

# Differential Parental Investment in the Southwestern United States

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## ABSTRACT

The Trivers-Willard model (1973) predicts differential parental investment in children by sex and income; wealthier families will invest more in boys, while poorer families will invest more in girls. We investigated the TW Hypothesis in a sample of 103 six month old Tucson babies and their mothers. Hierarchical multiple regression equations were used entering baby's age, baby's sex, mother's age, male paternal commitment, a dichotomous poverty measure, per capita income, and four interaction terms, baby's sex by 1) mother's age 2) mother's education, 3) male paternal commitment, 4) poverty, and 5) per capita income. We included three dependent variables in successive regression equations; mother's attitudes towards ideal baby size for boy versus girl babies, weeks breast fed and the baby's weight at six months. These variables measure attitude, behavior, and physical outcomes. Poverty was a significant predictor of differential preference in ideal body size for boys versus girls; poor mothers preferred bigger baby girls. There was no evidence of differential preference in breast feeding. Education was also a significant predictor; but in the opposite direction than predicted by the TWH. Mothers with higher levels of education had heavier baby girls. Within Hispanics only, poverty was a significant predictor of sex-biased weight; poor mothers had heavier baby girls. This effect was not seen in Caucasians. These results provide mixed evidence for the Trivers-Willard model in a resource rich environment for humans.

## INTRODUCTION

'In species with a long period of parental investment after birth of young, one might expect biases in parental behavior toward offspring of different sex, according to parental condition; parents in better condition would be expected to show a bias toward male offspring.' (Trivers and Willard, 1973)

The Trivers-Willard Hypothesis (TWH) proposes sex-biased resource allocation by parents in order to maximize the reproductive success of their offspring. The hypothesis is salient in species where variations in parental condition (either prenatally or after birth) contribute to the differential reproductive success by their offspring. When reproductive variance is higher for males than for females (an intrinsic function of polygyny), mothers in optimal condition (defined here by plentiful resources) will be more likely to invest in male offspring, while mothers in poor condition (defined by scarce resources), will be more likely to invest in female offspring. The TWH suggests that parents will differentially invest in the sex with the greatest chance for reproductive success.

Since 1973, the Trivers-Willard Hypothesis (TWH) has been the focus of hundreds of plant and animal studies that have examined both the sex ratio at birth and differential parental investment throughout the life cycle. The results of these studies have been mixed, as have been the result of several meta-analyses.

Brown and Silk (2002) examined sex ratios in non-human primates, and did not find support for the TW

Hypothesis. "Our analyses indicate that the data are distributed much as we would expect by chance and that maternal rank is not associated consistently with biased birth sex ratios in this data set on nonhuman primates." In a subsequent meta-analysis, Schino (2004) replicated Brown and Silk's overall results, but also found support for the TW Hypothesis in conditions with high resource availability and low sexual dimorphism. Cameron (2004) performed a meta-analysis of 381 studies examining sex ratios in mammals (excluding humans); only a third provided support for the TW Hypothesis. However, there was considerable heterogeneity in the dataset. When the data were examined within indicator of maternal condition and timing, there was a consistent effect of maternal body condition around the time of conception and the TW Hypothesis was supported nearly 90% of the time. Sheldon and West (2004) found the same results in a meta-analysis of ungulate mammals.

Within humans, there is evidence for sex-biased infanticide and differential mortality. However, the evidence for differential parental investment is not uniform; with half of the studies showing evidence consistent with the TW hypothesis and the other half rejecting it. This ambiguity may be due to the heterogeneity of indicators used in human studies, or to the absence of a TW effect.

Unfortunately, the number of studies testing the TW Hypothesis in humans remains limited, particularly for resource rich environments, and existing work in the United States has provided conflicting results. In a

heterogeneous set of studies using national samples in the United States, Gaulin and Robbins (1991), Kanazawa (2005), and Hopcroft (2005) all found evidence for the TW Hypothesis, while others (Freese and Powell 1999, Keller et al. 2001) found no indication of sex-biased investment.

It is our intention to investigate the Trivers-Willard Hypothesis in a resource-rich sample in the Southwestern United States. Our measures of parental investment are infant weight at six months, weeks breastfed, and discrepancies in the mother's preferred infant size for boys and girls at six months. These outcomes are on a continuum from attitude, behavior, to physical outcomes and each is intended to measure the underlying construct of parental investment. Our approach follows that of Donald Campbell's work on acquired behavioral dispositions. Rather than viewing behavior as different from attitude, Campbell viewed them as a continuum, noting that ". . . there has been a stubborn confusion of the fact that verbal behaviors and overt behaviors have different situational thresholds with the fact of consistency. . . . From the dispositional perspective, the supposed absence of relationship between attitudes and behavior disappears" (1963). In this framework, an attitude can be considered a behavior that is not yet observable because it has not passed the threshold into action. Further along the continuum are rare and infrequent behaviors, those that occur with fair regularity, and finally behaviors that are ingrained habits.

Discrepancies in perception of the best baby size for baby boys and girls is an indicator of the mother's attitude that she may not be consciously aware of. It is difficult, if not impossible to get candid answers to the question "Do you think that girl babies should be smaller than boy babies?" A common measure of attitudes regarding body size are the figural drawings pioneered by Stunkard et al. (1983). In this approach, respondents rate silhouettes of body size that correspond to standard height and weight percentiles. Discrepancy scores between ideal and current body size (current – desired) are used as measures of body dissatisfaction. In this study, discrepancy scores are used as a covert measure of maternal investment.

In a summary of breast feeding studies in humans, Quinlan et al. (2005) found inconsistent results across countries irrespective of resource level. Likewise, Margulis et al. (1993) reported no support for the TW hypothesis in a sample of Hutterites, while Gaulin and Robbins (1991) found evidence for the TW Hypothesis in length of breastfeeding in the United States.

We tested the TW Hypothesis in a sample of six month old babies, using several indicators of parental investment; maternal preference for baby size, months breastfed, and infant weight at 6 months. Differential preference for baby size is a measure of attitude; breast feeding is a measure of behavior, and infant weight is a physical outcome. Measures of parental condition in-

clude maternal age, education, male parental commitment, poverty, and per capita household income. Poverty and per capita household income are direct measures of resources, as is male parental commitment (measured by presence of a spouse or boyfriend in the household). The age of the mother and her education are proxies for rank and increased resources. We hypothesized that 1) mothers with greater resources will prefer larger baby boys than girls and mothers with few resources will prefer larger baby girls. 2) Mothers with greater resources will breastfeed boys longer, and those with few resources will breastfeed girls longer than boys. 3) Mothers with greater resources will have heavier baby boys, and mothers with few resources will have heavier baby girls.

## METHODS

### Subjects

The women were drawn from a number of pediatric clinics throughout a metropolitan area in Arizona, in order to include women from a wide range of backgrounds. Eligible subjects were mothers of infants between five and eight months old who were attending a pediatric clinic for their child's six-month well baby visit and spoke English. Exclusion criteria included attendance at the clinic for a sick child visit, and children brought to clinic by someone other than their mother. Mother-infant pairs were approached in pediatric waiting rooms, the sample was stratified by income and ethnicity, and 110 women completed the interview. The child's weight was recorded from the medical records after the visit. Weight was not collected for six of the babies, and these mother-child pairs were not included in the analyses. Two mother-child pairs were not included in the analyses; one child was adopted, and the other child had a birth defect that resulted in a very low weight. Approximately half of the babies were male, and their ages ranged from 23 to 37 weeks, and their weight ranged from 4554 to 10700 grams. The mothers' ages ranged from 17 to 39 years (Table 1).

### Procedure

Potential subjects were identified by the clinic staff and were approached by the research staff member and invited to participate in the study. The purpose of the study was explained, and written consent obtained from women who agreed to participate in the study. The mothers were interviewed while at the pediatric clinic for their baby's 6 month well baby exam. The interview elicited the mothers' opinions on body size for themselves and their child, current feeding practices, and demographic questions. The interviews took approximately twenty minutes to complete. In order to compensate the mother for her time and effort, each mother was given a toy for her baby. Actual weight was recorded

		Mean (SD)
Mother's age		27.2 (6.0)
Mother's education		13.6 (2.6)
Household size		4.3 (1.5)
Total income		\$28,214 (16,037)
Baby's age		28.5 weeks (4.0)
Baby's weight		7966 gr. (1079)
Discrepancy score		0.0 (0.70)
Weeks breastfed		11.72 (10.17)
		N (%)
Poverty	< \$15,000	27 (26.2)
	= \$15,000	76 (73.8)
Mother's ethnicity	Anglo	61 (59.2)
	Hispanic	42 (40.8)
Baby's sex	Male	52 (50.5)
	Female	51 (49.5)
Male paternal commitment	Does not live with partner	23 (22.3)
	Lives with boyfriend	11 (10.7)
	Lives with spouse	69 (67.0)

from the child's medical record. The study was approved by the Human Subjects Committee of the University of Arizona.

### Body Image

The measures for infant body size followed the figural approach developed by Stunkard, Sørensen and Schulsinger (1983). Figure rating scales have been widely used in body image research to measure attitudes and perceptions, and discrepancy scores between ideal and current body size (current – desired) have often been employed as measures of body dissatisfaction (Sørensen et al. 1983, Fallon and

Rozin 1985, Beebe et al. 1999, McArthur et al. 2005).

Seven line drawings for infants were developed based on photographs of actual infants at different points on the weight-for-length chart. The babies were between six and eight months old  $\pm$  2 weeks. The middle drawing (#4) represents infants at the 50th percentile on this chart, e.g. their weight is average for all infants of a similar length. Drawings #3 and #5 represent the 25th and 75th percentiles, drawings #2 and #6 the 10th and 90th percentiles, and drawings #1 and #7 correspond to <10<sup>th</sup> and > 90<sup>th</sup> percentiles (Figure 1). The figural approach has demonstrated reliability and validity (Sørensen et al. 1983, Stunkard 2000, Bulik et al. 2001).

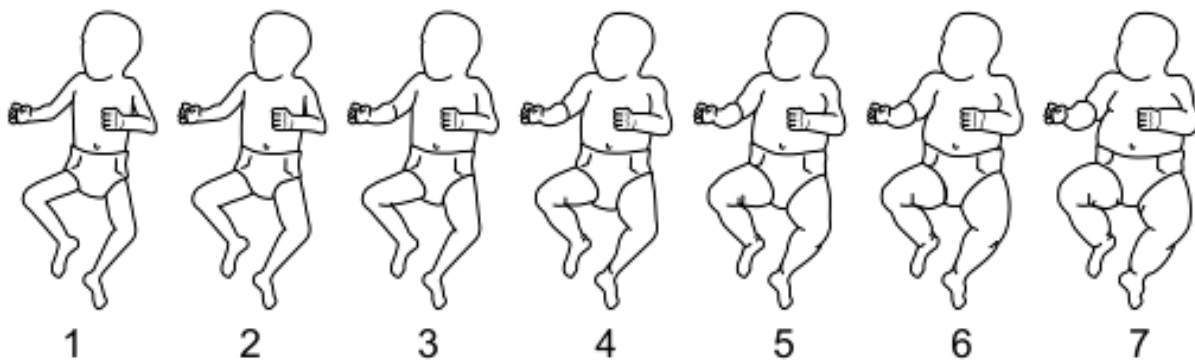
In this study, mothers were shown drawings of infants and were told that these were six month olds of the same sex as the mother's own child. The mothers were asked to indicate the ideal body size, as well as the range of acceptable body sizes. Mothers were then asked to imagine that the drawings represented six month old infants of the opposite sex, and were asked to rate the drawings on the same criteria. To prevent any systematic bias resulting from the order presentation, the infant drawings were presented in a prespecified random order.

### Discrepancy scores

The difference between current body size and desired body size has been frequently used as a measure of body dissatisfaction. Our measure of sex-biased parental investment was the mother's discrepancy between ideal body size for males minus the ideal body size for females. Overall, the mothers endorsed the silhouette 4 (the 50th percentile) for baby boys, and silhouette 4 for girls, with an average discrepancy score of 0.0. However, nearly half of the women chose either a heavier boy picture or a heavier girl picture.

### Parental condition

Measures of parental resources included the mother's age, her years of education, male parental



## Figural Drawings for six month old babies

**Figure 1.** Figural stimuli for 6 month old babies. The numbers 1-7 represent the following points on the weigh- for-length charts: 1 < 10%, 2 = 10%, 3 = 25%, 4 = 40%, 5 = 75%, 6 = 90%, 7 > 90%.

commitment (scored 1 for no partner, 2 for boyfriend, and 3 for spouse), poverty (<\$15,000 and >\$15,000) and per capita household income. The mother’s ethnicity (Hispanic or Caucasian) and the baby’s sex were also collected during the interview. Multivariate imputation was used for the few cases with missing predictors.

**Parental investment**

Measures included maternal preference in baby body size (discrepancy scores), the number of weeks the mother breastfed her baby (adjusted to 24 weeks for babies who were still being breastfed), and the baby’s weight as recorded by the medical staff.

**Hypotheses**

There are three specific hypotheses for this study. 1) Mothers with greater resources will prefer larger baby boys than girls; mothers with fewer resources will prefer larger baby girls. Greater resources include increased maternal age, education, male parental commitment, and income. 2) Mothers with greater resources will breastfeed boys longer than girls; mothers with fewer resources will breastfeed girls longer than boys. 3) Mothers with greater resources will have heavier baby boys than girls; mothers with few resources will have heavier baby girls.

**Data Analysis**

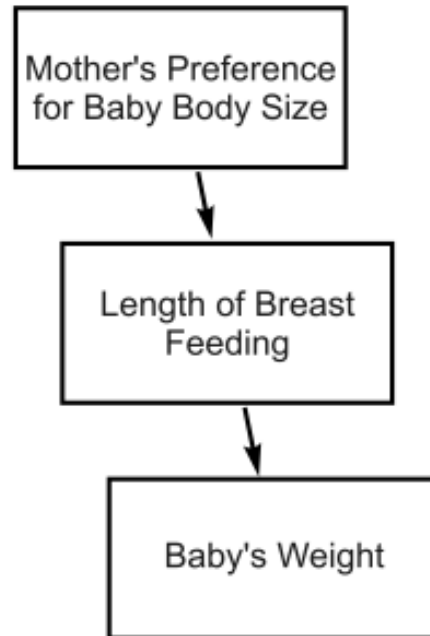
A series of sequential hierarchical regressions was executed in which the multiple dependent variables were analyzed according to a prespecified causal order. Because the dependent criterion variables were expected to influence each other, they were entered sequentially in a causal order in a series of multiple regression equations with each hierarchically prior criterion variable entered as the first predictor for the next. Each successive dependent variable was therefore predicted from the initial set of ordered predictor variables, and the immediately preceding dependent variable was entered hierarchically as the first predictor, followed by all of the ordered predictors from the previous regression equation. Each successive regression therefore entered all of the preceding dependent variables in reverse causal order to statistically control for the indirect effects that might be transmitted through them. Within this analytical approach, the estimated effect of each predictor was therefore limited to its direct effect on each of the successive dependent variables. The general format for these hierarchical multiple regressions is as follows:

$$\begin{aligned}
 Y1 &= X1 + X2 + X3 \\
 Y2 &= Y1 + X1 + X2 + X3 \\
 Y3 &= Y2 + Y1 + X1 + X2 + X3
 \end{aligned}$$

This procedure is conceptually equivalent to a sequential canonical analysis (Gorsuch and Figueredo 1991, Figueredo and Gorsuch, 2007), which controls

statistically for any indirect effects of the predictors through the causally prior dependent variables.

In this analysis, we followed a theoretically pre-specified order for the indicators of parental investment: Maternal preference for baby body size was assumed to precede the length of breast feeding, given the causal priority of attitude over behavior. In turn, weeks breastfed was assumed to be causally prior to the baby’s actual weight at six months. The causal order for the dependent variables is illustrated in Figure 2.



**Figure 2.** Theoretical and empirical model for parental investment.

The independent variables and their order of entry for the dependent variables were 1) mother’s age, 2) mother’s education, 3) male parental commitment, 4) poverty (above or below \$15,000), and 5) per capita household income. Each of these is an indicator of maternal condition, or socioeconomic resources. Ethnicity was entered next to examine possible differences in feeding practices in Hispanics versus Caucasians. The baby’s sex and interaction terms with sex were entered last.

The interaction terms test the TW hypothesis for weight and for breastfeeding. A significant sex by condition interaction in the appropriate direction is regarded as support for the hypothesis; “wealthy” mothers will invest more in sons and poor mothers will invest more in daughters. For preference, the dependent variable is already a measure of differential parental investment, and the main effects test the TW hypothesis.

## RESULTS

The relationships between the three measures of parental investment and the five measures of maternal condition were examined for colinearity. Correlations between the maternal condition measures ranged from .26 to .59. Correlations between the measures of parental investment ranged from -.13 to .15 and were not significant.

### Preference

On average, the mothers chose picture #4 (the 50<sup>th</sup> percentile) for the ideal baby boy and #4 for the ideal baby girl; resulting in an average discrepancy score of zero and a standard deviation of .7. While the average was zero, there was considerable variation; nearly half of the mothers chose either a bigger baby boy or baby girl picture. Table 3 shows the results of a hierarchical regression examining predictors of differential preference (best baby boy size minus best baby girl size). Because preference is already a difference score, the main effects test the TW Hypothesis.

**Table 2.** Hypothesis Tests for Predictors of Preference.

Predictor	F(1,102)	p
Mother's age	0.92	0.339
Mother's education	0.80	0.372
Male parental commitment	1.00	0.321
<b>Poverty</b>	<b>9.68</b>	<b>0.003</b>
Per capita household income	0.08	0.773
Hispanic ethnicity	0.21	0.645
Baby's sex	4.38	0.039

Of the five indicators of parental condition, one was significant and is bolded. Mothers whose incomes were below the poverty level preferred larger baby girls, with a standardized beta weight ( $\beta$ ) of 0.28. This provides support for the TW Hypothesis. The last two main effects do not test the TW Hypothesis and are included for consistency because they are used in subsequent analyses. There was no difference in body size by ethnicity. Mothers of girls preferred larger baby girls, and mothers of boys preferred larger baby boys ( $\beta = -0.21$ ).

### Breast feeding

Two indicators of maternal condition were associated with longer breast feeding (Table 3). Older mothers

**Table 3.** Hypothesis Tests for Predictors of Breast feeding.

Predictor	F(1,102)	p
Preference	2.10	0.151
Mother's age	19.07	<0.001
Mother's education	4.91	0.029
Male parental commitment	1.23	0.271
Poverty	0.99	0.332
Per capita household income	0.44	0.510
Hispanic ethnicity	1.19	0.278
Baby's sex	0.12	0.725
Interactions		
Ethnicity * poverty	5.04	0.027
Sex * preference	0.15	0.698
Sex * mother's age	0.02	0.881
Sex * mother's education	7.16	0.009
Sex * male parental commitment	0.17	0.682
Sex * poverty	0.01	0.944
Sex * per capita household income	0.01	0.938
Sex * ethnicity	0.07	0.794
Sex * ethnicity * poverty	4.62	0.034

breastfed their babies longer ( $\beta = 0.32$ ), and mothers with more education breastfed longer ( $\beta = 0.21$ ). For each additional year of mother's age, breastfeeding increased by .5 of a week; each additional year of education increased breastfeeding by .8 of a week. These differences provide evidence for the validity of education and age as indicators of maternal condition. There were no interactions by sex, and therefore no support for the TW Hypothesis for this outcome.

### Weight

The hypothesis tests for predictors of babies' weight are in Table 4. Only one main effect was significant, baby boys were heavier than baby girls ( $\beta = 0.57$ ). This term adjusts for normal sex differences in weight, and the first two interaction terms; sex \* breastfeeding and sex \* preference are included to control for the effect of previous dependent variables. Mothers of boys who preferred larger boys had larger boys, similarly, mothers of girls who preferred larger girls had larger girls ( $\beta = 0.16$ ). This effect may provide evidence for the link between weight preference and the actual weight of the baby. Or, mothers may simply prefer the size of the child that they have.

The remainder of the interaction terms with sex test the TW Hypothesis for weight; only one test was significant; mothers with more education had heavier baby girls ( $\beta = -0.40$ ). For each additional year of the mother's education, the baby girls were 61 grams heavier. This effect does not provide support for the TW Hypothesis because it was in the opposite direction.

Inspection of the data indicated a more complex relationship between income and weight that appeared to be associated with ethnicity. We therefore tested the interaction between ethnicity, poverty, and child's sex. Hispanic mothers in poverty had larger baby girls than Hispanic mothers with greater resources; in fact, their daughters were larger than baby boys born to Hispanic mothers in poverty ( $\beta = 0.11$ ). This was not seen in Caucasian mothers.

### Power analysis

With a sample size of 103 and 16 predictors in a multiple regression analysis, this study had the power to detect a small effect size ( $R^2 = .02$ ) 10% of the time, and a medium effect size ( $R^2 = .15$ ) 60% of the time. A standardized effect size of .22 would be detected approximately 80% of the time.

## DISCUSSION

We examined the TW Hypothesis in a resource rich metropolitan environment in the southwestern United States using three indicators of parental investment; maternal attitude, behavior, and baby's weight. This study was specifically designed to elicit information regarding feeding practices in mothers of young children. In these analyses, we included five measures of parental condition; mother's age, education, male parental commitment, a dichotomous measure of poverty, and per capita household income. Poverty appeared to be the only maternal condition that was associated with a TW effect in this resource rich environment, and the effect appeared to be more pronounced in Hispanic mothers.

Mothers showed a differential preference for baby body size by poverty and sex. This effect was not observed for income, but only when the dichotomous variable for poverty (<15,000) was used. Poorer mothers preferred heavier girl babies, and mothers with more resources preferred heavier boy babies. This is consistent with the TW Hypothesis. For breast feeding, there was no evidence of differential parental investment. This is consistent with Gaulin and Robbins (1999) who found no effect for breast feeding in a United States sample. For weight, mothers with more education had heavier girl babies, which was an effect that was in the opposite direction.

Interestingly, we observed a differential pattern by ethnicity; a TW effect was observed only in poor Hispanic mothers and not in poor Caucasian mothers. This result is puzzling. Why would a TW effect be active in

Hispanics, but not in Caucasians? We speculate that the difference could be due to the study protocol. The sample was stratified by income and considerable effort was taken to ensure the same percentages of Hispanics and Anglos were included in each income bracket. This resulted in an oversampling of affluent Hispanics in the study, when compared to the US Census (2005).

The use of discrepancy scores as a subtle measure of body satisfaction is a common use of figural drawings, and rating others with these drawings is also fairly typical. This is an example of a disguised method (Campbell 1950, Davis 2001), and is useful in a setting where the individual either may not be consciously aware of their belief, or may not be willing to share it.

There was no effect of parental condition on breastfeeding in this study, and the results are variable in other countries (Quinlan et al. 2005). Breast feeding information is problematic as a measure of parental investment, and variations in duration may be attributable to cultural, socioeconomic, or reporting error. An additional issue concerns a mother's inability to provide breast milk.

Were the measures we chose for parental condition valid in this sample and setting? In order to evaluate the effectiveness of the measures of parental condition we examined all main effects and interactions. Associations with parental investment, either for all children (main effect), or for some children (an interaction effect by sex) provide support for the value of each measure of condition. The study showed significant main effects for mothers' education and age, and significant interaction effects for poverty, providing evidence for the validity of three indicators of parental condition in a resource rich setting. However, only poverty was associated in a Trivers Willard effect.

Results from existing investigations of the TW Hypothesis are highly variable, and a meta-analytic approach will undoubtedly be required to tease out the effects of parental condition in humans. The benefits of meta-analysis in this area of research have been demonstrated in ungulates (Sheldon and West 2004), non-human primates (Shino 2004) and mammals (Cameron 2004). In each case, subtle effects were found based on either type of maternal condition or timing. To our knowledge, a meta-analysis in humans has not been attempted, and we await the results of such an endeavor with great interest.

Contrary to the TW Hypothesis, we found that the weights of baby girls at six months increased in tandem with the education of their mothers. Guggenheim (2004) also found a number of regional effects that were not consistent with the TW Hypothesis. Overall, this study provides ambiguous results for the TWH. It may well be that timing effects for the TWH in humans are consistent with other mammals, and any effect of the Trivers Willard Hypothesis takes place well before birth.

Other approaches, such as Life History Theory or Local Resource Competition may offer additional explanatory power. We recommend the use of multiple working hypotheses (Chamberlin 1890) in future studies.

There were several limitations to this study. The mothers were approached during their child's six month well baby visit and the sample was therefore restricted to mothers who were already investing resources in their children; in essence, the data were collected at the watering hole. The study was powered to detect a standardized effect size of .22 approximately 80% of the time. Such a sample size would detect some, but not all of the hypothesized differences.

These analyses provide a novel test of the Trivers-Willard Hypothesis in a resource-rich environment. We examined the effect of the TW Hypothesis on weight, breastfeeding, and differential preference; and found mixed support for the hypothesis in humans. Only poverty was associated with sex-biased maternal investment in both the mother's preference in baby size and for actual weight.

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