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Demographic Correlates of Paternity Confidence and Pregnancy Outcomes Among Albuquerque Men

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ABSTRACT We examine the demographic correlates of paternity confidence, or men's assessment of the likelihood that they are the genetic father of a particular child. Evolutionary theory predicts that men will provide less parental investment for putative genetic offspring who are unlikely to be their actual offspring, but confidence of paternity has not been as extensively examined as its importance would merit. Using self-reported data on paternity confidence in 3,360 pregnancies reported by men living in Albuquerque, New Mexico, we find that low paternity confidence is more common among unmarried couples and for unplanned pregnancies. We also find that men are more likely not to state paternity confidence (i.e., they refuse to answer the question) if a pregnancy is unplanned. We additionally examine the pregnancy outcomes associated with confidence of paternity. We find that low paternity confidence pregnancies are significantly more likely to be aborted, and pregnancies for which paternity confidence is unstated are more likely to be aborted or to miscarry. Both abortion and miscarriage are associated with unmarried couples, with unplanned pregnancies, and with couples who have fewer children together. Am J Phys Anthropol 131:560–571, 2006.

The attention paid by men to the chance that their putative children may have been fathered by another man (as well as the consequences if this turns out to be the case) is an ancient theme that remains a popular topic of contemporary fiction, talk shows, and gossip. Despite (or perhaps, because of) the controversy and interest elicited by the subject of nonpaternity, relatively little research has examined the demographic correlates of paternity confidence, or the life-history consequences associated with different levels of paternity confidence. This paper uses self-reported data on paternity confidence for a sample of men living in Albuquerque, New Mexico, to address these issues. Men in the sample rated pregnancies for which they were potentially responsible as either high or low paternity confidence, or they refused to answer the question (unstated paternity confidence). Using multivariate analysis to control for background variables, we investigated the relationship between paternity confidence and several demographic variables, including marital status, whether or not a pregnancy was planned, and the number of children a couple already has together. Additionally, we examined the relationship between paternity confidence and pregnancy outcomes, and specifically whether low paternity confidence pregnancies are more likely to be aborted or miscarried.

PATERNITY CONFIDENCE IN EVOLUTIONARY PERSPECTIVE

Evolutionary theory predicts that males will provide less parental investment for putative genetic offspring who are unlikely to be their actual offspring (e.g., Trivers, 1972; Alexander, 1974). All else being equal, males who invest in children who are not theirs will have lower reproductive fitness than men who limit their investments to their own children. However, determining paternity is an imperfect process. The mechanics of internal fertilization and live birth mean that while women are always sure of maternity, men can never be fully positive of paternity, but must rely instead on indirect cues such as mate fidelity or child resemblance to assess whether they are likely to be the father of a particular child.

There are important distinctions between actual paternity, nonpaternity, and paternity confidence. *Paternity* refers to the actual likelihood that a man is (or is not) the biological father of a particular child.[1] *Nonpaternity* is the

[1]This is a very different concept from "paternity" as used in the child support/child welfare literature, which refers to the establishment of a legal father for a child (e.g., Miller and Garfinkel, 1999; Nichols-Casebolt and Garfinkel, 1991). Under that definition, paternity is automatically established for married couples: the husband is the legal father of any children born in the marriage. "Paternity establishment" in that context refers to identifying a legal father for children born to unmarried mothers. In contrast, the current paper focuses on the likelihood that legal fathers believe themselves to be (or not to be) the biological fathers of their putative children.

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exclusion of paternity, and refers to the likelihood that a man is not the genetic father of a particular child. Modern paternity tests do not prove paternity; rather, they prove nonpaternity, by demonstrating that a given man is exceedingly unlikely to have fathered a particular child. (For further details on paternity tests and the calculation of nonpaternity, see Mickey et al., 1986; Gjertson et al., 1988; Jeffreys et al., 1991; Pena and Chakraborty, 1994.) *Paternity confidence* refers to a man's internal (not necessarily conscious or articulated) assessment of his paternity. In a world where men possessed perfect information, a man's actual paternity and his paternity confidence would always agree. In practice, however, men's information is not perfect, and they must rely on indirect cues to assess paternity.

Paternity and nonpaternity

The prediction that males will invest less in offspring who are unlikely to be theirs has received mixed support from mathematical modeling (e.g., Maynard Smith, 1977; Grafen, 1980; Whittingham et al., 1992; Xia, 1992; Westneat and Sherman, 1993), as well as from empirical studies of nonhuman species. Nonpaternity was studied extensively among birds, which often exhibit high rates of nonpaternity, and which lend themselves to experimental manipulation (Petrie and Kempenaers, 1998). In many avian species, it was shown that while males respond to decreased paternity with decreased parental care, the effect is not as strong or as universal as originally predicted (Møller and Birkhead, 1993; Schwagmeyer et al., 1999; Whittingham and Dunn, 2001). Among nonhuman primates, it was questioned whether paternal care ever reflects paternity (Van Schaik and Paul, 1996). Many studies of paternity in nonhuman species were criticized on methodological grounds, e.g., many studies that failed to find an association between paternity confidence and paternal care may not have manipulated paternity confidence in an ecologically appropriate manner for the species being studied (Schwagmeyer and Mock, 1993; Kempenaers and Sheldon, 1997; Sheldon, 2002).

Among humans, few studies reported data on nonpaternity. Nonpaternity rates are often cited as being 10% or greater, though little or no empirical support is generally provided for this assertion (e.g., Stewart, 1989; Cervino and Hill, 2000; Alfred, 2002), leading MacIntyre and Sooman (1991) to suggest that the 10% figure is an unfounded and largely unexamined myth. Several authors reported worldwide median nonpaternity rates ranging from 2.3–9%, though they were hampered by small sample sizes of generally less than 10 studies (MacIntyre and Sooman, 1991; James, 1993; Baker and Bellis, 1995; Allison, 1996). More recently, Anderson (2006) examined 67 studies on nonpaternity, classified into three groups: sources likely to have high paternity confidence (such as genetic studies, in which male participants were likely to be biased toward men with high paternity confidence); sources likely to have low paternity confidence (i.e., paternity-testing laboratories, whose clientele largely consist of men seeking paternity tests because they are contesting paternity); and sources in which paternity confidence could not be determined (because the study was unpublished, or the methodology was vague). Virtually none of the studies came from random population samples. Median nonpaternity rates were 1.9% for men with presumably high paternity confidence, 16.7% for the unknown paternity confidence group, 3.9% for the combined high and unknown paternity confidence groups, and 29.8% for men with low paternity confidence. These groups were all significantly different from one another, suggesting that men with high paternity confidence do indeed have higher paternity than men with low paternity confidence. Without knowing the proportion of men with high or low paternity confidence for a particular society, however, it is impossible to estimate the "true" rate of nonpaternity, although the 10% nonpaternity rate that is frequently cited as typical apparently has little basis in fact (MacIntyre and Sooman, 1991; Anderson, 2006).

Paternity confidence

Little is known about how men determine paternity confidence. Two likely methods by which men might assess paternity confidence are 1) monitoring their mate's sexual behavior around the time of conception, and 2) assessing physical resemblance to the child after the baby is born (Davis and Daly, 1997). Men in many cultures pay close attention to their mate's sexual behavior, and suspicion of infidelity is a common reason for divorce, infanticide, and uxoricide (Daly and Wilson, 1988; Betzig, 1989). Many men presumably reach a conclusion about their likelihood of paternity at the time their partner becomes pregnant, based on cues of their partner's sexual fidelity.

Once a child is born, men may update their assessment of paternity based on the resemblance between themselves and the child. Levine (1977; cited in Durham 1991) reported that among the polyandrous, ethnically Tibetan Nyinba of Nepal, in cases where paternity cannot be established due to an absence of potential fathers around the time of conception, the parents use physical resemblance to determine paternity. In Sierra Leone, Mende men used resemblance to deduce adultery (Harris and Sawyer, 1968; cited in Strassmann, 1992). Resemblance to children appears to matter to men in many situations, and mothers and maternal relatives apparently try to manipulate this postnatal assessment through positive comments on paternal resemblance (Daly and Wilson, 1982; Regalski and Gaulin, 1993; McLain et al., 2000). Platek et al. (2002, 2003) found that men were more likely to invest in children whose faces were computer-morphed to resemble them, while there was no effect of resemblance on women's intention to invest (but for conflicting results in which no gender difference was observed, see DeBruine, 2004). Similarly, in hypothetical adoption cases, resemblance is an important factor for men, and unimportant for women (Volk and Quinsey, 2002).

Burch and Gallup (2000) found that men's perception of how much putative children resembled them was positively correlated with the quality of the relationship with the child, and negatively correlated with physical abuse directed by men toward children's mothers, while Apicella and Marlowe (2004) reported that men's investment in children was positively correlated with perceived resemblance to children. Salter (1996) proposed that men will prefer mates whose physical traits will allow them to better assess resemblance to their putative children. Whether children actually resemble fathers more than mothers is currently unclear. Christenfeld and Hill (1995) reported that 1-year-old babies resembled fathers more than mothers, but subsequent studies failed to replicate this result (Brédart and French, 1999; McLain et al., 2000; Oda et al., 2002; Bressan and Grassi, 2004). Furthermore, it is not clear if children would benefit from strong resemblance to their fathers, because signaling pa-

ternity also signals nonpaternity (Pagel, 1997; Brédart and French, 1999). Lastly, a priori beliefs about paternity (perhaps based on a mate's perceived sexual fidelity) are likely to influence men's assessment of resemblance (Bressan and Dal Martello, 2002). Most of these studies relied on samples from the US; further cross-cultural work, as well as further research into the etiology of paternity confidence and the specific mechanisms by which men assess paternity, is clearly needed.

Paternity confidence and paternal investment in children

The relationship between paternity confidence and paternal care has long been recognized as important. Many historical, anecdotal, ethnographic, and literary examples suggest that men tend to abandon children who are not theirs (Wilson, 1987; Rudavsky, 1999). Western legal tradition recognizes that men should not be held responsible for putative children who are in fact not theirs (Wilson, 1987), and American men who do not pay child support often claim nonpaternity as justification (Dubey, 1995). Medical ethicists, recognizing that revealing nonpaternity to putative fathers may have strong negative effects on relationships with wives and children, often argue against disclosing nonpaternity, framing it as an issue of women's confidentiality (Lisker et al., 1998; Wertz et al., 1990). However, others argue that withholding information on nonpaternity from men is unethical, on the grounds that men always have the right to know if they have been cuckolded (Ross, 1996; Wright et al., 2002).

There is great variation across cultures in the degree to which biological and social fatherhood overlap (e.g., Levine, 1987; Beckerman et al., 1998; Hrdy, 2000), but cross-culturally, paternity confidence is positively associated with men's involvement with children, or with investment or inheritance from paternal kin (Greene, 1979; Kurland, 1979; Gaulin and Schlegel, 1980; Flinn, 1981; Hartung, 1985; Diamond and Lorcay, 1989; Huber et al., 2004). Within societies, greater investment by matrilineal than patrilineal kin suggests significant levels of nonpaternity, or more precisely it suggests reduced levels of paternity confidence (Euler and Weitzel, 1996; Gaulin et al., 1997; McBurney et al., 2002; but for mixed results, see Pashos, 2000).

No study has directly examined the relationship between actual paternity and investment in or involvement with children, and only two studies examined the relationship between confidence of paternity and paternal care. Fox and Bruce (2001), using a sample of men in Knoxville County, Tennessee, found that paternity confidence was positively correlated with affective involvement with children and with a composite fathering variable. Additionally, Anderson et al. (2006), using data on paternity confidence and paternal investment by men living in Albuquerque, New Mexico, reported that men spend less time with low paternity confidence children, and are less likely to be extensively involved with their schooling. Men are more likely to divorce or break up with women if the men have low paternity confidence in the children the women bear, which further reduces investment in low paternity confidence children, because men in this sample invested less in children following divorce (e.g., Anderson et al., 1999).

HYPOTHESES

As reviewed above, although both paternity and paternity confidence play important roles in evolutionary models of male parental behavior, many questions remain about both paternity and confidence of paternity. Little is known about the determinants or correlates of paternity confidence, and virtually no work has been done on the demographic consequences of paternity confidence, apart from investment in children. This paper will analyze both the correlates of paternity confidence in a sample of men in the contemporary US, as well as the impact of paternity confidence on pregnancy outcomes in the same sample. It will also examine the extent to which nonresponse to sensitive questions on paternity confidence is associated with particular demographic characteristics.

1) Correlates of paternity confidence

While other researchers focused primarily on resemblance between children and fathers in the determination of paternity confidence (e.g., Daly and Wilson, 1982; Regalski and Gaulin, 1993; Christenfeld and Hill, 1995; Brédart and French, 1999; Burch and Gallup, 2000; McLain et al., 2000; Oda et al., 2002; Platek et al., 2002, 2003; Volk and Quinsey, 2002), we will instead focus on demographic correlates of paternity confidence. It is likely that many men make up their minds about the likelihood of their being the father of a particular child before that child is born, based in part on their perceptions of the sexual fidelity of their mates, and the degree of trust and commitment within the couple. Some men are more likely than others to be in sexual relationships in which low paternity confidence is a more likely outcome (such as casual partners). Thus, we will examine whether demographic characteristics of the man and of the relationship predict the level of paternity confidence in a particular pregnancy. We focus on three specific predictors: marital status (because married couples presumably have greater sexual fidelity and commitment to each other than unmarried couples); whether or not the pregnancy was planned (because unexpected pregnancies might be associated with extrapair sexual behavior); and number of children the couple has together (because couples who have not yet had children together may have a lower degree of commitment to each other). We also control for and examine background characteristics that might influence paternity confidence, e.g., age, income, education, calendar year, and ethnicity.

The relationship between birth order and paternity confidence may be complicated. On the one hand, couples who have children together may have been self-selected for greater trust and fidelity than couples with no children; it makes sense that men would not have a second, third, or fourth child with a woman whose first child was of dubious paternity. However, once a couple has several children together, a woman's extrapair infidelity may be more likely to go unpunished (or undetected), because a man who abandoned his spouse after the birth of a low paternity confidence, high-parity child would decrease investment not only in that last child, but also in the previous high paternity confidence children. As long as a man has high paternity confidence in most of his children, he might be better off (in fitness terms) remaining with his spouse (and investing in all of the children) than unilaterally withdrawing (for a similar argument in the context of

avian broods, see Whittingham et al., 1992; MacDougall-Shackleton and Robertson, 1998).

A man's confidence of paternity is, by definition, an internalized calculation: it cannot be assessed by an outsider through observational methods. We recognize that asking questions about paternity confidence is socially difficult or awkward in many situations, and men may be tempted to lie outright or refuse to answer the question. Refusal to discuss paternity confidence could result from two situations: men simply do not want to discuss paternity confidence under any circumstances (perhaps because they are offended by the question), or they may be willing to discuss it for some children, but are unwilling to discuss it for a particular child. In either case, it is possible that concerns of nonpaternity are driving the discomfort with the subject matter, e.g., men may have doubts about paternity, but are unwilling either to admit them or to lie about them. We predict that refusal to discuss paternity confidence will not occur randomly, but will be associated with men's demographic characteristics in a manner similar to low paternity confidence children. We will examine whether men will be more likely not to discuss paternity confidence for the following demographic parameters: if they are married to the woman having the pregnancy, if a pregnancy is unplanned, or for higher-parity children.

2) Paternity confidence and pregnancy outcomes

Men and women are expected to react and counterreact to the reproductive and investment decisions made by each other (e.g., Chase, 1980; Borgerhoff Mulder, 1992; Bergstrom, 1996). Men are likely to invest less in low paternity confidence offspring, and may be more likely to end relationships with women who bear them low paternity confidence offspring. Because women can anticipate this reaction from men in response to a low paternity confidence pregnancy, and because early abandonment and nonmarital births may have adverse effects on women's fitness (e.g., Anderson and Low, 2003), it may be in women's interests not to carry a low paternity confidence pregnancy to term (Hill and Low, 1992; Lycett and Dunbar, 1999; Tullberg and Lummaa, 2001). We thus predict that elective abortions will be more common if paternity confidence in a pregnancy is low.

Pregnancy outcomes include live births, elective abortions, miscarriages, and stillbirths. The distinction between a miscarriage and a stillbirth varies, and has changed over time: generally, a pregnancy that ends before 20–28 weeks is considered a miscarriage, while one that ends later is considered a stillbirth (Cai and Feng, 2005). The causes of fetal loss are not completely understood, but both miscarriages and stillbirths are influenced by biosocial factors such as nutrition, stress, and social crises (Cai and Feng, 2005). Low paternity confidence might also increase the likelihood of a pregnancy ending in miscarriage or stillbirth if, for example, the increased stress likely to be associated with low paternity confidence (caused by arguments between partners, possible abandonment by the male, etc.) increases the probability of spontaneous abortion. However, we do not expect paternity confidence to have as much effect on miscarriages and stillbirths as on elective abortions.

We use multivariate analysis to examine whether paternity confidence influences pregnancy outcomes once background variables are controlled for. Background variables include the man's age and income at time of pregnancy, the man and the woman's educational levels, the calendar year of the pregnancy, and the man's race/ethnicity. Additionally, we will examine whether paternity confidence is a significant predictor of pregnancy outcomes once several additional independent variables are controlled for: 1) marital status, since voluntary abortions are much more common among unmarried than married women (Henshaw et al., 1985; Adu, 1996; Lycett and Dunbar, 1999); 2) whether or not a pregnancy is planned, which is likely to influence whether an abortion occurs (Puffer, 1993) as well as pregnancy health in general (Korenman et al., 2002); and 3) the couple's previous parity, which is also likely to influence the probability of an abortion (Adu, 1996; Tullberg and Lummaa, 2001). We predicted above that these three demographic variables will influence paternity confidence. Thus, it is important to examine whether paternity confidence has an effect on pregnancy outcomes once these variables are controlled for.

METHODS

Data set

To test our hypotheses, we use self-reported data on paternity confidence for a sample of men from Albuquerque, New Mexico, collected between 1990–1993. The Albuquerque Men data set consists of two complementary interviews that were administered to participants recruited at the Bernalillo County (New Mexico) Motor Vehicle Division (MVD). The short interview took about 7 min to administer; approximately 7,100 participants were given this interview in a private area at the MVD. On the basis of information obtained in the short interview, eligible participants were invited to participate in the long interview. The criteria for eligibility were: 1) being age 25 or over, and 2) having come to the MVD for the purpose of license origination or renewal, or for a photo ID. If the subject agreed to participate in the long interview, an appointment was made to conduct the interview either in a mobile office vehicle, in an office at the University of New Mexico, or at the subject's home. Interviews were conducted in private by trained student interviewers. Approximately 1,325 men participated in long interviews, for which they were paid $30 each. The long interviews took from 2–6 hr to administer (for further details, see Kaplan et al., 1998).

The long interview was designed to collect data on, among other things, each respondent's marital and reproductive histories. Men were asked about their reproductive behavior in the context of married, cohabiting, and short-term relationships. Men were asked to list all pregnancies that were attributed to them, including those that did not result in live births. This list included women whom the men suspected they might have gotten pregnant. After removing cases with missing data on relevant variables, the data set used in the current analysis contains 3,360 pregnancies reported by 1,099 men.

No paternity tests were conducted with this data set, so measures of actual paternity are not available. The data set does contain a measure of paternity confidence, which is the main variable of interest in this analysis. For each pregnancy men listed, they were asked, "Are you certain that you are the father of this pregnancy?" and given the choice of answering yes (certain he is the father), no (certain he is not the father), or uncertain (may or may not be the father). These responses were recoded into a dichotomous measure of low paternity confidence, scored as one if a man indicated any doubts that the offspring might be

his (uncertain or certain he is not the father), and zero if he expressed no doubts. Of the 3,066 pregnancies in the sample, men expressed low paternity confidence for 49 (1.46%) of them.

Given the sensitive nature of paternity confidence, it is not surprising that some men refused to answer the question for at least some of the pregnancies they had listed. In fact, twice as many men declined to answer the question (102 pregnancies, or 3.04%) as volunteered low paternity confidence. Rather than discard these missing cases, we decided to examine whether men's unwillingness to answer the question might be nonrandom: specifically, whether it might show the same relationship to key predictor variables as low paternity confidence. There were 85 men in the sample with more than one pregnancy in the data set who refused to answer the paternity confidence question for at least one pregnancy. Only six of these men refused to answer the paternity confidence question for *all* pregnancies. The other 79 men willingly answered the paternity confidence question *for at least some pregnancies*, indicating that they did not object to the question on principle. This raises the possibility that the refusal of some of these men to respond to the question may be an indirect admission of low paternity confidence. It is also possible that their paternity confidence was reduced for these pregnancies, but not reduced sufficiently for them to disavow the pregnancy entirely, or to admit they were not sure if they were the father (see the discussion on thresholds of nonpaternity among birds in Whittingham et al., 1992). We therefore retained these observations in our sample, so that the measure of paternity confidence used in this paper has three levels: high paternity confidence (95.50%), low paternity confidence (1.46%), and unstated paternity confidence (3.04%).

For every pregnancy men listed, three outcomes were recorded: live birth, elective abortion, or miscarriage/stillbirth.[2] Of 3,360 pregnancies in the data set, 2,880 (85.71%) resulted in live births, 121 (3.60%) were terminated in elective abortions, and 359 (10.68%) ended in miscarriage/stillbirth.

Several potential sources of bias and error in the data set should be mentioned. First, it is likely that the sample underreports pregnancies. These are retrospective data, which are subject to recall error; furthermore, men tend to underreport fertility relative to women in retrospective reports (e.g., Becker, 1996). Also, men can only report the pregnancies they know about. A substantial fraction of pregnancies are terminated naturally before being clinically diagnosed (and presumably before men are probably informed of the pregnancy) (Wilcox et al., 1988; Ellison, 2001; Zinaman et al., 1996). Additionally, men could not report pregnancies from short-term relationships that ended before a pregnancy was apparent (or before they were told about it). The sample is also likely to underreport low paternity confidence pregnancies. Women may be less likely to inform men about pregnancies in cases where they anticipate the men will have extremely low paternity confidence, and men might not list pregnancies which they believe they had nothing to do with.

An additional source of potential error concerns pregnancy outcomes. Because elective abortions are socially undesirable, they are often underreported (Udry et al., 1996). Men may choose to report abortions as miscarriages, or they may have been misinformed by their partner that an aborted pregnancy miscarried. We have no reason to believe that a pregnancy reported as ending in live birth did not do so.

Despite these potential limitations, the Albuquerque Men data set is the only one we know of that can address questions on the demographic patterning of paternity confidence, and the relationship between paternity confidence and pregnancy outcomes, both important questions for evolutionary and demographic investigations into human parenting and reproductive behavior.

Statistical analysis

This paper presents two sets of analyses: 1) predictors of paternity confidence, and 2) predictors of pregnancy outcomes. Each dependent variable will be examined initially through simple univariate descriptive statistics, before presenting multivariate models that control for a number of background characteristics. Multivariate models control for a man's age at time of pregnancy, his income at time of pregnancy (in 1990 dollars, logged), and his highest level of education (in years); the woman's highest level of education (in years); the calendar year a pregnancy occurred; and the man's ethnicity (coded as dummy variables for Hispanic and other ethnicity, with Anglo[3] being the baseline; the 18 African American men in the sample were grouped with "other"). These background variables were shown to influence the probability of a pregnancy being aborted (e.g., Henshaw et al., 1985; Tullberg and Lummaa, 2001), and are likely to influence paternity confidence as well. We also include variables measuring whether the couple was married at time of pregnancy; retrospective recall of whether the pregnancy was planned; and number of children the couple had had together at the time the pregnancy occurred, not counting the pregnancy itself.

One potentially important variable that is lacking for many observations is woman's age at time of pregnancy, which was shown to vary with pregnancy outcome (e.g., Henshaw et al., 1985; Lycett and Dunbar, 1999; Tullberg and Lummaa, 2001). Unfortunately, this question was not added to the Albuquerque Men instrument until halfway through data collection, and thus we have the mother's age for only 1,941 (57.8%) pregnancies. Including this variable in analyses would greatly restrict the number of observations of rare outcomes (specifically, low paternity confidence, unstated paternity confidence, and elective abortions). For cases where a woman's age is known, it is highly correlated with the man's age (Spearman's rho $=$ 0.816, $P < 0.0001$, N $=$ 1,941): so highly correlated, in fact, that including both variables in the same model would violate assumptions of independent variables. We thus use the man's age as a proxy for the woman's age at pregnancy.

[2]The Albuquerque Men instrument did not define the difference between miscarriage and stillbirth; this definition changes over time, and varies across cultures (e.g., Cai and Feng, 2005). For this reason, and because of relatively small numbers, pregnancies that ended in miscarriage or stillbirth are combined for the present analysis.

[3]In New Mexico, the term "Anglo" refers to all individuals of non-Hispanic European descent, regardless of whether or not they are of Anglo-Saxon heritage. Most Hispanics in our sample were born in the US and are not recent immigrants. The sample used in the analysis contains 702 Anglo men (2,007 pregnancies), 348 Hispanic men (1,192 pregnancies), and 49 men of other or undefined ethnicities (161 pregnancies).

TABLE 1. Descriptive statistics, by paternity confidence

	Paternity confidence						
	High		*Low*		*Unstated*		
	Mean	SD	Mean	SD	Mean	SD	F
His age	29.13	6.11	26.73	5.76	30.01	6.71	4.80**
Logged income (1990 dollars)	9.90	1.58	9.44	2.57	10.00	0.96	2.30
His education (years)	15.83	3.45	15.55	3.62	13.83	4.52	16.27***
Her education (years)	14.20	3.57	12.73	3.44	13.68	3.83	5.02*
Calendar year of pregnancy	1,963.9	13.3	1,967.8	12.1	1,964.3	14.8	2.05
Ethnicity							
Anglo	0.602	0.489	0.673	0.474	0.402	0.493	8.89***
Hispanic	0.348	0.476	0.306	0.466	0.588	0.495	12.80***
Other ethnicity	0.050	0.217	0.020	0.143	0.010	0.099	2.12
Couple was married	0.966	0.181	0.653	0.481	0.912	0.285	66.95***
Pregnancy was planned	0.497	0.500	0.184	0.391	0.010	0.099	57.50***
Number of children couple has had together	1.180	1.462	0.612	0.909	1.765	1.857	11.67***
Pregnancy outcome							
Live birth	0.874	0.331	0.714	0.456	0.382	0.488	108.36***
Abortion	0.028	0.164	0.204	0.407	0.216	0.413	73.55***
Miscarriage/stillbirth	0.098	0.297	0.082	0.277	0.402	0.493	49.44***
N	3,209.0		49.0		102.0		

** $P < 0.01$.
*** $P < 0.001$.

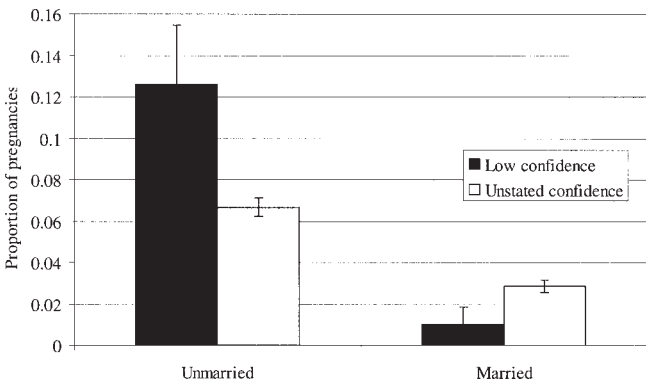

Fig. 1. Paternity confidence of pregnancies, by marital status at time of pregnancy (bars denote standard errors).

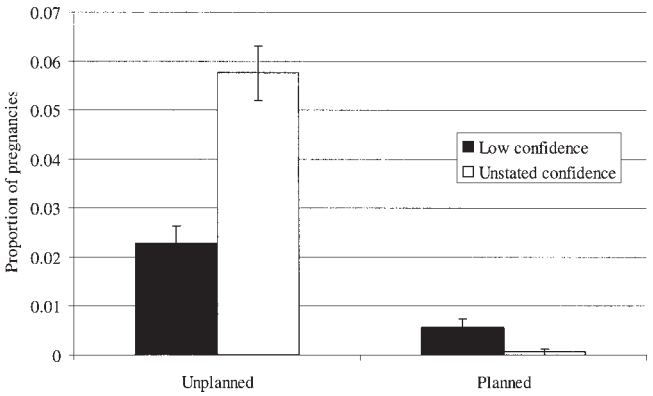

Fig. 2. Paternity confidence of pregnancies, by whether pregnancy was planned (bars denote standard errors).

Both of the dependent variables under consideration have three outcome levels. Paternity confidence is coded as high, low, or unstated, while pregnancy outcome is coded as live birth, abortion, or miscarriage/stillbirth. We will analyze these dependent variables using multinomial logistic regression, a statistical technique that is similar to logistic regression, except that it allows multiple levels of the dependent variable rather than only two. The technique does not assume that the levels are ordinal, i.e., that one level is above or greater than the other. Because the data set contains multiple pregnancies per respondent, all multivariate analyses will adjust the standard errors to control for correlations between pregnancies ascribed to the same man, using the "cluster" option in Stata, version 8.2.

RESULTS

Paternity confidence

Table 1 presents descriptive statistics for all variables used in the analyses, by paternity confidence (high, low, or unstated). The final column of Table 1 gives the F-statistic and *P*-value associated with an analysis of variance examining whether there is significant variation in each variable by paternity confidence. Virtually every variable shows significant variation with respect to paternity confidence, with the exceptions of income, calendar year of pregnancy, and belonging to other (non-Anglo/non-Hispanic) ethnicity. With respect to pregnancy outcomes, live births are less common when paternity confidence status is unstated, abortions are much more likely among both low and unstated paternity confidence pregnancies, and miscarriages/stillbirths are reported at much higher rates for pregnancies whose paternity confidence status is unstated.

Paternity confidence status is related in a complex manner to marital status, whether a pregnancy is planned, and number of children the couple have already had together. Figure 1 illustrates an interaction between marital status at time of pregnancy and paternity confidence. Both low and unstated paternity confidence are much higher among unmarried couples than married couples (two-tailed *t*-tests, $P < 0.0001$ for low paternity confi-

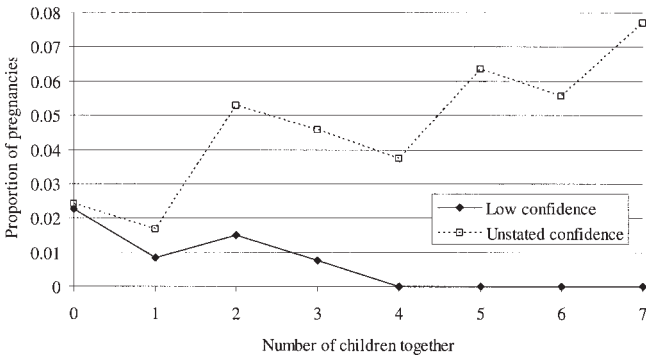

Fig. 3. Paternity confidence of pregnancies, by number of children couple already had together.

dence; $P = 0.0121$ for unstated paternity confidence). However, the relative frequency of each type of paternity confidence changes with marital status. If a couple is unmarried, the man is marginally more likely to have low paternity confidence than unstated paternity confidence in the pregnancy (two-tailed $t = 1.653$, $P = 0.0996$). For married couples, unstated paternity confidence is more likely than low paternity confidence (two-tailed t-test, $t = -5.522$, $P < 0.0001$). This suggests that unmarried men are more likely to rate pregnancies as low paternity confidence rather than unstated paternity confidence, while married men are more likely not to state paternity confidence than rate the pregnancy as low confidence.

Figure 2 shows that paternity confidence varies by whether or not a pregnancy is planned. Absolute values of low paternity confidence and unstated paternity confidence are much higher for unplanned pregnancies than for planned ones (two-tailed t-tests, $P < 0.0001$ for low paternity confidence and unstated paternity confidence). For unplanned pregnancies, men are more likely not to answer the question on paternity confidence than respond that paternity confidence is low (two tailed t-test, $t = -5.2627$, $P < 0.0001$). For planned pregnancies, however, men virtually never refused to answer the question, and were much more likely to admit low paternity confidence than not to respond (two tailed t-test, $t = 2.5355$, $P = 0.0113$).

Figure 3 displays the proportion of pregnancies with low or unstated paternity confidence, by the couple's previous fertility together. Rates of both low and unstated paternity confidence are similar for couples with no children. Reports of low paternity confidence decrease with parity, falling to zero by the fourth child, while unstated paternity confidence increases after the first child. In other words, a man's willingness to evaluate paternity confidence with respect to a specific child decreases significantly as the number of children he already has with that woman increases.

Because the univariate relationships presented in Table 1 and Figures 1–3 may be confounded by other variables, we performed a more detailed multinomial logistic regression of the man's paternity confidence for each pregnancy in the sample (Table 2). The model has two outcomes: low paternity confidence or unstated paternity confidence, with high paternity confidence as the baseline level. In terms of control variables, low paternity confidence is less likely to occur if a woman has a higher level of education. Unstated paternity confidence, in contrast, is less likely if the man is more educated, and more likely if the man is

TABLE 2. Multinomial logistic regression of paternity confidence: high (baseline), low, or unstated[1]

	Paternity confidence			
	Low		Unstated	
	Coeff.	Std. error	Coeff.	Std. error
Intercept	−35.912	26.788	−0.138	33.330
Respondent's age	−0.042	0.026	0.030	0.022
Logged income (1990 dollars)	−0.059	0.085	0.063	0.101
His education (years)	0.018	0.092	−0.127	0.058*
Her education (years)	−0.156	0.059**	0.093	0.074
Calendar year of pregnancy	0.019	0.014	−0.002	0.017
Anglo (reference group)				
Hispanic	−0.521	0.483	0.893	0.331**
Other ethnicity	−1.689	1.133	−1.556	1.081
Couple was married	−2.227	0.424***	−0.610	0.487
Pregnancy was planned	−1.068	0.485*	−4.596	1.018***
Number of children they have together	−0.218	0.146	0.028	0.080

[1] N = 3,360, chi-square = 134.51, $P < 0.0001$. Coeff., coefficient; Std. error, standard error.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

Hispanic. The man's age, which was significantly correlated with paternity confidence in the univariate comparison (Table 1), loses significance in the multivariate model. In terms of the hypothesized predictor variables, being married and the pregnancy being planned both decrease the likelihood of a man having low paternity confidence in a pregnancy. For unstated paternity confidence, only the pregnancy being planned remains a significant predictor: men are much more likely to leave paternity confidence unstated if a pregnancy was unplanned. The couple's previous fertility has no effect on paternity confidence, once background characteristics are taken into consideration.

Pregnancy outcomes

Table 3 presents descriptive statistics for all variables, by pregnancy outcome (live birth, elective abortion, or miscarriage/stillbirth). Nearly every variable under consideration varies by pregnancy outcome. With respect to marital status, abortions are much less common among married couples, relative to live births and miscarriages/stillbirths. Abortions are also less common if a pregnancy is planned in advance, and among couples who have more children together. With respect to paternity confidence, high paternity confidence pregnancies are less likely to end in abortions, while low paternity confidence pregnancies are most likely to end in abortions. Both abortions and miscarriages/stillbirths are more common among pregnancies whose paternity confidence is unstated.

Table 4 presents multinomial logistic models of pregnancy outcomes. There are two outcomes: elective abortion or miscarriage/stillbirth, with live birth being the baseline outcome. Model 1 presents control variables plus paternity confidence. Among the control variables, calendar year is a significant positive predictors of abortion, while the respondent's age and income are negative predictors of abortion. Calendar year also raises the likelihood of miscarriage/stillbirth, while being Hispanic is associated with a lower probability of miscarriage/still-

TABLE 3. Descriptive statistics, by pregnancy outcome

	Live birth		Elective abortion		Miscarriage/stillbirth		
	Mean	SD	Mean	SD	Mean	SD	F
His age	28.99	6.02	29.63	7.59	29.97	6.37	4.55*
Logged income (1990 dollars)	9.90	1.56	9.56	2.45	9.93	1.39	2.92^{+}
His education (years)	15.67	3.56	16.83	2.91	16.16	3.17	8.88***
Her education (years)	14.03	3.68	15.60	2.84	14.77	2.79	17.18***
Calendar year of pregnancy	1,963.3	13.02	1,976.0	9.01	1,965.4	14.6	57.17***
Ethnicity							
Anglo	0.585	0.493	0.661	0.475	0.671	0.470	5.97**
Hispanic	0.367	0.482	0.289	0.455	0.276	0.448	7.05**
Other ethnicity	0.047	0.212	0.050	0.218	0.053	0.224	0.12
Couple was married	0.976	0.154	0.628	0.485	0.944	0.230	205.39***
Pregnancy was planned	0.507	0.500	0.041	0.200	0.393	0.489	58.08***
Number of children couple has had together	1.231	1.499	0.579	0.998	1.061	1.350	13.00***
Paternity confidence of pregnancy							
High paternity confidence	0.974	0.158	0.736	0.443	0.875	0.332	114.63***
Low paternity confidence	0.012	0.110	0.083	0.276	0.011	0.105	73.55***
Unstated paternity confidence	0.014	0.116	0.182	0.387	0.114	0.319	49.44***
N	2,880.0		121.0		359.0		

$^{+}$ $P < 0.10$.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

TABLE 4. Multinomial logistic regression of pregnancy outcomes: live births (baseline), elective abortion, or miscarriage/stillbirth

	Elective abortion		Miscarriage/stillbirth	
	Coeff.	Std. error	Coeff.	Std. error
Model 1[1]				
Intercept	−181.901	18.315***	−25.892	11.081*
Respondent's age	−0.051	0.023*	0.010	0.012
Logged income (1990 dollars)	−0.110	0.055*	−0.004	0.039
His education (years)	0.079	0.047^{+}	0.018	0.027
Her education (years)	0.074	0.047	0.034	0.023
Calendar year of pregnancy	0.091	0.009***	0.012	0.006*
Anglo (reference group)				
Hispanic	−0.610	0.316^{+}	−0.492	0.184**
Other ethnicity	−0.311	0.526	0.037	0.294
High paternity confidence (reference group)	—		—	
Low paternity confidence	2.202	0.409***	0.079	0.531
Unstated paternity confidence	3.561	0.457***	2.525	0.363***
Couple was married				
Pregnancy was planned				
Number of children they have together				
Model 2[2]				
Intercept	−150.749	20.049***	−20.501	10.777^{+}
Respondent's age	−0.014	0.019	0.024	0.012^{+}
Logged income (1990 dollars)	−0.045	0.063	0.007	0.040
His education (years)	0.084	0.051^{+}	0.021	0.027
Her education (years)	0.122	0.054*	0.032	0.023
Calendar year of pregnancy	0.075	0.010***	0.009	0.006
Anglo (reference group)				
Hispanic	−0.451	0.311	−0.422	0.186*
Other ethnicity	−0.347	0.549	0.018	0.304
High paternity confidence (reference group)				
Low paternity confidence	0.893	0.497^{+}	−0.198	0.557
Unstated paternity confidence	2.975	0.485***	2.436	0.360***
Couple was married	−1.735	0.302***	−0.558	0.296^{+}
Pregnancy was planned	−3.163	0.489***	−0.432	0.167*
Number of children they have together	−0.359	0.131**	−0.150	0.065*

[1] N = 3,360, chi-square = 231.24, $P < 0.0001$. Coeff., coefficient, Std. error, standard error.
$^{+}$ $P < 0.10$.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.
[2] N = 3,360, chi-square = 255.44, $P < 0.0001$. Coeff., coefficient, Std. error, standard error.

birth. Other background variables that were significant in univariate comparisons (Table 3), including the education of the respondent and the mother, lose significance in the multivariate model. With respect to paternity confidence, low paternity confidence is a positive predictor of abortion only, and is nonsignificant with respect to miscarriage. Unstated paternity confidence, on the other hand, is associated with an increased probability of both abortion and miscarriage.

Model 2 of Table 4 adds additional demographic variables, both to examine their effects on pregnancy outcomes and to see if the effects of paternity confidence on pregnancy outcome remain, above and beyond the effects of these additional variables. We find that the couple being married, the pregnancy being planned, and the number of children the couple already has are all significant negative predictors of abortion. Planned pregnancy status and prior fertility are both significant negative predictors of miscarriage/stillbirth, though marital status is not. With these demographic characteristics added to the model, low paternity confidence becomes only marginally significant as a predictor of abortion ($P = 0.072$), and does not predict miscarriage at all. Unstated paternity confidence, however, remains a positive predictor of each outcome. All else being equal, pregnancies for which men were not willing to discuss paternity confidence were less likely to produce a live birth.

DISCUSSION

This paper presents an examination of paternity confidence from a new perspective. Rather than focusing on resemblances between men and children, we examined how men's demographic characteristics predict whether they rate pregnancies as high confidence or low confidence, or refuse to answer the question of paternity confidence altogether. Our results show that low paternity confidence is associated with less educated mothers, with unmarried couples, and with unplanned pregnancies. Men are much more likely not to answer questions on paternity confidence if they have less education, if they are Hispanic, or if a pregnancy is unplanned. Marital status appears to influence both low and unstated paternity confidence in a univariate comparison (Fig. 1), but in multivariate analysis, it predicts only low paternity confidence. Unplanned pregnancies are more likely to be rated as either low or unstated paternity confidence in both univariate and multivariate analyses (Fig. 2, Table 2). We had also hypothesized that men were more likely to refuse to answer questions on paternity confidence for high-parity children: this hypothesis received support in the univariate plot (Fig. 3), but was not supported in multivariate analysis (Table 2). Previous parity was not significant when entered into the model without marital or planned status included (results not shown).

The key predictors that were supported in multivariate analysis of paternity confidence, i.e., marital status (for low paternity confidence) and whether a pregnancy was planned (for low and unstated paternity confidence), are both associated with the degree of trust and commitment established between sexual partners. Men presumably are more suspicious of their partner's sexual fidelity when the couple is not married; unplanned pregnancies are also apparently viewed with more suspicion. Our results are consistent with cross-cultural measures of paternity confidence, which measure paternity confidence in terms of spousal fidelity for that culture (e.g., Gaulin and Schlegel, 1980; Flinn, 1981; Huber et al., 2004). However, while we examined demographic variables that are likely to be correlated with spousal fidelity instead of the resemblance between men and their putative offspring, we should note that offspring resemblance and spousal fidelity are not mutually exclusive methods by which men might assess paternity confidence. It is likely that men use cues of spousal fidelity to assess paternity confidence before birth, and reevaluate this assessment using physical resemblance after birth. The causal pathways influencing paternity confidence are different for each system of cues as well. Spousal behavior affects paternity, and paternity affects offspring resemblance. Offspring resemblance does not affect paternity (the actual relationship between a man and a child), but can influence paternity confidence. In this sense, demographic factors may be more distal variables on paternity confidence than resemblance.

We also examined the relationship between paternity confidence and pregnancy outcomes, arguing that low paternity confidence is likely to increase the odds of a pregnancy being aborted. Controlling for background factors, both low and unstated paternity confidence increased the odds of an elective abortion, while unstated paternity confidence increased the odds of miscarriage/stillbirth (Table 4, model 1). Factors associated with the commitment and sexual fidelity of the parents were also related to pregnancy outcome: abortions were more likely if the couple was unmarried, if a pregnancy was unplanned, or if the couple had fewer children together, while miscarriages were associated with unplanned pregnancies and lower parity (Table 4, model 2). With these additional factors in the model, low paternity confidence was only marginally significant in predicting abortion, though unstated paternity confidence remained a significant predictor of both abortion and miscarriage. The effect of low paternity confidence on pregnancy outcomes appears to be mediated by demographic factors such as divorce, which echoes the mediating relationship of divorce on paternity confidence and paternal investment seen for some measures of paternal care (Anderson et al., 2006). As reviewed above, mathematical models as well as empirical studies of birds suggest that decreased paternity confidence does not necessarily favor reduced paternal investment (e.g., Maynard Smith, 1977; Grafen, 1980; Whittingham et al., 1992; Xia, 1992; Møller and Birkhead, 1993; Schwagmeyer et al., 1999; Whittingham and Dunn, 2001). Our study demonstrates that, at least among men living in Albuquerque, paternity confidence, in particular unstated paternity confidence, does influence pregnancy outcomes. This suggests that paternity confidence has played, and continues to play, an important role in life-history outcomes for human males.

A final contribution of this paper concerns the categorization of unstated paternity confidence. The refusal rate for questions on paternity confidence was fairly high. While very few men refused to discuss paternity confidence unilaterally (93% of men with more than one pregnancy who refused to answer the question on paternity confidence for one pregnancy answered it for others), roughly twice as many men refused to discuss it for some pregnancies as admitted they had low confidence of paternity. We had hypothesized that if these refusals were due to suspected low paternity confidence, then unstated paternity confidence would have the same predictors as low paternity confidence. While we find that nonresponse to questions of paternity confidence is not a random phenomenon, and that it shares some of the same predictors as

low paternity confidence (e.g., unplanned pregnancies), the patterning and correlates of low and unstated paternity confidence differ in many details (Tables 1 and 2). As shown in Figures 1–3, low and unstated paternity confidence differ in their relationship to marital status, planned pregnancy status, and previous fertility. In some respects, unstated paternity confidence resembles high paternity confidence as much as low paternity confidence. Clearly, further work on men's willingness to discuss and rate paternity confidence is needed.

CONCLUSIONS

We demonstrated that paternity confidence varies with specific demographic characteristics of men and their relationships. Men are more likely to have low paternity confidence if the mother is less educated, the couple is unmarried, or a pregnancy is unplanned. Men are more likely not to state paternity confidence if the man is less educated or is Hispanic, or if a pregnancy is unplanned. When background factors are controlled for, the man's age and income, and the couple's previous fertility together do not influence paternity confidence.

We also found that paternity confidence is correlated with pregnancy outcomes. Pregnancies are more likely to be aborted if the man has low paternity confidence; however, this effect becomes statistically nonsignificant once marital status, whether a pregnancy is planned, and the couple's previous fertility are controlled for. Pregnancies for which the man is unwilling to state paternity confidence are more likely to end in either an elective abortion or a miscarriage/stillbirth.

While most previous research on paternity confidence focused on father/child resemblance, we found that demographic variables relating to spousal fidelity are significant predictors of paternity confidence, as well as pregnancy outcomes. We also found that men's refusal to answer questions about paternity confidence is nonrandom, but is correlated with many of the same variables that are associated with low paternity confidence. Unstated paternity confidence is not identical to low paternity confidence, but should clearly not be ignored in future analyses of assessment of paternity.

In conclusion, the attention men pay to whether or not they fathered the children attributed to them has implications not only for evolutionary models of human behavior, but also for fertility patterns and reproductive outcomes in contemporary society.

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