLAY	OUTLET	SEXEXP	TURNON
SEXSCORE	.954					
COITUS	.263	.213				

(conitinued)

Appendix C Table C1 (continued)

	SEXSCORE	COITUS	SELFPLAY	OUTLET	SEXEXP	TURNON
SELFPLAY	.113	.012	.220			
OUTLET	.492	-.017	.738	4.896		
SEXEXP	2.576	.838	.225	1.474	11.246	
TURNON	.486	.130	.217	.995	1.737	4.808
THINKSEX	.693	.156	.209	.851	2.090	2.126
FUTURSEX	1.160	.541	.224	.639	4.168	1.502
IFELTHER	.804	.238	.056	.275	2.400	.315
SHEFELT	.730	.230	.062	.339	2.080	.308
SHOOT	.272	-.099	.552	3.967	.998	.596
NOSHOOT	.005	-.044	.183	.775	-.013	.236
FANTASYS	.102	.016	.058	.259	.201	.514

	THINKSEX	FUTURSEX	IFELTHER	SHEFELT	SHOOT	NOSHOOT
THINKSEX	2.569					
FUTURSEX	1.309	5.323				
IFELTHER	.512	.991	.796			
SHEFELT	.481	1.162	.627	.767		
SHOOT	.532	.038	.160	.143	3.731	
NOSHOOT	.227	.087	-.060	-.018	.197	.632
FANTASYS	.299	.229	.066	.106	.188	.076

	FANTASYS
FANTASYS	.246

APPENDIX D

Appendix D Table D1

Comparison of Udry's model, Model 1 (SEXSCORE), Model 1B (WEIGHTED), Model 1C (SEXEXP)

Effects Among the Concepts	Udry's model	Model 1	Model 1B	Model 1C
Age to T	.49*	.494*	.494*	.494*
		*(1.584)**	*(1.584)**	*(1.584)**
Age to SHBG	-.36*	-.362*	-.362*	-.362*
		*(-6.221)**	*(-6.221)**	*(-6.221)**
Age to Pubertal D.	.26*	.245*	.245*	.245*
		*(.269)**	*(.269)**	*(.269)**
Age to Sexuality	.08	.156	-.025	.059
		(.190)	*(-.096)*	*(.247)*
T to Pubertal D.	.42*	.412*	.412*	.412*
		*(.141)**	*(.141)**	*(.141)**
SHBG to Pubertal D.	-.20*	-.203*	-.203*	-.203*
		*(-.013)**	*(-.013)**	*(-.013)**
Pubertal D. to Sexuality	.04	-.012	.063	.096
		(-.013)	*(.218)*	*(.366)*
T to Church Attendance	-.30*	-.280*	-.280*	-.280*
		*(-.116)**	*(-.116)**	*(-.116)**
SHBG to Church A.	.06	.039	.039	.039
		(.003)	*(.003)*	*(.003)*
T to Sexuality	.44*	.331*	.259*	.228*
		*(.125)**	*(.306)**	*(.297)**
SHBG to Sexuality	-.35*	.-176	-.186	-.168
		(-.012)	*(-.041)*	*(-.041)*
Church A. to Sexuality	-.17*	-.129	-.184	-.188*
		(-.118)	*(-.524)*	*(-.589)**
Sexuality R^2	not available	.299	.209	.245
χ^2 (d.f.)	not available	1.60 (3 d.f.)	1.61 (3 d.f.)	1.61 (3 d.f.)
p	not available	.660	.657	.657
AGFI	not available	.963	.963	.963
Number of cases	approx. 102	100	101	101

* = LISREL T value > 2.00 ("Parameters whose t-values are larger than two in magnitude are normally judged to be different from zero", Joreskog and Sorbom, 1989, p. 89).

APPENDIX E

Appendix E Table E1

Comparison of Udry's model, Model 3 (SEXSCORE), Model 3B (WEIGHTED), Model 3C (SEXEXP)

Effects Among the Concepts	Udry's Model	Model 3	Model 3B	Model 3C
Age to T	.49*	not in model	not in model	not in model
Age to Free T	not in model	.562*	.562*	.562*
		*(18.773)**	*(18.773)**	*(18.773)**
Age to SHBG	-.36*	not in model	not in model	not in model
Age to Pubertal D.	.26*	.294*	.294*	.294*
		*(.325)**	*(.325)**	*(.325)**
Age to Sexuality	.08	.167	-.026	.056
		(.204)	*(-.099)*	*(.235)*
T to Pubertal D.	.42*	not in model	not in model	not in model
Free T to Pubertal D.	not in model	.399*	.399*	.399*
		*(.013)**	*(.013)**	*(.013)**
SHBG to Pubertal D.	-.20*	not in model	not in model	not in model
Pubertal D. to Sexuality	.04	.075	.125	.149
		(.083)	*(.431)*	*(.566)*
T to Church Attendance	-.30*	not in model	not in model	not in model
Free T to Church A.	not in model	-.273*	-.273*	-.273*
		*(-.011)**	*(-.011)**	*(-.011)**
SHBG to Church A.	.06	not in model	not in model	not in model
T to Sexuality	.44*	not in model	not in model	not in model
Free T to Sexuality	not in model	.296*	.288*	.263*
		*(.011)**	*(.033)**	*(.033)**
SHBG to Sexuality	-.35*	not in model	not in model	not in model
Church A. to Sexuality	-.17*	-.145	-.189*	-.191*
		(-.133)	*(-.541)**	*(-.602)**
Sexuality R^2	not available	.269	.199	.240
χ^2 (d.f.)	not available	.29 (2 d.f.)	.30 (2 d.f.)	.30 (2 d.f.)
p	not available	.863	.862	.862
AGFI	not available	.991	.991	.991
Number of cases	approx. 102	100	101	101

* = LISREL T value > 2.00 ("Parameters whose t-values are larger than two in magnitude are normally judged to be different from zero", Joreskog and Sorbom, 1989, p. 89).

APPENDIX F

Appendix F Table F1

Model 1's Sensitivity to Listwise versus Pairwise Deletion of Missing Values

Effects Among the Concepts:	Model 1 LISTWISE DELETION standardized	*(non-stan.)*	Model 1 PAIRWISE DELETION standardized	*(non-stan.)*
Age to T	.470 *	*(1.504)* *	.494 *	*(1.584)* *
Age to SHBG	-.345 *	*(-5.861)* *	-.362 *	*(-6.221)* *
Age to Pubertal D.	.281 *	*(.288)* *	.245 *	*(.269)* *
Age to Sexuality	.104	*(.127)*	.156	*(.190)*
T to Pubertal D.	.387 *	*(.124)* *	.412 *	*(.141)* *
SHBG to Pubertal D.	-.184 *	*(-.011)* *	-.203 *	*(-.013)* *
Pubertal D. to Sexuality	.106	*(.126)*	-.012	*(-.013)*
T to Church Attendance	-.244 *	*(-.100)* *	-.280 *	*(-.116)* *
SHBG to Church A.	.027	*(.002)*	.039	*(.003)*
T to Sexuality	.288 *	*(.110)* *	.331 *	*(.125)* *
SHBG to Sexuality	-.164	*(-.012)*	-.176	*(-.012)*
Church A. to Sexuality	-.163	*(-.151)*	-.129	*(-.118)*
Sexuality R^2	.307		.299	
χ^2 probability	1.75	(3 d.f., p = .625)	1.60	(3 d.f., p = .660)
AGFI	.956		.963	
Number of cases	94		100	

* = LISREL T value > 2.00 ("Parameters whose t-values are larger than two in magnitude are normally judged to be different from zero", Joreskog and Sorbom, 1989, p. 89).