Family of Origin, Age at Menarche, and Reproductive Strategies: A Test of Four Evolutionary-Developmental Models

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Abstract

Four evolutionary-developmental models within a Life History Theory framework were compared as to their predictions of the influences of family of origin on age at menarche and differences in reproductive strategies. Predictions of Paternal Investment Theory (Draper & Harpending, 1982), Psychosocial Acceleration Theory (Belsky, Steinberg, & Draper, 1991), Polygyny Indication Model (Kanazawa, 2001), and Child Development Theory (Ellis, 2004) were tested by structural equation modeling in an internet study of 439 women between the ages of 18 and 30. Results show that the existence of a father figure has an impact on the age at menarche, which influences the age at first sexual intercourse. The directions of influences confirm the predictions of Paternal Investment Theory (Draper & Harpending, 1982), Psychosocial Acceleration Theory (Belsky et al., 1991), and Child Development Theory (Ellis, 2004), but not the predictions of the Polygyny Indication Model (Kanazawa, 2001). No significant associations could be found between age at menarche and other reproductive strategy markers; this supports one of the central assumptions of Child Development Theory (Ellis, 2004). Instead, it was the age at first sexual intercourse, influenced by the age at menarche, the existence of a father figure, and participant's educational level, that was most critical for the future reproductive strategies.

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Twenty-five years ago, Draper and Harpending (1982) introduced an influential evolutionary-developmental theory that related the early rearing environment to later reproductive strategies. Since then, several authors proposed modifications of this theory, each of them implying different causal mechanisms (for a review see Ellis, 2004).

The aim of the present study is to replicate findings of familial influences on the age at menarche (e.g., Bogaert, 2005; Doughty & Rodgers, 2000; Ellis & Garber, 2000; Ellis, McFadyen-Ketchum, Dodge, Petit, & Bates, 1999; Hoier, 2003a,b) and to replicate the effect of pubertal timing on differences in reproductive strategies (Chasiotis, 1999; Helm & Lidegaard, 1989; Hoier, 2003a,b; Kim & Smith, 1998; Kim, Smith, & Palermiti, 1997; Mikach & Bailey, 1999).

A large body of literature exists about the influence of family composition on girl's pubertal maturation. While converging evidence shows that girls growing up without a biological father mature earlier than those from two parent households (e.g. Doughty & Rodgers, 2000; Ellis et al., 1999), investigations on stepfather presence and its influences on the timing of puberty in step-daughters show mixed results (e.g. Bogaert, 2005; Ellis & Garber, 2000; Hoier, 2003a,b; Mekos, Hetherington, & Clingempeel, 1992). Furthermore, results on the influences of single-mother households on girls' pubertal timing also are not consistent (e.g. Mekos et al., 1992; Surbey, 1990).

The association between earlier pubertal timing and earlier age at first sexual intercourse has received substantial support from a lot of studies (e.g., Bingham, Miller, & Adams, 1990; Miller, Norton, Curtis, Hill, Schvaneveldt, & Young, 1997; Phinney, Jensen, Olsen, & Cundick, 1990). In contrast, relatively little is known about the relation between pubertal timing and differences in reproductive strategies (but see Hoier, 2003a, b). In his extensive review of the literature, Ellis (2004) found only five investigations which analyzed explicitly the relation between age at menarche and number of sexual partners and only two of them investigated sociosexual orientation in this context (Helm & Lidegaard, 1989; Hoier, 2003a,

b; Kim & Smith, 1998; Kim et al., 1997; Mikach & Bailey, 1999). None of them found a significant association. Chasiotis (1999) also examined the relation between age at menarche and number of sexual partners. In contradiction to most theories he found a positive correlation.

The present study contrasts four evolutionary-developmental models with one another:

Paternal Investment Theory (Draper & Harpending, 1982)

Paternal investment theory (Draper and Harpending, 1982) assumes that the context of low paternal investment, father's absence and a stepfather's presence trigger accelerated menarche (Barkow, 1984), early sexual intercourse, and an orientation toward relatively unstable pair bonding. Consequently, women in this context should be more unrestricted in their sociosexuality.

Psychosocial Acceleration Theory (Belsky, Steinberg, & Draper, 1991)

Belsky et al. (1991) proposed multiple qualities and features of the family ecology that influence pubertal development and reproductive strategies. According to their model, insecure attachment, early menarche, and a more quantitative reproduction strategy (early sexual intercourse, unrestricted short-term mating) are most likely to occur under conditions of high levels of stress (e.g. scarcity or instability of resources, marital discord, harsh, rejecting family relationships, single parenthood, unstable employment). We operationalized the high-stress developmental context with the variables of single-mother parenting, the absence of a father-figure (biological father or stepfather), low parental investment, and low parental socioeconomic status.

The Polygyny Indication Model (Kanazawa, 2001)

The polygyny indication model (Kanazawa, 2001; Kanazawa & Still, 1999) does also predict early menarche and early sexual intercourse when a father figure (biological father or stepfather) was absent during childhood. According to the model, the absence of a father figure marks a cue for a polygynous mating system. Polygyny leads to a scarcity of available

women of reproductive age, since in addition to potential mates of the same age, there are also older men on the marriage market who have accumulated enough resources to care for a large family with multiple wives. Therefore, in such a mating system, girls who enter the marriage market earlier by accelerated maturation have a reproductive advantage. Because of their good strategic position on the mating-market (shortage of women implies high probability of finding a high quality mate), Hoier (2003a) predicted that these early maturing women should be more restricted in their sociosexuality.

Child Development Theory (Ellis, 2004)

Child development theory (Ellis, 2004) predicts early menarche in low quality social-developmental childhood environments. We operationalized low quality environments as growing up in a non-regular family (with mother and stepfather, or only with mother), experience of an absent father figure, and low parental investment. As proposed by the model, early menarche should be associated with early sexual intercourse, but not with differences in sexual and mating behavior, such as greater number of partners or other aspects of sociosexuality. However, child development theory does not exclude the possibility that the family environment has a direct impact on sexual and mating behavior. It just underlines that timing of menarche is not an intervening factor in these relations.

Table 1 describes the hypotheses derived from the four conditional evolutionary-developmental models in a short form. They were tested with both correlations and structural equation modeling of data obtained from a German internet sample of young women.

Method

Procedure

Data was collected between March and November 2004 in the context of a large internet study on sociosexuality. Immediately after participation, participants received online feedback on their sociosexual attitudes and behaviors and on their mate-choice preferences in relation to other same-sex participants.

Participants

Participants were selected from the data set according to the following criteria[1]: females, heterosexual orientation, aged between 18 and 30 years, native speakers of German, not married, never divorced, no children. Furthermore, participants had to have at least one romantic relationship of at least one month duration and experiences with sexual intercourse. Finally, 439 women met these criteria. The mean age was 21.4 (*SD* = 3.2).

As their highest degree, 14.4% (63) of the participants had a university degree or post graduate education, 51.7% (227) indicated as their highest degree to have finished high-school and 28.6% (125) had lower educational levels or no degree. Of all participants, 4.6% (20) indicated other educational degrees and 0.7% (4) did not indicate their educational level. Comparison data from the representative German Socio-Economic Panel Study of 2004 indicate that of women between the ages 18 and 30 who were not married and who had no children, 10.1% had 16 years of education or more, 33.7 % had between 12 and 15 years of education, while 37.7% indicated less than 12 years of education (German Institute for Economic Research, 2004). Thus, the present sample was somewhat biased toward higher education.

Until the age of seven, 85.2% (374) grew up with their biological parents, 3% (13) with their biological mother and a stepfather, and 8.2% (36) only with their biological mother; 3.4% (15) grew up in another family structure (only biological father, with stepmother, other kin, or with adoptive parents).

After the age of seven, 71.5% (314) lived together with both of their biological parents, 8.7% (38) lived with their biological mother and stepfather, and 16.2% (71) lived in single-mother homes. The remaining 3.4% (15) lived in another family structure (only biological father, with stepmother, other kin, with adoptive parents or in orphanage). One participant did not indicate her family composition.[2]

Of this sample, 16.8% (74) reached menarche before age 12 and, therefore, can be considered as early maturers (for classification use of early, normal and late maturers see also Caspi & Moffit, 1991; Hoier, 2003a; Reese, Silbereisen, & Wiesner, 2000). Another 50.6% (222) experienced menarche between ages 12 and 13 (normal maturers), 19.4% (85) had menarche at 14 or later (late maturers), and 13.2% (58) did not indicate their age at menarche. The mean age at menarche was at 12.6 years (*SD* = 1.4), with a range of 9 to 17 years. This is consistent with the age at menarche (*M* = 12.4; Range = 10 – 16) that Reese et al. (2000) reported for a representative German sample (*N* = 162) born between 1980 and 1983, and therefore is comparable with the age group of this sample.

Measures

The retrospective self-report questionnaire obtained data on family composition and perceived support as well as puberty and post pubertal attitudes and behaviors.

Childhood measures. Primarily, family composition was obtained through eight categories: biological parents; only mother; mother and stepfather; biological father; biological father and stepmother; other kin; adoptive parents; orphanage. For both time intervals (birth to age seven and after age seven) two variables were created to calculate influences of family composition. First, family composition was dichotomized into growing up with 1 = both biological parents versus 0 = only with mother or with mother and stepfather, to measure the influence of ecological and familial stress, or simply influences of non-regular families. Second, this variable was dichotomized into growing up with 1 = both biological parents or mother and stepfather versus 0 = only with mother, to reflect influences of presence versus absence of an adult male in the girls' home, or influences of single parenthood.

The existence of a "father figure" was assessed for both time intervals (birth to age seven and since age seven) by three answer categories (yes, none for a short time period [e.g.

because father was often away on business trips]; no there was none). Both variables were dichotomized into 1 = yes or none for a short time versus 0 = no there was no father figure.

Material support and other support (i.e., emotionally, through practical help and so forth) were assessed for both time intervals on 7-point scales: 1 = not at all to 7 = very high, separated into support of biological father and biological mother. The average score of these items yielded a parental investment scale score for the two time intervals. The average score of the two items assessing fathers support (materially and emotionally) was used to build the paternal investment scale score for each time interval. An exemplary item of the paternal investment scale is "How much did your biological father support you materially and financially until the age of seven?".

Socioeconomic status during childhood was measured by using the Hollingshead Index of Social Position (ISP, Hollingshead & Redlich, 1958) applied to participant's parents. This two-factor index consists of a weighted sum of parents' occupational prestige and levels/years of education. The ISPs of participants were calculated as an average score of mothers' and fathers' ISPs. This classification system has a range from 11 (upper social position) to 77 (lower social position). This index was reversed such that high scores indicate high socioeconomic status.

Measures of puberty, education, and post-pubertal attitudes and behaviors. Data were obtained for timing in years for menarche and age at first sexual intercourse. Additionally, educational level was assessed by nine categories (from 1 = no school finished to 9 = doctoral degree). Sociosexual orientation was assessed by a revised version of the Sociosexual Orientation Inventory (Penke & Asendorpf, 2007).[3] Drawing on the original sociosexuality construct (Gangestad & Simpson, 1990), Penke and Asendorpf extended the Sociosexual Orientation Inventory (Simpson & Gangestad, 1991) by developing three subscales (with three items each) which assess the behavioral, the attitudinal, and the desire facets of

sociosexual orientation independently. Generally, higher scores indicate a more unrestricted sociosexual orientation.

Results

Descriptive Statistics and Reliabilities for the Main Variables

Presence of a father figure. A total of 358 participants reported to have had a father figure most of the time until seven years of age, 74 stated to have not had such a figure. Of all participants, 323 reported having had a father figure since age seven and 109 indicated having not had a father figure since this age. For both time intervals, seven values were missing. See Table 2 for further descriptive statistics and reliabilities.

To avoid skewness and outliers, rank order transformations were conducted for educational level, paternal and parental investment scales, age at menarche, age at first sexual intercourse, and subscales of the revised Sociosexual Orientation Inventory.

Data Analysis Procedure

To compare the predictions of the four evolutionary-developmental models, structural equation modeling using LISREL 8.20 (Jöreskog & Sörbom, 1996a) was conducted based on central results of correlation analyses (Figure 1). The PRELIS program (Jöreskog & Sörbom, 1996b) was used to obtain the correct covariance matrix. As the method of parameter estimation, Generalized Least Squares (GLS) was used because of its less stringent multivariate normality assumption. At the same time, it provides an approximate chi-square test of model fit to the data. Because of a varying number of missing values for each variable we used the maximum possible sample size for each test in order to maintain statistical power.

Correlational Analyses

Spearman correlations were conducted with all variables of family composition and support, parental socioeconomic status, age at menarche, age at first sexual intercourse, subscales of the revised Sociosexual Orientation Inventory, and educational level. The results indicate that age at menarche was significantly correlated only with the existence of a father

figure after the age of seven (r (374) = .13, p < .01) and with the age at first sexual intercourse (r (380) = .17, p < .01). By contrast, the age at first sexual intercourse was not only significantly correlated with the existence of a father figure after the age of seven (r (430) =.12, p < .05) but also with the sociosexual behavior subscale (r (369) = -.32, p < .001) and the sociosexual attitude subscale (r (436) = -.19, p < .001). Results indicated no significant association between the age at first sexual intercourse and the sociosexual desire subscale (r (373) = -.10, p > .05). Additionally, the age at first sexual intercourse was significantly correlated with participants educational level (r (413) = .25, p < .001). Participants educational level was significantly associated with parents' socioeconomic status (r (385) = .26, p < .001) and marginally significantly correlated with growing up with both biological parents until the age of seven (r (400) = .09, p < .10). No further significant correlations with participants educational level were found. Figure 1 gives a summary of the central results.

Structural Equation Modeling

Six recursive full latent variable models were examined that differ in their exogenous variables derived from the four theories to be compared (see Figure 2).

Model one comprises the exogenous variable "grown up with both biological parents", model two the variable "paternal investment", model three the variable "grown up with an adult male in the home", and model four the variable "parental investment". Model five comprises the exogenous variable "parental socioeconomic status", which is not divided into two time intervals. Parental socioeconomic status refers to the whole time period before and after the age of seven. Therefore, this model is only investigated in step one of model tests. Finally, model six includes the exogenous variable "presence of a father figure".

Model one and two test the predictions derived from paternal investment theory (Draper & Harpending, 1982), models three to five test the predictions derived from psychosocial acceleration theory (Belsky et al., 1991), while model six was used to test the polygyny indication model (Kanazawa, 2001).

After exposing the model with the most appropriate fit, we tested whether there is a direct relationship between the age at menarche and differences in reproductive strategies, or if there is no relationship at all (as hypothesized by child development theory, Ellis, 2004).

Finally, participant's educational level and its correlates were added to the final model (see Figure 1) for a general model test.

The exogenous latent variables were varied in three steps of model tests:

1. as a factor underlying the childhood experiences until the age of seven *and* after the age of seven
2. as a factor which describes only childhood experiences until the age of seven
3. as a factor which describes only childhood experiences after the age of seven .

Concerning the endogeneous latent variables, age at menarche was the only indicator of the latent variable "age at menarche". The latent variable "age at first sexual intercourse" comprised also only one indicator, which was the age at first sexual intercourse. The latent variable "reproductive strategy" was built to represent variation in reproductive strategies on the basis of the significant variables. Factor loadings ($N = 365$) on this factor were .79 for sociosexual behavior, and .72 for sociosexual attitude. Thus, the endogenous latent variable "reproductive strategy" accounted for 62% of the variance in sociosexual behavior and 52% of the variance in sociosexual attitude.

The results of step one of the structural equation modeling tests show adequate Goodness of Fit Indices for the three models with the exogenous latent variables "paternal investment" (χ^2 (9, $n = 304$) = 16.47, $p > .05$), "parental investment" (χ^2 (9, $n = 286$) = 14.03, $p > .05$), and "parental socioeconomic status" (χ^2 (5, $n = 286$) = 9.31, $p > .05$). However, none of the exogenous latent variables accounted for a significant amount in either the age at menarche variance (γ between -.002 and .12, t between -.41 and 1.74) or the age at first sexual intercourse variance (γ between -.01 and .09, t between -.11 and .91). Therefore, to identify an

adequate model not only statistically, but also theoretically, step two of structural equation modeling tests was conducted.

In step two, the six models were reanalysed with exogenous latent variables composed of only one variable, which measures the different childhood experiences and conditions until the age of seven. The results of step two of structural equation modeling tests show adequate Goodness of Fit Indices for the two models with the exogenous latent variables "grown up with an adult male in the home" (χ^2 (5, n = 286) = 10.85, $p > .05$), and "parental investment" (χ^2 (5, n = 286) = 10.74, $p > .05$). However, none of the exogenous latent variables accounted for a significant amount of the age at menarche variance (γ between -.001 and .07, t between -.02 and 1.29) and the age at first sexual intercourse variance (γ between -.09 and .10, t between -.12 and 1.45).

In step three, the five models were reanalysed, again, with exogenous latent variables composed of only one variable. This variable measures the different childhood experiences and conditions reported for the period after the age of seven. The results of step three of structural equation modeling tests show adequate Goodness of Fit Indices for the two models with the exogenous latent variables "grown up with an adult male in the home" (χ^2 (5, n = 286) = 9.91, $p > .05$), and "presence of a father figure" (χ^2 (5, n = 302) = 10.38, $p > .05$). In each of the five models, the age at first sexual intercourse significantly predicted the reproductive strategy (β between -.21 and -.22, t between -4.87 and -5.23). The age at menarche accounted for a significant amount of the age at first sexual intercourse variance in all of the five models (β between .17 and .20, t between 2.48 and 3.02). Thus, the results replicate the significant findings of the correlation model (Figure 1), that women who experienced menarche at an earlier age tended to have their first sexual intercourse at an earlier age, which led to a more unrestricted reproductive strategy. Finally, the two exogenous latent variables "grown up with an adult male in the home" and "presence of a father figure" accounted for a significant amount of the age at menarche variance (γ = .14, t = 2.27 and γ =

.19, t = 3.10). “Grown up with an adult male in the home” did not predict significantly the age at first sexual intercourse (γ = .02, t = .29), while the effect of “presence of a father figure” was marginally significant (γ = .13, t = 1.80). Therefore, the significant results of correlation analyses (Figure 1) could mainly replicated by structural equation modeling.

To decide which of the two models represents the sample data better there are two ways of evaluation. First, the models can be compared statistically in a heuristic way according to their Goodness of Fit Statistics, because the chi-square difference test is only applicable to nested model comparisons and there is no firm standard for assessing the difference in indices of practical fit (e.g. Bagozzi & Yi, 1990; Widaman, 1985). Second, the models can be compared according to their practical and substantive meaning. As the results show, difference scores in chi-square and in practical fit were very small ($\Delta \chi^2$ (0, n = 286, 302) = .05, Δ Root Mean Square Error of Approximation *(RMSEA)*, Comparative Fit Index *(CFI)*, Goodness of Fit Index *(GFI)*, Adjusted Goodness of Fit Index *(AGFI)* all $\leq$ .005). Therefore, it can be suggested that there is not a strong difference in overall model fit between the two models.

Concerning the prediction of the age at menarche, the variable “presence of a father figure” accounted for a larger amount of variance in comparison to the variable “grown up with an adult male in the home”. Additionally, the effect of the “presence of a father figure” on the age at first sexual intercourse was marginally significant, whereas the influence of “grown up with an adult male in the home” was almost zero. Regarding the content of the two indicator variables, there is also small difference: The family composition, especially when having lived with the biological or a stepfather in the home, is most probably strongly associated with the perception of a father figure. The predictive validity of the less objective definition of a father figure is slightly better than the more precise definition of the presence of the biological father or a stepfather in the home. This indicates that the model “presence of a father figure” should be preferred (Figure 3).

Direct influence of age at menarche on differences in reproductive strategies. According to child development theory (Ellis, 2004), the age at menarche should not account for a significant amount of reproductive strategy variance. To explicitly test the prediction of child development theory, an additional path was added to the model shown in Figure 3 (age at menarche => reproductive strategy). The results indicate that the age at menarche did indeed fail to account for a significant proportion of the reproductive strategy variance (β = .05, t = 1.09). The Goodness of Fit Statistics revealed an adequate model fit (χ^2 (4, n = 302) = 9.43, p > .05).

To compare the model fit with that of the model as shown in Figure 3, chi-square difference test was conducted. Results indicate that there is almost no difference between the two models ($\Delta \chi^2$ (1, n = 302) = .95, p > .05) and a comparison of the indices of practical fit showed difference scores for the indices *RMSEA, CFI, GFI* and *AGFI* which were lower than .01. For reasons of parsimony and because of its uselessness in explaining variation in the reproductive strategy, the path menarche => reproductive strategy was not integrated in the "presence of a father figure" model.

General model test. Finally, the "presence of a father figure" model was completed by the significant associations of parent's socioeconomic status and family composition until the age of seven with participant's educational level, which influenced the age at first sexual intercourse (see Figure 1). Results show that, except for the direct path between the presence of a father figure and the age at first sexual intercourse (γ = .13, t = 1.80), all defined associations reached significance (Figure 4) and the final model fitted perfectly to the data (Table 3).

The results presented in Figure 4 suggest that there are two developmental pathways influencing the age at first sexual intercourse, which seems to be critical for differences in reproductive strategy. One is a biological developmental pathway in which the age at menarche mediates the influence of the presence of a father figure after the age of seven on

the age at first sexual intercourse. The presence of a father figure after the age of seven decelerates the age at menarche. A later age at menarche leads to a later age at first sexual intercourse.

The other developmental pathway seems to be influenced mainly by environmental conditions. Participant's educational level, which is predicted by their socioeconomic backgrounds and the family composition until the age of seven, seems to explain a slightly larger amount of the age at first sexual intercourse variance than does the age at menarche. Results suggest that women with higher socioeconomic backgrounds and who grew up with both biological parents in their first seven years of life tend to be more highly educated, which in turn led to a later age at first sexual intercourse. Generally, results were very consistent in that women who experienced their first sexual intercourse at a later age tend to be more restricted in their sociosexual behavior and attitude.

Discussion

Our results replicate earlier findings on the influences of the family of origin on age at menarche (e.g. Bogart, 2005; Hoier, 2003a,b). In a US national probability sample, which comprised 1921 women, Bogaert (2005) found that the effect of a stepfather did not add unique variance to the prediction of pubertal onset. Hoier (2003a,b) also found no accelerating effect of stepfathers in a German sample of 321 women. Therefore, Hoier (2003a,b) proposed the concept of a father figure (biological father or stepfather) leading to a decelerated menarche. Our results support that notion. It was the presence of a father figure after the age of seven which had a decelerating effect on the age at menarche. Structural equation modeling additionally indicated that growing up in a home with an adult male (biological father or stepfather, in contrast to single-mother homes) also accounted for a significant amount of variability in age at menarche. Regarding their meaning, these two predictor variables are quite similar. When grown up in a home with the biological father or a stepfather, it is probable that this man was perceived and functioned as a father figure.

However, the apperception of a father figure, which is also related to the subjective perceived quality of the relationship, predicted the age at menarche slightly better than the family composition (presence of the father or stepfather) per se.

Some authors (Ellis & Garber, 2000; Mekos et al., 1992) proposed that exposure to pheromones from unrelated males could be the mechanism which explains an accelerational effect on a stepdaughter's menarche and that the presence of an related adult male would indicate an opposite effect (e.g. Hoogland, 1982). The results of this study do not support this view. As Hoier (2003a,b) concluded, the function of a father figure as protector and supporter, independent of biological relatedness, should move into the focus of further research, whereas pheromone exposure as the proposed mechanism for explaining the effects of family composition seems more doubtful.

Influences of Age at Menarche on Reproductive Strategies

The results of structural equation modeling on the associations between pubertal timing and markers of reproductive strategies replicated previous findings, in that earlier timing of menarche was associated with an earlier age at first sexual intercourse. Although there seems to be only six studies that examined the relation between age at menarche and differences in reproductive strategies (Chasiotis, 1999; Helm & Lidegaard, 1989; Hoier, 2003a,b; Kim & Smith, 1998; Kim et al., 1997; Mikach & Bailey, 1999), results of this study are highly consistent with most of the previous findings: no direct influences of age at menarche on reproductive strategy over and above the age at first sexual intercourse were found. The only significant paths between family of origin, timing of menarche and reproductive strategy were the absence of a father figure after the age of seven and the absence of an adult male (biological father or stepfather) in the girl's home after the age of seven. These two variables had an accelerational effect on menarche, leading to an earlier age at first sexual intercourse. Results of correlation analyses showed that the absence of a father figure after the age of seven also was significantly associated with an earlier age at first sexual intercourse. This

direct relation is consistent with previous findings (e.g. Ellis, Bates, Dodge, Fergusson, Horwood , Pettit et al., 2003; Hoier, 2003a). In the structural equation model, however, the direct effect of the father figure on the age at first sexual intercourse lost significance, while the effect size remained similar. This was probably due to the smaller sample size of the structural equation modeling analysis. In the present study, the age at first sexual intercourse was the critical factor influencing reproductive strategy. An earlier age at first sexual intercourse was associated with a more unrestricted sociosexuality on the behavioral and attitudinal level, but not on the level of desires. Consequently, our findings support the notion that there exist different developmental paths which lead to differences in reproductive strategies.

Interestingly, age at first sexual intercourse was not only influenced by the presence of a father figure and the age at menarche, but there was also a significant association with participants' educational level. More highly educated women tended to have higher socioeconomic backgrounds, and most of them grew up with both biological parents until the age of seven. There exists empirical evidence that parental divorce is associated with a decline in academic performance (e.g. Barber, 1998). Since education can be viewed as a path to economic advancement, academic work can be construed as an investment in the future, and therefore, a manifestation of a long-term reproductive strategy.

Our results provide some support for this hypothesis. Higher educational level was linked with a later age at first sexual intercourse and indirectly with a more restricted sociosexuality, especially on the behavioral level. We have to keep in mind, however, that these correlational results should not be interpreted causally - educational level may also be influenced by the age at first sexual intercourse.

Comparison of the Results with the Four Evolutionary-Developmental Models

Paternal investment theory. Paternal investment theory posits that the presence and investment of the biological father is the central factor explaining interindividual differences

in reproductive strategies. Stepfathers are regarded as indicators of low-quality paternal investment. In this study, however, it was not only the presence of the biological father which influenced the timing of menarche and the age at first sexual intercourse. Instead, it was the presence of a "father figure" that did so. This could have been the biological father, the stepfather, or any other related adult male, or even an unrelated person with a consistent presence, like a teacher. The association between the age at menarche and the age at first sexual intercourse was predicted by the model and evidenced by these data. Furthermore, the influence of earlier sexual intercourse, which leads to a more unrestricted reproductive strategy, supports the predictions of paternal investment theory.

In sum, the accentuation of the influence of the biological father on differences in reproductive strategy by paternal investment theory appears to be an important and fruitful approach. The predicted influence of the biological father on the quality of the mating strategy, as described by Draper and Harpending (1982), was partly confirmed by the data. The critical factor, however, does not seem to be the biological relationship, but the function of a caring, responsible adult male which influences pubertal timing in girls, the age at first sexual intercourse, and, indirectly, her reproductive strategy. As our results suggest, this function can also be fulfilled by the stepfather. This might explain that the influence of paternal investment on the age at menarche and the age at first sexual intercourse reached no significance level. This variable only asked for the perceived emotional and material investment of the biological father.

Concerning the predicted influence of the biological father on the age at menarche and the age at first sexual intercourse, the question remains open as to what extent the father figure is represented by the biological father. Further questions are: If the father figure has a protective function, what defines a father figure? How can this protective function be realised? What mechanisms start operating in response to the existence of a father figure after

the age of seven, and how are they mediated? In times of high divorce rates and patch-work families, it seems to be important to find answers to these questions.

Psychosocial acceleration theory. In contrast to Draper and Harpending's theory, Belsky et al. (1991) penned a broader approach concerning the influences on pubertal development and differences in reproductive strategies. They conceptualized a generally stressful family environment (marital discord, high levels of stress, inadequate resources) as the original, influential factor leading to differences in reproductive strategies. In our study, stressful familial environment was operationalized with the variables of growing up in single mother homes, the absence of a father figure, a low investment by biological parents, and lower parental socioeconomic status. The results partly support the model: Growing up in a single mother home and the absence of a father figure accelerated menarche, which led to an earlier age at first sexual intercourse. A younger age at first sexual intercourse was associated with a more unrestricted reproductive strategy.

However, parental investment did not show any significant associations with the age at menarche. This is probably due to the fact that this variable assessed the investment of biological parents exclusively, instead of the perceived investment of strongly related persons in general. Also, parental socioeconomic status was not associated with age at menarche, which contradicts the theory. However, there was an indirect association with the age at first sexual intercourse mediated by participant's educational level.

In sum, the hypothesized predictor variables "growing up in single mother homes", "absence of a father figure", and "parental socioeconomic status" seem to indirectly influence the age at first sexual intercourse and the related reproductive strategy, but on somewhat different developmental pathways and by other mediators (educational level) as proposed by Belsky and associates. The proposed direct association of a younger age at menarche not only with a younger age at first sexual intercourse, but also with a generally more unrestricted sociosexuality could not be found in this investigation.

Polygyny indication model. According to the polygyny indication model, the absence of a father figure is a cue for a polygynous mating system, in which early maturing girls are at reproductive advantage. Polygyny leads to a scarcity of women of reproductive age, because there are also older men on the marriage market who already have accumulated enough resources to support and care for a large family. In support of this model, our results show that women who had no father figure tend to experience menarche and first sexual intercourse at an earlier age. But our results contradict the model concerning the hypothesized resulting long-term reproductive strategy. Empirical evidence exists supporting a negative correlation of age at menarche and the degree of polygyny in international comparison, controlling for the effects of socioeconomic status, race, and year of investigation (Kanazawa, 2001). Additionally, the age at menarche has a positive association with the age of marriage in intercultural studies (Kanazawa, 2001), although the effect sizes were small. This should, theoretically, lead to a more long-term oriented reproductive strategy. In contrast to the model's prediction, however, early maturing women were not more restricted in their sociosexuality. Instead, we found an indirect association between an earlier age at menarche and less restricted sociosexual behavior and attitude.

Our findings pose important questions concerning this model: Which other factors may affect the reproductive strategies of women over and above family composition and support and age at first sexual intercourse? Are the predicted associations only valid for a subgroup of women?

It would be interesting for further research to integrate the concept of mate value in the examination of this approach (see Penke, Todd, Lenton, & Fasolo, 2007). Early maturing women might be more restricted in their sociosexuality and more sexually faithful when they evaluate the mate value of their partner highly on both genetic quality (e.g. physical attractiveness) and resources. To establish and maintain a relationship with such men, these women have to display high mate value themselves. If a lower mate value makes it impossible

for a woman to get that highly viable and resource-rich man, the most adaptive way for her seems to be a mixed reproductive strategy: maintaining a relationship with a high investing man, while cuckolding him with highly viable men, who have good genetic quality, but are less willing or able to invest in offspring. In this case, the women would evaluate her partner's mate value to be a bit lower and the women's mate value would also be lower. As consequence, these women would have a more unrestricted sociosexuality and a greater number of sex partners. In principle, this is what the strategic pluralism model (Gangestad & Simpson, 2000) might propose under certain conditions (polygynous mating system and early age at menarche). An integration of evolutionary-developmental approaches with this model would be desirable.

Child development theory. Ellis (2004) reconceptualized the function of pubertal timing as part of an integrated developmental strategy that conditionally alters the length of childhood as a response to the quality of the childhood environment. High quality childhood environments enable greater development of socio-competitive competencies and higher educational opportunities. According to the theory, children should be selected to capitalize on these benefits by delaying maturation and, consequently, having their first sexual intercourse at a later age. The quality of social developmental childhood environments was operationalized in the present study alternatively by growing up in a non-regular family, experiencing an absent father figure, and diminishing parental investment.

Results support the reconceptualization of pubertal timing, in that the presence of a father figure leads to a later age at menarche and both decelerated the age at first sexual intercourse. Additionally, growing up with both biological parents and higher parental socioeconomic status predicted higher educational levels, which were associated with a later age at first sexual intercourse.

According to Ellis (2004), menarche marks the transition from a pre-reproductive state to a reproductive state, and that constitutes a change in allocation of resources from physical

growth to mating and parenting. Therefore, age at menarche should be linked with what he called "sexual and reproductive milestones" like age at first sexual intercourse. But Ellis claims that pubertal timing should not be associated with differences in mating and parenting strategies in a direct way. These predictions were supported by our data.

Evaluation of the Predictions of the Four Evolutionary-Developmental Models

The directions of influences confirm the predictions of paternal investment theory, and psychosocial acceleration theory, but not the predictions of the polygyny indication model. Age at menarche was found to be a component of differences in reproductive strategy. This supports paternal investment theory and psychosocial acceleration theory, but not child development theory. The age at menarche, however, was neither the only nor the critical factor influencing the age at first sexual intercourse and no association with sociosexuality could be found. Therefore, the timing of menarche can not be considered as the crucial, generative mechanism through which experiences in the family influence reproductive strategies. These results support the central assumption of child development theory and contradict paternal investment theory, and psychosocial acceleration theory.

General discussion

Some authors proposed multiple unique influences on pubertal timing including independent effects of family stress and father absence (e.g. Ellis & Garber, 2000; Moffitt, Caspi, Belsky, & Silva, 1992; Surbey, 1990). Our results suggest that there are also multiple unique influences on the age at first sexual intercourse leading to differences in the quality of reproductive strategy. First, the existence of a father figure has an effect on biological development (menarche). Second, there seems to be a more environmentally caused developmental pathway in which parent's socioeconomic status and family composition until the age of seven predict participant's educational level, which in turn affected the age at first sexual intercourse. The age at first sexual intercourse was critical for differences in reproductive strategy. An important question arises from these results: Which features of the

environment during adolescence influence the age at first sexual intercourse over and above the family of origin, timing of menarche, and educational level (e.g. attitudes and behaviors of the peer group)?

Finally, it is important to note that developmental environments, including family structure and relationships, as well as socioeconomic status, have a heritable component (e.g. Plomin, DeFries, McClearn, & McGuffin, 2001). Thus, the association between family environment, timing of pubertal maturation in girls, and reproductive strategy probably may be due to genetic transmission (e.g., Rowe, 2000). Recent research supports this possibility (Comings, Muhleman, Johnson, & MacMurray, 2002; Mendle, Turkheimer, D'Onofrio, Lynch, Emery, et al., 2006; Rowe, 2002). Using a children-of-twins design, Mendle et al. (2006) found no differences in age at menarche among cousins discordant for stepfathering. However, the authors were unable to determine whether the familial confound was genetic or environmental in origin. Furthermore, when mother's age of menarche was controlled for, differences in menarcheal age associated with stepfathering in unrelated girls disappeared. Therefore, the authors assumed that selection, and not causation, accounts for the relationship between family structure (stepfathering) and early menarche. Comings et al. (2002) found support for a more specific version of the genetic transmission theory. They proposed that fathers who carry the AR16-repeat-allele on their X chromosome tend to be higher on aggression and impulsivity, sexual promiscuity, and associated patterns of marital conflict and dissolution. Transmitted to daughters, these genes are associated with paternal absence, earlier age at menarche, and precocious sexual activity. Jorm, Christensen, Rodgers, Jacomb, and Easteal (2004), however, found no support for this hypothesis, and it is not yet clear whether this allele constitutes a causal reason for pubertal timing in women. According to Hoier (2003a), it might be possible that this gene structure is coupled with another gene structure which influences the quality of reproductive strategies. Results of the present study, however, do not contradict this behavioral genetic explanation.

Limitations

The current study had some limitations. For example, the reliability of retrospective age at menarche reports could not be determined because it was not retested. Long-term prospective studies, however, established test-retest reliability and found correlations ranged from .67 to .79 (Casey, Dwyer, Coleman, Krall, Gardner, & Valadian, 1991; Damon, Damon, Reed, & Valadian, 1969; Livson & McNeill, 1962; Must, Phillips, Naumova, Blum, Harris, Dawson-Hughes et al., 2002). Another critical point is that we only assessed the age at menarche and age at first sexual intercourse in years instead of months. Additionally, the assessment of family composition can not be considered as the optimal measure of familial stress. To address the problem of non-shared environmental influences, participants are supposed to be asked about the perceived relationship quality with family members, frequency of interaction with parents and the amount of stress during their childhood. Furthermore, the sample seems to be biased towards higher education, higher paternal and parental investment. Education was assessed in a way that did not enable us to reveal whether participants are still students or already working. Finally, the results of this study are based on cross-sectional data, retrospectively assessed. Thus, no causal inferences can be made.

Future research

Over and above the already mentioned research questions derived from the four evolutionary-developmental models, future research should focus on the concept and meaning of father figures and the influences of stepfathers. Is a stepfather's presence an index for a stressful familial environment because of previous divorce and structural changes in the girl's home? Or could stepfathers have a protective function? Additionally, it may be important to not only consider and examine women and men separately, but also to examine women and men at different life stages. Life and reproductive conditions, and coupled life-history trade-offs are different for each sex and also different according to a certain life stage. Therefore, it seems to be important to link research on sexuality more precisely to specific life stages. Finally, an

integration of behavior genetic models, evolutionary-developmental models and evolutionary models of human mating would be desirable.

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Footnotes

Footnote 1:

We used these criteria to control for the effect of cohorts, to avoid socially desirable response tendencies (e.g. due to marriage), and due to the fact, that the case numbers within each marital status group or child/childless group would have been too small for structural equation modeling.

Footnote 2:

Family composition until the age of seven of participants who indicated their age at menarche: both biological parents (N = 332), mother and stepfather: (N = 12), only with mother (N = 26), other family structure (N = 10), missing (N = 1).

After the age of seven: both biological parents (N = 276), mother and stepfather (N = 33), only with mother (N = 60), other family structure (N = 11), missing: (N = 1).

Footnote 3:

The revised Sociosexual Orientation Inventory is available upon request from the third author.

Tables

Table 1: *Hypotheses Derived from the Four Conditional Evolutionary-Developmental Models*

Model	Early menarche if	Associated with earlier sexual intercourse	Sociosexual orientation
PI-Theory, Draper & Harpending (1982); Barkow (1984)	father absence, stepfather presence, low paternal investment	yes	more unrestricted
PA-Theory, Belsky, Steinberg, & Draper (1991)	single-mother home, absence of a father figure, low parental investment low parental socioeconomic status	yes	more unrestricted
PG-Model, Kanazawa (2001)	absence of a father figure	yes	more restricted
CD-Theory, Ellis (2004)	low quality childhood environment: non-regular family, absence of a father figure, low parental investment	yes	no association with age at menarche

Table 2: *Descriptive Statistics and Reliabilities for the Main Variables*

Variable	*N*	*M*	*SD*	Median	Range	Cronbach's α
Paternal investment until 7 (2 Items)	437	5.02	1.78	5.50	1 – 7	.73
Paternal investment after 7 (2 Items)	435	4.63	1.89	5.00	1 – 7	.76
Parental investment until 7 (4 Items)	437	5.48	1.21	5.75	1 – 7	.64
Parental investment after 7 (4 Items)	438	5.20	1.30	5.50	1 – 7	.64
Age at menarche	381	12.60	1.36	13.00	9 – 17	-
Age at first sexual intercourse	437	16.37	2.15	16.00	12 – 28	-
Sociosexual Orientation Inventory, Revised	368	3.66	1.53	3.67	.78 – 7.89	.77
- subscale: behavior	369	1.76	1.63	1.33	.00 – 7.67	.76
- subscale: attitude	437	5.53	2.36	5.67	1 – 9	.83
- subscale: desire	375	3.72	1.85	3.67	1 – 9	.84

Table 3: *Fit Indices for the Final Structural Equation Model*

χ^2	*df*	*p*	*RMSEA*	*CFI*	*GFI*	*AGFI*	R^2		
							Menarche	1st sexual intercourse	Sexual strategy
13.37	17	.71	.000	1.00	.99	.98	.04	.10	.14

Note. *N* = 272. *RMSEA* = Root Mean Square Error of Approximation; *CFI* = Comparative Fit Index; *GFI* = Goodness of Fit Index; *AGFI* = Adjusted Goodness of Fit Index

Figure captions

Figure 1. Central results of correlation analyses.

Figure 2. Template of the recursive full latent variable model.

Figure 3. Recursive full latent variable model with the most appropriate fit.

Figure 4. Final structural equation model.

Figures

Figure 1

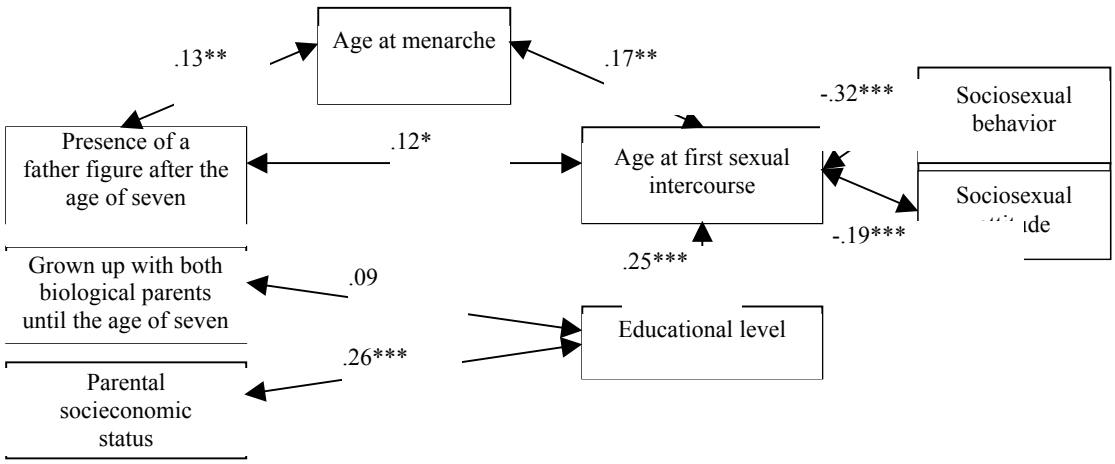


Figure 2

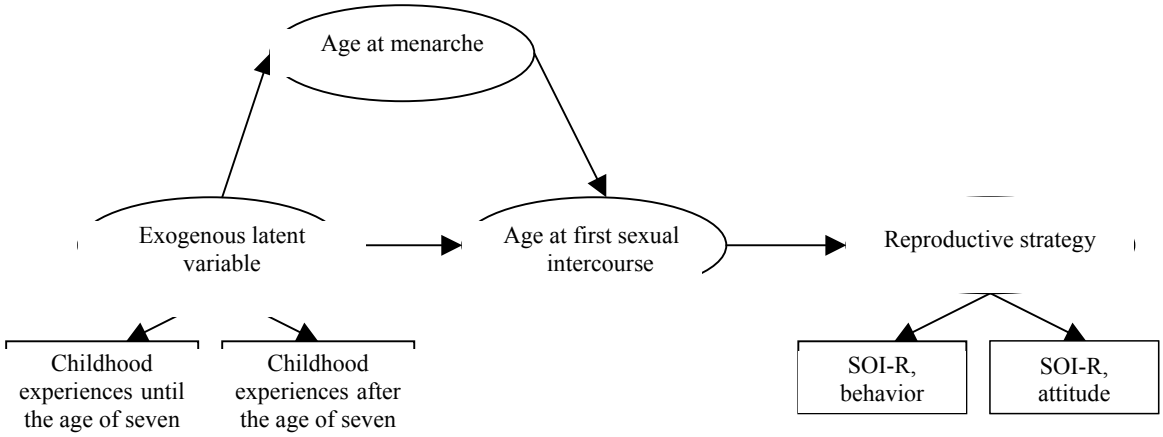
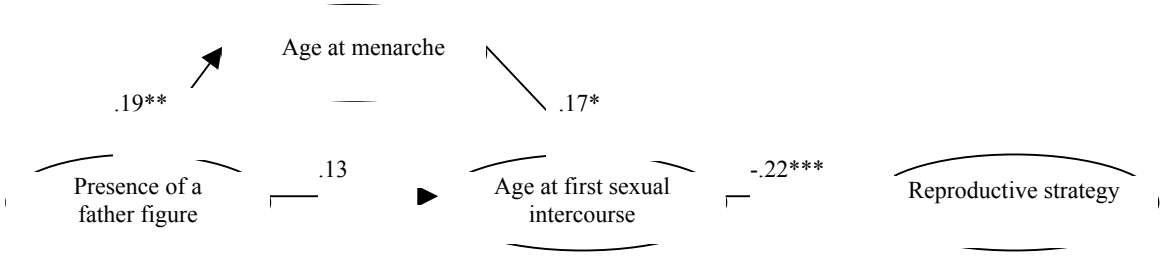
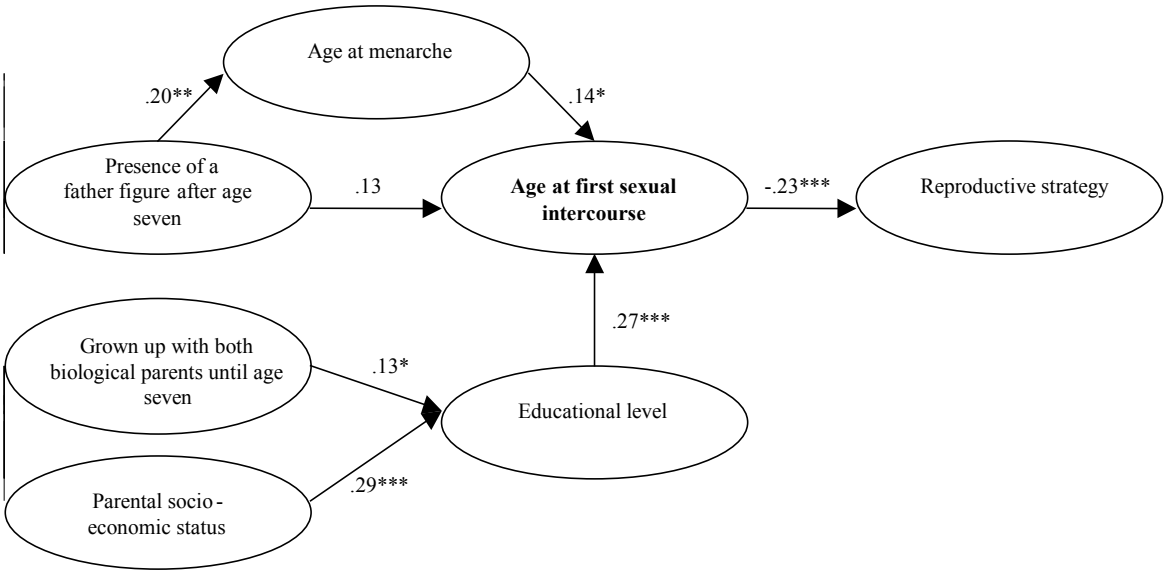

Age at menarche
Exogenous latent variable
Age at first sexual intercourse
Reproductive strategy
Childhood experiences until the age of seven
Childhood experiences after the age of seven
SOI-R, behavior
SOI-R, attitude

Figure 3



* $p < .05$; ** $p < .01$; *** $p < .001$

Figure 4



* $p < .05$; ** $p < .01$; *** $p < .001$