Why Can't a Woman Bid More Like a Man?*

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Abstract

We find systematic evidence that demographic characteristics, especially gender, race and the number of siblings, education backgrounds, as well as menstrual cycle, significantly affect bidder behavior in the first- and second-price sealed-bid auction in the laboratory. In particular, we find that women bid significantly higher than men in the first-price auction, while the likelihood of dominant strategy play in the second-price auction is not different between men and women. This finding provides support for the hypothesis that risk attitude rather than cognitive ability is the main driving force for the gender gap in competitive environments. At a biological level, we find that, in the first-price auction, during menstruation, when levels of estrogen and progesterone are the lowest, women do not bid differently from men. The gender difference in the first-price auction is driven by women during other phases of the menstrual cycle with higher levels of estrogen and progesterone.

Keywords: demographics, gender, menstrual cycle, auction
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1 Introduction

The gender gap in the labor market has been a persistent and puzzling phenomenon. Even though women now fill almost half of the country's managerial jobs, they continue to come up short in their paychecks. In 1999, for example, women's earnings were 76 percent of men's earnings (US Department of Labor, 1999). The government's General Accounting Office reports that in seven out of ten industries the gap has actually started to widen. This gap has been attributed to differences in labor market experience, educational attainment, and more fundamentally, to women's choices (US Department of Labor, Chapter 2, 1999).

Gender difference in decision making has long fascinated economists, psychologists and other social scientists. In a recent survey, Croson and Gneezy (2004) synthesize studies of preference differences between men and women in laboratory and field experiments in economics and psychology, focusing on risk taking, social preferences and reaction to competition. They find that, on average, women are more risk averse than men, with a few caveats and exceptions. Furthermore, various studies find that women's preferences for competitive situations are lower than men (e.g., Gneezy, Niederle and Rustichini (2003), Niederle and Vesterlund (2004)).

These experimental results are consistent with findings from survey data. Jianakoplos and Bernasek (1998) examine household holdings of risky assets to determine whether there are gender differences in financial risk taking. They find that as wealth increases, proportion of wealth held in risky assets increases by a smaller amount for single women than for single men. They find that gender differences in financial risk taking is also influenced by race, age and the number of children. Hersch (1996) examines data from a large national survey, and finds that there are substantial differences by gender and race in risky behavior such as smoking, seat belt use, preventive dental care, exercise and whether an individual checks his or her blood pressure. Overall, women make safer choices than men, and whites make safer choices than blacks.

While both experimental and survey results are consistent with preference-based explanations for the gender gap in wages, we are not aware of any study which directly compares the preference- vs. ability-based explanations in the same environment. In this paper, we ask the fundamental question of whether the gender gap in a competitive environment is due to systematic differences in risk preferences or cognitive abilities. At a biological level, we investigate whether the gender difference can be explained by hormonal changes.

By conducting laboratory experiments on the first- and second-price sealed-bid auctions in combination with a post-experiment survey, we investigate the gender difference in risk preferences using the first-price auction, and in cognitive abilities using the second-price auction. We find that,

- In the first-price auction, women bid significantly higher than men. However, in the second-price auction, the proportion of dominant strategy play is not significantly different between men and women.

These two results together suggest that risk attitude, rather than cognitive ability, is the driving force behind the gender gap in competitive bidding in the first-price auction. To investigate the biological causes of this gender gap, we take advantage of the natural hormonal variations during the menstrual cycle, and examine whether women's behavior systematically changes during different menstrual phases. We find that

- In the first-price auction, there is no significant difference in bidding behavior between women during the menstrual phase and men. However, women in the follicular, peri-ovulatory, luteal and premenstrual phases bid significantly higher than men.

Therefore, during menstruation, when the levels of estrogen and progesterone are the lowest, women do not bid differently from men. The gender difference in the first-price auction is driven primarily by women during other phases of the menstrual cycle with higher levels of estrogen and progesterone.

Our result provides support for the Hampson-Kimura hypothesis (1992). Hampson and Kimura hypothesize and find supporting evidence that women's performances on certain male-oriented tasks (e.g., spatial

ability) are significantly better during menstruation. Conversely, women's performance on certain female-oriented tasks (e.g., articulatory speed and accuracy) are better during periods of high estrogen levels. An implication of this hypothesis is that the gender gap should be smallest during menstruation, and largest during the peri-ovulatory and luteal phases of the menstrual cycle. We find that the gender difference is indeed statistically insignificant during menstruation when levels of estrogen and progesterone are the lowest. Meanwhile, women bid significantly higher during the other four phases of the menstrual cycle.

As far as we are aware of, our paper presents the first study in economics on how the menstrual cycle affects behavior. We provide a biological explanation for the observed gender difference in the first-price auction. The medical and psychology literature on menstrual cycles and cognition has never examined the domain of auctions or other competitive tasks. Thus, this paper contributes to the general literature on menstrual cycle and cognition by opening up a new and important domain.

In addition to gender and menstrual cycle, we also examine the impact of other demographic characteristics, such as the number of siblings, race and age. We find that

- Participants with more siblings bid significantly less in the first-price auction. However, the number of siblings has no significant effect on bidding behavior in the second-price auction.

This finding is consistent with findings from the psychology literature on sibling relationships and social, emotional and cognitive development. For example, Bryant (1989) finds that sibling caretaking adds significantly to the prediction of social perspective taking, empathy, attitudes towards competition, and locus of control. Relevant to our finding in the first-price auction, having more siblings increases a child's preference for competitive situations. In the first-price auction, this could translate into more risk taking behavior. Using a large data set from the National Longitudinal Survey of Youth, Rodgers *et al.* (2000) conclude that there is no direct causal link found between family size and children's intelligence. Our result on the effect of siblings in the second-price auction is consistent with this finding.

Using demographics without controlling for educational background might lead to the omitted variable bias due to the correlation between demographic characteristics and educational background and the impact of educational background on bidding.[1] In order to address this concern, we repeat the analysis controlling for subjects' education background, constructed as a vector of the number of college classes in five different categories: mathematics and statistics, science and engineering, economics and business, other social science, and humanities and other courses. All of our results for the demographic and menstrual cycle variables are robust to this additional set of control variables. That is, these results are not driven by the omitted variable bias. With respect to the education background variables themselves, we find that

- In the second-price auction, participants who have taken more economics and business courses are significantly more likely to play the dominant strategy. They are also significantly less likely to overbid.

We are aware of two other papers which examine the effects of demographics in auctions. Rutström (1998) presents an experimental study of the English, Vickrey and the Becker-DeGroot-Marschak (1964) mechanisms, using home-grown values.[2] Participants bid on a box of gourmet chocolate truffles. Bidder values for the chocolate are home-grown and assumed to be private. The demographic variables include gender, race, marital status, graduate status, age, and annual income. She finds that pooling across all auctions, whites submit lower bids on average, and females exhibit more variance in bidding behavior than males. As bidder values are not induced, the causes for these gender and race effects remain unknown.

[1] For example, women might be less likely to take economics or engineering courses. Meanwhile, participants with a background in economics or engineering might be better at the strategic analysis of the auction game and therefore bid systematically differently.

[2] Home-grown values refer to the subjective values participants have formed for a good, in the absence of any values induced by the experimenter. It is often used in field experiments.

Casari, Ham and Kagel (2004) study demographic and ability effects in common value auctions, using the induced-value method. The demographic and ability variables include gender, SAT and ACT scores, major, and class standing (freshman, sophomore, etc.). They find that inexperienced women bid higher and thus suffer more from the winner's curse than do men, while experienced women do at least as well as men. They also find that inexperienced subjects with lower SAT/ACT scores, as well as business and economics majors are more likely to overbid and bankrupt. We will compare these results with our results in more detail in Section 3.

Our paper differs from Casari, Ham and Kagel (2004) in four important ways. First, we investigate the effects of demographics and education in the private value environment, while they use the common value environment. The latter is theoretically more complex. For example, while the effect of risk aversion on bidding is unambiguous in our private value environment, it is ambiguous in their common value environment. Second, we compare both first-price and second-price sealed bid auctions, while they examine various treatments in the first-price auction. Third, we elicit a more comprehensive list of demographics variables, while the only demographic variable in Casari, Ham and Kagel (2004) is gender. Finally, we elicit menstrual cycle information, which enables us to explore the gender difference at a biological level.

This paper contributes to the economics literature on gender by separating the risk and ability hypothesis, and by bringing in the biological explanation to account for the gender difference in competitive bidding. It contributes to the auction literature by introducing a comprehensive list of demographic and education variables and demonstrating their systematic effects on bidding behavior. From the perspectives of auction theory and design, these findings are important for at least two reasons. First, many real-world auctions combine bidders of vastly different demographic and educational backgrounds. One prominent example is auctions on the Internet. The online auction technology allows bidders to be geographically dispersed and bidding to be asynchronous. These conveniences make it easier to obtain a relatively large and heterogeneous group of bidders. Therefore, it is important to investigate the systematic effects of various dimensions of heterogeneity. Second, if observable characteristics of bidders lead to predictable differences in bidding behavior, then the auctioneer may choose the auction form depending on the particular group of bidders.

The rest of the paper is organized as follows. Section 2 presents the experimental design and post-experiment survey. Section 3 presents our main results. Section 4 concludes the paper.

2 Experimental Design

The experimental design is explained in detail in Chen, Katuscak and Ozdenoren (2002). In this section, we summarize the main features of the design and the post-experiment questionnaire.

2.1 Economic Environments and Experimental Procedure

We use a full factorial ($2 \times 2 \times 2$) design. In the first four treatments, the first-price auction with known and unknown distributions and the second-price auction with known and unknown distributions, each session consists of eight bidders randomly re-matched into groups of two each round. In the other four treatments, each session consists of eight bidders and four auctioneers, each of whom is randomly re-matched into a group of three each round, with each group consisting of one auctioneer and two bidders.

[Table 1 about here.]

Table 1 summarizes the relevant features of the experimental sessions, including information conditions, number of subjects per session, auction mechanisms, exchange rates and the total number of subjects in each of the eight treatments. For each treatment, we conducted five independent sessions using networked computers at the Research Center for Group Dynamics Laboratory at the University of Michigan. This design gives us a total of forty independent sessions and four hundred subjects, recruited from an email list of Michigan undergraduate and graduate students, which excludes graduate students in Economics.

The choice of the $2 \times 2 \times 2$ design is based on the following considerations. The first dimension (the first- vs. second-price auctions) is the focus of this paper. Since risk attitude is important in bidding in the first-price auction, while the likelihood of playing the dominant strategy in the second-price auction is determined by the ability to figure out the dominant strategy, comparison of behavior in the first- and second-price auctions allows us to separate the risk vs. ability effect in the gender difference. As the second dimension (known vs. unknown distributions) and the third dimension (eight- vs. twelve-subject) are the focus in Chen, Katuscak and Ozdenoren (2002), we refer the reader to that paper for relevant analysis and results.

In our experiments, bidder valuations are known to be independent draws from either the low value distribution $F^1(\cdot)$ or the high value distribution $F^2(\cdot)$. In the experiment, the support set of these distributions is given by $\{1, 2, \cdots, 100\}$, and the respective densities f^1 and f^2 are given by

$$f^1(x) = \begin{cases} \frac{3}{200} & \text{if} \quad x \in \{1, .., 50\} \\ \frac{1}{200} & \text{if} \quad x \in \{51, .., 100\} \end{cases}$$
$$f^2(x) = \begin{cases} \frac{1}{200} & \text{if} \quad x \in \{1, .., 50\} \\ \frac{3}{200} & \text{if} \quad x \in \{51, .., 100\} \end{cases}.$$

In both treatments with and without ambiguity, we set the probability that bidder value is drawn from $F^1(\cdot)$ to be $\delta = 0.70$. We announce this in treatments without ambiguity, but do not provide any information about it in treatments with ambiguity.

At the beginning of each session, subjects randomly drew a PC terminal number. Then, each subject was seated in front of the corresponding terminal, and given printed instructions. After the instructions were read aloud, subjects completed a set of Review Questions, to test their understanding of the instructions. Afterwards, the experimenter checked answers and answered questions. The instruction period varied between fifteen to thirty minutes depending on the treatment. In the eight-subject sessions, all eight subjects were seated in the same room. In the twelve-subject sessions, the four auctioneers went to an adjacent lab after the instruction period while the bidders remained in the original lab. In the treatments with ambiguity, the auctioneers were privately informed of the value of δ on their screen at the beginning of each round. Each round consisted of the following stages:

1. In each of the twelve-subject treatments, each auctioneer set a reserve price, which could be any integer between 1 and 100, inclusive.

2. Meanwhile, for treatments with an unknown distribution only, each bidder estimated the chance that the valuation of the *other* bidder in the group was drawn from the high value distribution, i.e., an estimate of $1 - \delta$.

3. Next, each bidder was informed of the reserve price of his auctioneer (in the twelve-subject treatments) and his own valuation. In the eight-subject treatments, the reserve price was implicitly set to zero. Then each bidder simultaneously and independently submitted a bid, which could be any integer between 1 and 100, inclusive. Bidders were instructed that if they did not want to buy they could submit any positive integer below the reserve price.

4. Bids were then collected in each group and the object was allocated according to the rules of the auction.

5. Afterwards, each bidder received the following feedback on his screen: his valuation, his bid, the reserve price, the winning bid, whether he received the object, and his payoff.

   Each auctioneer received the following feedback: whether the object was sold, his reserve price, the bids in his group, and his payoff.

In each treatment, each session lasted thirty rounds with no practice rounds. At the end of thirty rounds, all participants completed a questionnaire to elicit demographic information (see section 2.2 for details).

The experiments were conducted from October 2001 to January 2002. Each session lasted from forty minutes to an hour. The exchange rates are presented in Table 1. The average earning was $18.78. Instructions are included in Appendix A. The data are available from the authors upon request.

2.2 Demographics, Menstrual Cycle and Educational Background Variables

To study the impact of demographics, menstrual cycle and educational background on competitive bidding behavior, we obtain demographic and menstrual cycle information from our subjects by using a survey at the end of the experiment. The survey is included in Appendix B.

In the survey, we elicit the following information: gender, race, age, number of siblings, self-described personality, and self-described emotions during the experiment. For female participants, we also elicit the number of days from the next menstrual cycle, as well as the presence of premenstrual syndrome (PMS). Menstrual cycle information is elicited, as we want to take advantage of the natural variation in hormone levels to understand the biological basis of the gender difference in competitive environment. In this paper, we report the effects of objective measures of demographics, therefore, we do not include variables on self-described personality or emotions (Questions 5 and 6 in the survey[3]). We initially included the PMS variable in our analysis, but it was not statistically significant in any of the results. We therefore exclude it from further analysis presented here.

When using regression analysis to evaluate the impact of the elicited demographic and biological characteristics on bidding, the interpretation of the results might be contaminated by the omitted variable bias due to the fact that (omitted) educational background might also affect bidding behavior, and this background might be correlated with some of the demographic variables. For example, subjects who have taken more courses in science and engineering or economics and business might be better at analytical reasoning, and hence bid differently. At the same time, men might be more likely to have taken these classes than women. To address this issue, we obtained the list of courses from the Registrar Office at the University of Michigan that our subjects had taken prior to their participation in our experiment. We categorize these courses into five mutually exclusive categories: Mathematics and Statistics, Science and Engineering, Economics and Business, Other Social Sciences, and Humanities and Other.[4] In our analysis, we then measure the educational background by a vector that records the number of courses that the subject has taken in each of these five categories.

Due to the small number of auctioneers, we only present results on bidder behavior in this paper. Analogous results for auctioneer behavior are available from the authors upon requests. We have 320 bidders in our experiment. Among them, we are able to obtain course information for 287 bidders. We are not able to match the remaining subjects based on their identifying information (name and social security number) with the records at the Registrar Office. Of all female bidders, five refuse to reveal their menstrual cycle information. To avoid sample composition issues, we only use observations with a complete set of data. There are 282 bidders that satisfy this criterion. Summary statistics are presented in Table 2.

[Table 2 about here.]

Our variables of interest fall into three natural categories:

[3]These two questions were included as our primary objective in our companion paper, Chen, Katuscak, Ozdenoren (2002), was to study the ambiguity attitude. These personality information could be used to estimate the boundary for the set of priors in the α-MEU framework.

[4]We categorize courses that we could not directly map to any of these categories (such as "Research") based on a subject's major. Similarly, we categorize a cross-listed course to an earlier category on our list. Finally, we use our own judgement to categorize a few of the remaining courses.

- Demographic variables (1)-(5): Of the 282 subjects, 149 are female. Of the six racial categories in the survey, we find that 54% of the participants are White, 33% are Asian/Asian American, while only 13% are African American, Hispanic, Native American or Other. We group the latter into a combined "Other Ethnicities" category for under-represented minorities.

- Education variables (6)-(10): these variables record the number of courses a participant has taken in each category prior to the experiment.

- Menstrual phase variables (11)-(15): Using their answer to Question 7 in the survey, we categorize the female participants into one of five phases, based on a common definition of phases[5] for a normal 28-day menstrual cycle. Menstrual phases are characterized by varying levels of several hormones (e.g., Richardson 1992, Chapter 1).

  - Menstrual phase (days 1-5 of the cycle): If fertilization does not occur, secretion of estrogen and progesterone ceases, followed by degeneration and expulsion of the uterine lining. Women during this phase have the lowest levels of estrogen and progesterone.
  - Follicular phase (days 6-12): Follicle-stimulating hormone stimulates an ovarian follicle to develop and secrete estrogen. The increased level of estrogen causes reconstruction and proliferation of the uterine lining and stimulates the pituitary to produce the luteinizing hormone.
  - Peri-ovulatory phase (days 13-15): The luteinizing hormone reaches its peak at mid-cycle, which causes the mature follicle to release the ovum through the wall of ovary. Under the influence of the luteinizing hormone, the original site of the ovum develops into a secretory organ known as the corpus luteum.
  - Luteal phase (days 16-23): Estrogen and progesterone are secreted by the corpus luteum to prepare the uterine lining for implantation should fertilization occur.
  - Premenstrual phase (days 24-28): This phase is sometimes called the late luteal phase.

  Throughout the cycle, estrogen and progesterone are at their lowest level during the menstrual phase, start to increase during the follicular phase, reach their peak during the peri-ovulatory and luteal phase, and start to decrease during the premenstrual phase.

Of these three categories of variables used in our analysis, demographic information should be accurate, unless a participant has a particular reason to lie. Course information is also accurate, as they are obtained directly from the Registrar's Office. Menstrual cycle information, however, relies on a participant's estimate of the number of days from the next menstrual cycle, and therefore, might be subject to estimation or rounding error. The exception is for women in the menstrual phase, where we would expect accurate information. We also note that day count is not the most reliable method of defining menstrual phases, even though it is the most frequently used method in menstrual cycle studies (Sommer (1992)). The most reliable method is direct assay of hormones, which requires invasive procedures such as blood collection. As Sommer (1992) notes, however, day count could be used as a legitimate indicator of hormone level if the sample size is large. Most medical and psychology studies use around 20 subjects, while we have 149 subjects.

[Table 3 about here.]

Table 3 presents the correlations for the demographic, education, and menstrual phase variables. In addition to some obvious correlations, we find several correlations interesting. For example, women are less likely to take science and engineering courses than men. Asians/Asian Americans are more likely to take Mathematics and Statistics, and Economics and Business courses than other subjects. They are less likely

[5] An alternative coarser definition, for example, calls the first 15 days the follicular phase, and the second half the luteal phase.

to take Other Social Science courses, and Humanities and Other courses. These correlations underscore the importance of controlling for educational background when investigating the impact of demographics and menstrual cycle on bidding in order to limit the omitted variable bias.

3 Results

We now present analysis of demographics, menstrual cycle and educational background on bidding in the first- and second-price auctions.

We first point out some common features that apply throughout our analysis. First, for treatments with auctioneers, we only use observations for which the value is at least as great as the reserve price, since otherwise it is rational to bid anything below the reserve price without affecting the outcome of the auction. Second, in all the empirical models that we estimate, we adjust the standard errors for clustering at the session level. This is because participants, due to their interaction within a session, might affect each other's behavior in a dynamic sense, and therefore observations on individual subjects within a session cannot be assumed to be independent. Third, we use a 5% statistical significance level (unless stated otherwise) to claim existence of any causal effects. Fourth, in interpreting the results of the multivariate analysis, the omitted category is White Male.

Recall that in a first-price private-value auction, more risk aversion leads to higher bids (Riley and Samuelson, 1981). In Chen, Katuscak and Ozdenoren (2002), we prove that a similar conclusion holds for ambiguity aversion. In that paper, we use a structural approach to estimate the bidding function. Since our emphasis here is on the impact of demographics, menstrual cycle and education, we adopt a simpler reduced form approach by using a polynomial approximation of the bidding function.

[Table 4 about here.]

Table 4 presents an OLS analysis of the impact of demographics, educational background, and menstrual cycle on bidding behavior in the first-price auction. The dependent variable is the Bid. The explanatory variables are the demographic, education, and menstrual cycle variables. Furthermore, each specification also includes a cubic polynomial in value and reserve price and period indicator variables to control for learning.[6] In specification (1), we only use the demographic variables. To control for educational background, we add the education variables in specification (2). To understand the gender effect at the hormone level, we add the menstrual cycle variables in specification (3). All three categories are included in specification (4).[7]

We then perform similar analysis for the second-price auction. Recall that in the second-price auction, bidding one's true value is a weakly dominant strategy. This is true regardless of whether the distribution of other bidders' valuations is known or unknown. Therefore, neither risk nor ambiguity attitude affects the optimal bidding strategy in the second-price auction. Whether a subject can figure out the dominant strategy can be an indication of her cognitive ability. In our sample, 38 percent of all bids equal their corresponding value (dominant strategy play), while 46 percent are above value (overbidding) and 16 percent are below value (underbidding).

[Table 5 about here.]

Table 5 presents a logit analysis of the impact of demographics, educational background, and menstrual cycle on the likelihood of playing the dominant strategy in the second-price auction. The dependent variable

[6] Estimates are not displayed but are available from the authors upon request.

[7] In addition to the specifications presented in Table 4, we also estimated a specification that included Age^2 along with Age as an additional regressor to capture age nonlinearities, and a specification that converted the Sibling variable into three indicator variables: 1 sibling, 2 siblings, 3 or more siblings (0 siblings being the omitted category) to capture non-linearities in the number of siblings. The results are qualitatively the same as those presented in Table 4.

is an indicator variable for bidding one's true value, while the independent variables are the same as those in the analysis of the first-price auction.[8]

We now summarize the results in the first- and second-price auctions in the order of gender, menstrual cycle, number of siblings, race, and educational background.

Result 1 (Gender). *In the first-price auction, women bid significantly higher than men. However, in the second-price auction, the likelihood of dominant strategy play is not significantly different between men and women.*

Support. *In specifications (1) and (2) in Table 4, the coefficients for Female are positive and highly significant. In specifications (1) and (2) in Table 5, the coefficients for Female are not significant.* ∎

While we do not rule out other plausible explanations, our gender effect in the first-price auction is consistent with findings from many previous studies which conclude that women are more risk averse (see Croson and Gneezy 2004 for a survey). The absence of gender effect in the second-price auction, however, indicates that women's ability to figure out the dominant strategy is not significantly different from men's.

In a closely related study, Casari, Ham and Kagel (2004) find that in common value auctions, inexperienced women bid substantially higher than men and thus suffer more from the winner's curse, while experienced women do at least as well as men. Unlike in our private value environment where risk aversion unambiguously leads to higher bids, the theoretical prediction of more risk aversion is ambiguous in their common value environment. Therefore, it is not clear whether their gender effect is due to risk or not.

Nevertheless, we take seriously the possibility that women tend to bid higher, regardless of auction institutions. In particular, this conjecture implies that women should be more likely to overbid than men in the second-price auction. To investigate the validity of this conjecture, we use a logit analysis to explore whether there are gender effects on the likelihood of overbidding in the second-price auction.[9]

[Table 6 about here.]

Table 6 reports the logit analysis on the effects of demographics, education, and menstrual cycle on the likelihood of overbidding. The dependent variable is an indicator variable for bidding above one's true value, while the independent variables are the same as those in Tables 4 and 5. We find that there is no gender difference in the likelihood of overbidding, as the coefficients for Female in specifications (1) and (2) are insignificant. This refutes the conjecture that women tend to bid higher regardless of auction institutions. We will summarize other results from Table 6 in each appropriate demographic and education category below.

To understand the gender effects in Result 1, we further explore whether there are biological explanations for this result. We do so by using the menstrual cycle information from the survey. In Tables 4, 5 and 6, we replace the Female variable with the five menstrual phase variables in specifications (3) and (4). Specification (3) does not include education variables, while specification (4) does. In both cases, the omitted category is Male. Therefore, the coefficient on each of the menstrual phase variables compares bids of women in that particular menstrual phase with men's bids. Our analysis reveals some interesting findings.

Result 2 (Menstrual Cycle). *In the first-price auction, there is no significant difference in bids between women in the menstrual phase and men. However, women in the follicular, peri-ovulatory, luteal and premenstrual phases bid significantly higher than men. In the second-price auction, the likelihood of dominant strategy play is not significantly different between men and women in any of the phases.*

Support. *In specifications (3) and (4) in Table 4, the coefficients for the Menstrual Phase are insignificant, while the coefficients for the Follicular, Peri-Ovulatory, Luteal and Premenstrual Phases are all positive and significant. In specifications (3) and (4) in Table 5, none of the coefficients for the menstrual phases is significant.* ∎

[8] We have also estimated an analogous probit specification, results of which closely parallel those of the logit analysis.

[9] We thank John Kagel for suggesting this analysis.

To our best knowledge, this is the first result in the economics literature which examines the effect of menstrual cycle on behavior. During the menstrual phase, when levels of estrogen and progesterone are the lowest, women do not bid differently from men in either the first-price or second-price auctions. The gender gap in the first-price auction is driven by women during the other phases of the menstrual cycle during which the levels of estrogen and progesterone are higher.

The medical and psychology literature on menstrual cycle and cognition builds upon hormone variations and cognition. The list of cognitive tasks include "simple arithmetic, short-term memory, verbal skills, visual-spatial, rote speed tasks, motor coordination, frustration tolerance, flexibility, stress responsivity, creativity, dressing behavior, asymmetric hemispheric activity, facial preference, body image and interest in erotica" (Epting and Overman 1998). Sommer (1992) reviews 45 such studies. Epting and Overman (1998) summarize 62 such studies. Based on these two articles and our own reading of more recent studies, the findings are mixed. Some report consistent cognitive changes across menstrual phases (e.g., Komnenich 1974; Wuttke et al. 1976; Hausmannn et al. 2000). Some studies report mixed cognitive changes, while others report no menstrual cycle variation. Among those who report consistent changes, Hausmannn et al. (2000) find a significant cycle difference in spatial ability as tested by Mental Rotation Test, with high scores during the menstrual phase and low scores during the luteal phase. As levels of estrogen and progesterone are the lowest during the menstrual phase and highest during the peri-ovulatory and luteal phases, it leads to a key hypothesis (Hampson and Kimura 1992) that women's performances on certain male-oriented tasks (e.g., spatial ability) are significantly better during menstruation. Conversely, women's performance on certain female-oriented tasks (e.g., articulatory speed and accuracy) are better during periods of high estrogen levels (peri-ovulatory and luteal phases).

Although we are not aware of any study which examines menstrual cycle and bidding (or other competitive tasks), Result 2 provides some support for the Hampson-Kimura hypothesis, in the sense that gender difference is statistically insignificant during the menstrual phase when levels of estrogen and progesterone are the lowest, while it is statistically significant in all other menstrual cycle phases.

Finally, we note that in specification (4) in Table 6, while there is no gender difference in the likelihood of overbidding in the second-price auction, when we separate women into five categories according to their menstrual phases, women in the luteal phase are significantly less likely to overbid compared to men.

In addition to gender, we also examine the effects of other demographic variables. Among them, we find that age has no significant effects on bidding in either auctions. The number of siblings and race, however, do have interesting effects.

Result 3 (Number of Siblings). *Participants with more siblings bid significantly less in the first-price auction. In the second-price auction, however, the number of siblings has no significant effect on the likelihood of dominant strategy play.*

Support. *In each of the four specifications in Table 4, the coefficient for the Number of Siblings is negative and significant. In Table 5, however, none of the coefficients for the Number of Siblings is significant.* ∎

There are numerous studies in the psychology literature on how sibling relationships might have long term effects in cognitive, emotional and social development of both older and younger siblings. For example, using direct observations and interviews, Bryant (1989) finds that among the six components of social-emotional functionings (empathy, social perspective taking, acceptance of individual differences, locus of control, attitudes toward competition, and attitudes towards individualism), sibling caretaking added significantly to the prediction of all six measures. Longitudinal prediction was enhanced on four of the six measures, i.e., social perspective taking, empathy, attitudes towards competition, and locus of control. Relevant to our finding in the first-price auction, having more siblings increases a child's preference for competitive situations. In the first-price auction, this could translate into more risk taking behavior.

The relationship among family size and intelligence have been the subject of much earlier research (e.g., Anastasi (1956)). Using a large data set from the National Longitudinal Survey of Youth, Rodgers *et al.*

(2000) conclude that there is no direct causal link found between family size and children's intelligence. Our result on the effect of siblings in the second-price auction is consistent with this finding.

We find one other economic study of the effect of the number of siblings on behavior in the laboratory. Glaeser et al. (2000) find that in trust games, only children are much less likely to return money when they are recipients, which can be interpreted as being less trust worthy. We are not aware of any study in economics which examines the number of siblings and risk attitudes.

Result 4 (Race). *In the second-price auctions, participants from Other Ethnicities are significantly less likely to play the dominant strategy compared to Whites. Furthermore, Asian/Asian Americans are significantly more likely to overbid.*

Support. *In each of the four specifications in Table 5, the coefficient for Other Ethnicities is negative and significant. In each of the specifications (2) to (4) in Table 6, the coefficient for Asian/Asian American is positive and significant.* ∎

Result 4 indicates that participants from Other Ethnicities are significantly less likely to play the dominant strategy, compared to Whites. Furthermore, Asian/Asian Americans are significantly more likely to overbid. We are not aware of other studies which examine cognitive abilities across racial groups in competitive situations.[10]

In addition to Result 4, we also find that in the first-price auction, Asian/Asian Americans bid weakly less than Whites, which is significant at the 10% level (specification (2) - (4) in Table 4). This is consistent with Asians being more risk taking than Whites. Using survey response in the Health and Retirement Study, Barsky et al. (1997) find that Asians are the most risk tolerant of all ethnic groups.

Lastly, we examine the effect of educational background on bidding behavior.

Result 5 (Education). *In the second-price auction, participants who have taken more economics and business courses are significantly less likely to overbid.*

Support. *In specification (2) and (4) in Table 6, the coefficients for Economics and Business Courses are negative and significant.* ∎

Result 5 examines the effects of economics and business *courses*, while Casari, Ham and Kagel (2004) examines the effects of economics and business *majors*. They find that economics and business majors substantially overbid in common value auctions relative other majors. Their explanation that "these students have a mind set such that they are more concerned with 'winning' the auctions than with maximizing their total profits from bidding, or that they are by nature overly aggressive in business transactions." While it is plausible that there is a self-selection bias in economics and business majors, we find that taking more economics and business courses *per se* does significantly reduce overbidding. One other plausible explanation is that private value auctions are covered in many intermediate level economics courses, while this is not true for common value auctions. Therefore, students taking more economics and business courses might have learned not to overbid in the second-price auction in one of their courses.

In addition to Result 5, we find that in the first-price auction, participants who take more Science and Engineering courses, as well as those who take more Other Social Science courses bid weakly less. As shown in specification (2) in Table 4, the coefficients for Science and Engineering Courses as well as Other Social Science Courses are negative and weakly significant at the 10% level.

To summarize, we find systematic evidence that demographic characteristics and college education backgrounds significantly affect bidder behavior in the first- and second-price sealed bid auctions. In particular, we find that women bid significantly higher than men in the first-price auction, while the likelihood of dominant strategy play in the second-price auction is not significantly different. This finding provides support

[10]There is a related controversial literature on race and cognition, which mostly relies on IQ test, e.g., Herrnstein and Murray (1994), Jacoby and Glauberman (1995).

for the hypothesis that risk attitude rather than cognitive ability is the main driving force for the gender gap in competitive environments. At the biological level, we find that during menstruation, when levels of estrogen and progesterone are the lowest, women do not bid differently from men. The gender difference in the first-price auction is driven by women during other phases of the menstrual cycle with higher levels of estrogen and progesterone.

4 Conclusions

Understanding the gender gap in labor markets has important policy implications. Our paper examines two fundamental questions in gender research in competitive environments.

First, is the gender difference in decision making due to risk preferences or cognitive abilities? We use data from the first-price sealed-bid private value auction to evaluate the gender difference due to risk preferences, and those from the second-price sealed-bid auction to evaluate any difference in cognitive abilities. We find that women bid significantly higher than men in the first-price auction. This is consistent with the findings in other contexts that women are more risk averse. Meanwhile, we do not find any gender difference in the likelihood of dominant strategy play in the second-price auction. This indicates that, at least in our environment, there is no gender difference in the cognitive abilities to figure out the dominant strategy.

We take seriously an alternative explanation that the gender difference in the first-price auction is due to women's tendency to bid high regardless of auction institutions. In particular, this implies that they are more likely to overbid in the second-price auction. We examine the likelihood of overbidding in the second-price auction, and find that there is no gender difference in the likelihood of overbidding.

Second, having observed the robust gender difference in the first-price auction, we ask what the biological basis for such gender difference might be. We take advantage of the natural hormonal variations during the menstrual cycle to investigate whether the gender difference is driven by sex hormones. We find that in the first-price auction, there is no difference in bidding behavior between men and women during menstruation, when the estrogen and progesterone levels are the lowest. The gender difference is driven by bidding behavior of women during other phases of the menstrual cycle with higher levels of estrogen and progesterone. This result is consistent with the Hampson-Kimura hypothesis (1992), which implies that the gender gap should be smallest during menstruation, and largest during the peri-ovulatory and luteal phases of the menstrual cycle. We find that the gender difference is indeed statistically insignificant during menstruation. The largest gender gap we find in our study occurs during the follicular, peri-ovulatory and luteal phases. To our best knowledge, this is the first paper in the economics literature, which examines the gender gap at the biological level.

In addition to the two questions, we also examine whether other demographic and education background variables systematically affect bidding behavior. We find that participants with more siblings systematically bid lower in the first-price auction, while the number of siblings does not have any effect on the likelihood of dominant strategy play in the second-price auction. This finding is consistent with findings from social and cognitive psychology that while having more siblings increases a person's preference for competitive situations (Bryant 1989), it does not have any direct effect on children's intelligence (Rogers et al. 2000).

Race turns out to have significant effects on bidding in the second-price auction. We find that participants from Other Ethnicities are significantly less likely to play the dominant strategy compared to whites. Furthermore, Asian/Asian Americans are more likely to overbid in the second-price auction. We do not have a good explanation for this finding. Nor are we aware of any other studies which examines cognitive abilities across racial groups in competitive situations.

When controlling for educational backgrounds, we find that, in the second-price auction, participants who have taken more economics and business courses are significantly less likely to overbid. We speculate that this might be due to the fact that the second-price sealed-bid private value auction might have been

covered in several intermediate undergraduate courses. Therefore, some of our subjects might have learned to avoid overbidding in class.

To summarize, this paper presents systematic evidence that gender, race, the number of siblings, and educational background significantly affect bidder behavior in the first- and second-price sealed-bid auctions in a private value environment. We offer a separation of the risk attitude vs. cognitive ability hypotheses to account for the gender gap in behavior. Furthermore, we use, for the first time in economics, menstrual cycle information to provide a biological basis for the gender difference in behavior.

We hope that this study will spur more interests in the biological foundations of gender difference in behavior in economics.

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APPENDIX A. INSTRUCTIONS

The complete instructions for the twelve-subject, first-price auction with known distribution treatment are shown here. Instructions for the twelve-subject, first-price auction with unknown distribution treatment are identical except that 30% is replaced by x% and that bidders are asked to give an estimate of x. Instructions for the corresponding eight-subject treatments are identical to their twelve-subject counterpart except that the parts concerning auctioneers are deleted.

Instructions for the second-price auction are identical to their first-price counterpart except for "The Rules of the Auction and Payoffs" section and the "Review Questions", hence only those two parts are shown here.

Experiment Instructions – K1$_{12}$
Name_____ PCLAB __ Total Payoff _____

Introduction

- You are about to participate in a decision process in which an object will be auctioned off for each group of participants in each of 30 rounds. This is part of a study intended to provide insight into certain features of decision processes. If you follow the instructions carefully and make good decisions you may earn a considerable amount of money. You will be paid in cash at the end of the experiment.
- *During the experiment, we ask that you please do not talk to each other.* If you have a question, please raise your hand and an experimenter will assist you.

Procedure

- You each have drawn a laminated slip, which corresponds to your PC terminal number. If the number on your slip is from PCLAB 2 to PCLAB 9, you will stay in this room and you will be a bidder for the entire experiment. If the number on your slip is from PCLAB 10 to PCLAB 13, you will go to Room 212 after the instruction, and you will be an auctioneer for the entire experiment.
- In each of 30 rounds, you will be *randomly* matched with two other participants into a group. Each group has an auctioneer and two bidders. You will not know the identities of the other participants in your group. Your payoff each round depends ONLY on the decisions made by you and the other two participants in your group.
- In each of 30 rounds, each bidder's **value** for the object will be randomly drawn from one of two distributions:
  - **High value distribution**: If a bidder's value is drawn from the high value distribution, then
    - with 25% chance it is randomly drawn from the set of integers between 1 and 50, where each integer is equally likely to be drawn.
    - with 75% chance it is randomly drawn from the set of integers between 51 and 100, where each integer is equally likely to be drawn.

    For example, if you throw a four-sided die, and if it shows up 1, your value will be equally likely to take on an integer value between 1 and 50. If it shows up 2, 3 or 4, your value will be equally likely to take on an integer value between 51 and 100.
  - **Low value distribution**: If a bidder's value is drawn from the low value distribution, then
    - with 75% chance it is randomly drawn from the set of integers between 1 and 50, where each integer is equally likely to be drawn.

    - with 25% chance it is randomly drawn from the set of integers between 51 and 100, where each integer is equally likely to be drawn.

    For example, if you throw a four-sided die, and if it shows up 1, 2 or 3, your value will be equally likely to take on an integer value between 1 and 50. If it shows up 4, your value will be equally likely to take on an integer value between 51 and 100.

  - Therefore, if your value is drawn from the high value distribution, it can take on any integer value between 1 and 100, but it is three times more likely to take on a higher value, i.e., a value between 51 and 100.

    Similarly, if your value is drawn from the low value distribution, it can take on any integer value between 1 and 100, but it is three times more likely to take on a lower value, i.e., a value between 1 and 50.

  - In each of 30 rounds, each bidder's value will be randomly and independently drawn from the high value distribution with 30% chance, and from the low value distribution with 70% chance. You will not be told which distribution your value is drawn from. The other bidders' values might be drawn from a distribution different from your own. In any given round, the chance that your value is drawn from either distribution does not affect how other bidders' values are drawn.

- Each round consists of the following stages:

  - Each auctioneer will set a minimum selling price, which can be any integer between 1 and 100, inclusive.
  - Bidders are informed of the minimum selling prices of their auctioneers, and then each bidder will simultaneously and independently submit a bid, which can be any integer between 1 and 100, inclusive. If you do not want to buy, you can submit any positive integer below the minimum selling price.
  - The bids are collected in each group and the object is allocated according to the rules of the auction explained in the next section.
  - Bidders will get the following feedback on their screen: your value, your bid, the minimum selling price, the winning bid, whether you got the object, and your payoff.

    Auctioneers will get the following feedback: whether you sold the object, your minimum selling price, the bids, and your payoff.

- The process continues.

Rules of the Auction and Payoffs

- **Bidders**: In each round,

  - if your bid is less than the minimum selling price, you don't get the object:
    Your Payoff = 0
  - if your bid is greater than or equal to the minimum selling price, and:
    - if your bid is greater than the other bid, you get the object and pay your bid:
      Your Payoff = Your Value - Your Bid;
    - if your bid is less than the other bid, you don't get the object:
      Your Payoff = 0.
    - if your bid is equal to the other bid, the computer will break the tie by flipping a fair coin. Therefore,

- with 50% chance you get the object and pay your bid:
  Your Payoff = Your Value - Your Bid;
- with 50% chance you don't get the object:
  Your Payoff = 0.

- **Auctioneers**: In each round, you will receive two bids from your group.
  - If both bids are less than your minimum selling price, the object is not sold, and :
    Your Payoff = 0;
  - if at least one bid is greater than or equal to your minimum selling price, you sell the object to the higher bidder and
    Your Payoff = the Higher Bid.

- For example, if the minimum selling price is 1, bidder A bids 25, and bidder B bids 55, since $55 > 1$ and $55 > 25$, bidder B gets the object. Bidder A's payoff = 0; bidder B's payoff = her value - 55; the auctioneer's payoff = 55.

- There will be 30 rounds. There will be no practice rounds. From the first round, you will be paid for each decision you make.

- Your total payoff is the sum of your payoffs in all rounds.

- Bidders: the exchange rate is $1 for _____ points.

- Auctioneers: the exchange rate is $1 for _____ points.

We encourage you to earn as much cash as you can. Are there any questions?

Review Questions: you will have ten minutes to finish the review questions. Please raise your hand if you have any questions or if you finish the review questions. The experimenter will check each participant's answers individually. After ten minutes we will go through the answers together.

1. Suppose your value is 60 and you bid 62.
   If you get the object, your payoff = __.
   If you don't get the object, your payoff = __.

2. Suppose your value is 60 and you bid 60.
   If you get the object, your payoff = __.
   If you don't get the object, your payoff = __.

3. Suppose your value is 60 and you bid 58.
   If you get the object, your payoff = __.
   If you don't get the object, your payoff = __.

4. In each of 30 rounds, each bidder's value will be randomly and independently drawn from the high value distribution with __% chance.

5. The minimum selling price is 30 and your bid is 25, your payoff = __.

6. True or false:
   (a) __If a bidder's value is 25, it must have been drawn from the low distribution.
   (b) __If a bidder's value is 60, it must have been drawn from the high distribution.

(c) __You will be playing with the same two participants for the entire experiment.

(d) __A bidder's payoff depends only on his/her own bid.

(e) __If you are an auctioneer and your minimum selling price is higher than both bids, your payoff will be zero.

Experiment Instructions – $\mathbf{K2}_{12}$

. . . . . .

Rules of the Auction and Payoffs

- **Bidders**: In each round,
  - if your bid is less than the minimum selling price, you don't get the object:
    Your Payoff = 0
  - if your bid is greater than or equal to the minimum selling price, and:
    - if your bid is greater than the other bid, you get the object. The price you pay depends on the minimum selling price and the other bid:
      - if the other bid is greater than or equal to the minimum selling price, you pay the other bid:
        Your Payoff = Your Value - the Other Bid;
      - if the other bid is less than the minimum selling price, you pay the minimum selling price:
        Your Payoff = Your Value - the Minimum Selling Price;
    - if your bid is less than the other bid, you don't get the object:
      Your Payoff = 0.
    - if your bid is equal to the other bid, the computer will break the tie by flipping a fair coin. Therefore,
      - with 50% chance you get the object and pay the other bid:
        Your Payoff = Your Value - the Other Bid;
      - with 50% chance you don't get the object:
        Your Payoff = 0.

- **Auctioneers**: In each round, you will receive two bids from your group.
  - If both bids are less than your minimum selling price, the object is not sold, and :
    Your Payoff = 0;
  - if both bids are greater than or equal to your minimum selling price, you sell the object to the higher bidder and
    Your Payoff = the Lower Bid.
  - if one bid is greater than or equal to your minimum selling price and the other bid is less than your minimum selling price, you sell the object to the higher bidder and
    Your Payoff = the Minimum Selling Price.

- For example, if the minimum selling price is 1, bidder A bids 25, and bidder B bids 55, since $55 > 1$ and $55 > 25$, bidder B gets the object.
  Bidder A's payoff = 0;
  bidder B's payoff = bidder B's value - bidder A's bid = bidder B's value - 25;
  the auctioneer's payoff = 25.
- There will be 30 rounds. There will be no practice rounds. ¿From the first round, you will be paid for each decision you make.
- Your total payoff is the sum of your payoffs in all rounds.
- Bidders: the exchange rate is $1 for _____ points.
- Auctioneers: the exchange rate is $1 for _____ points.

We encourage you to earn as much cash as you can. Are there any questions?

Review Questions: you will have ten minutes to finish the review questions. Please raise your hand if you have any questions or if you finish the review questions. The experimenter will check each participant's answers individually. After ten minutes we will go through the answers together.

1. Suppose the minimum selling price is 1, your value is 60, and you bid 62.
   If the other bid is 59, you get the object. Your payoff = __.
   If the other bid is 61, you get the object. Your payoff = __.
   If the other bid is 70, you don't get the object. Your payoff = __.
2. Suppose the minimum selling price is 1, your value is 60, and you bid 60.
   If the other bid is 55, you get the object. Your payoff = __.
   If the other bid is 60,
   - with __ chance you get the object, your payoff = __;
   - with __ chance you don't get the object, your payoff = __.

   If the other bid is 70, you don't get the object. Your payoff = __.
3. Suppose the minimum selling price is 1, your value is 60, and you bid 57.
   If the other bid is 55, you get the object. Your payoff = __.
   If the other bid is 58, you don't get the object. Your payoff = __.
   If the other bid is 70, you don't get the object. Your payoff = __.
4. The minimum selling price is 30 and your bid is 25, your payoff = __.
5. True or false:
   (a) __If a bidder's value is 25, it must have been drawn from the low distribution.
   (b) __If a bidder's value is 60, it must have been drawn from the high distribution.
   (c) __You will be playing with the same two participants for the entire experiment.
   (d) __A bidder's payoff depends only on his/her own bid.
   (e) __If you are an auctioneer and your minimum selling price is higher than both bids, your payoff will be zero.

APPENDIX B. POST-EXPERIMENT SURVEY

We are interested in whether there is a correlation between participants' bidding behavior and some socio-psychological factors. The following information will be very helpful for our research. This information will be strictly confidential.

1. What is your gender?
    - Male ___
    - Female ___
2. What is your ethnic origin?
    - White ___
    - Asian/Asian American ___
    - African American ___
    - Hispanic ___
    - Native American ___
    - Other ___
3. What is your age? ___
4. How many siblings do you have? ___
5. Would you describe your personality as (please choose one)
    - optimistic ___
    - pessimistic ___
    - neither ___
6. Which of the following emotions did you experience during the experiment? (You may choose any number of them.)
    - anger ___
    - anxiety ___
    - confusion ___
    - contentment ___
    - fatigue ___
    - happiness ___
    - irritation ___
    - mood swings ___
    - withdrawal ___
7. For female participants only:
    - How many days away is your next menstrual cycle? ___
    - Do you currently experience any symptoms of PMS? (please choose one)
        - none ___
        - mild ___
        - severe ___

Table 1: Features of Experimental Sessions

Information Conditions	No. Subjects Per Session	Auction Mechanisms	Exchange Rates		Total No. Subjects
			Bidders	Auctioneers	
Known Distribution	8	1st Price	20	-	40
	8	2nd Price	20	-	40
	12	1st Price	12	60	60
	12	2nd Price	12	60	60
Unknown Distribution	8	1st Price	20	-	40
	8	2nd Price	20	-	40
	12	1st Price	12	60	60
	12	2nd Price	12	60	60

Table 2: Summary Statistics of Demographics, Educational Background, and Menstrual Cycle for Bidders

Label	Variable	Obs.	Mean	Std. Dev.	Min	Max
(1)	Female	282	0.53	0.50	0	1
(2)	Age	282	20.87	2.81	18	41
(3)	Number of Siblings	282	1.55	1.23	0	9
(4)	Asian/Asian American	282	0.33	0.47	0	1
(5)	Other Ethnicities	282	0.13	0.34	0	1
(6)	Math and Stats Courses	282	1.99	2.23	0	20
(7)	Science and Engineering Courses	282	7.25	8.95	0	36
(8)	Economics and Business Courses	282	2.55	4.45	0	28
(9)	Other Social Science Courses	282	4.29	4.82	0	22
(10)	Humanities and Other Courses	282	7.17	7.43	0	44
(11)	Menstrual Phase	149	0.23	0.42	0	1
(12)	Follicular Phase	149	0.14	0.35	0	1
(13)	Peri-Ovulatory Phase	149	0.15	0.36	0	1
(14)	Luteal Phase	149	0.30	0.46	0	1
(15)	Pre-Menstrual Phase	149	0.18	0.39	0	1

Notes:
Summary statistics for the menstrual cycle phase variables are reported for women only.

Table 3: Correlations of Demographic, Education, and Menstrual Phase Variables for Bidders

		(1) Female	(2) Age	(3) Sibl.	(4) Asian	(5) Other	(6) MathStat	(7) SciEng	(8) EconBus	(9) Soc.Sci.	(10) Hum.	(11) Mens.	(12) Folli.	(13) Peri-Ovu.	(14) Luteal	(15) Premens
(1)	Female	1.00														
(2)	Age	-0.04	1.00													
(3)	No. Sibl.	-0.02	0.04	1.00												
(4)	Asian/As. Am.	-0.02	0.12**	-0.13**	1.00											
(5)	Other Ethn.	0.09	-0.04	0.09	-0.27***	1.00										
(6)	Math & Stats	-0.05	0.04	-0.06	0.13**	0.07	1.00									
(7)	Science & Eng.	-0.14**	0.07	0.07	-0.02	0.04	0.22***	1.00								
(8)	Econ. & Bus.	-0.04	-0.06	-0.08	0.14**	-0.02	0.23***	-0.17***	1.00							
(9)	Other Soc. Sci.	0.12**	0.07	0.00	-0.12**	-0.03	-0.10	-0.20***	0.09	1.00						
(10)	Hum. & Other	0.09	-0.17***	0.02	-0.19***	0.11*	-0.02	-0.10*	0.06	0.13**	1.00					
(11)	Menstrual	0.35***	-0.07	0.02	-0.03	0.05	-0.10	-0.08	-0.05	-0.02	0.02	1.00				
(12)	Follicular	0.27***	-0.08	-0.02	0.03	-0.03	0.07	-0.04	-0.01	-0.01	0.02	-0.11*	1.00			
(13)	Peri-Ovulatory	0.27***	-0.02	-0.08	-0.04	0.08	-0.10*	-0.08	0.02	0.15**	0.06	-0.11*	-0.08	1.00		
(14)	Luteal	0.41***	0.14**	0.00	0.07	-0.05	0.00	-0.04	-0.03	0.13**	0.06	-0.16***	-0.12**	-0.13**	1.00	
(15)	Premenstrual	0.31***	-0.08	0.03	-0.07	0.12**	0.05	0.01	0.01	-0.06	-0.01	-0.12**	-0.09	-0.09	-0.14**	1.00

Notes:
Significant at: * 10% level; ** 5% level; *** 1% level.

Table 4: Demographics, Education and Menstrual Cycle on Bids in the First-Price Auction.

Dependent variable (estimation method):	Bid in FPA (OLS)			
	(1)	(2)	(3)	(4)
Female	3.2036***	3.2243***		
	(0.6693)	(0.6455)		
Age	-0.0789	-0.0753	-0.0854	-0.0924
	(0.1351)	(0.1484)	(0.1079)	(0.1237)
Number of Siblings	-0.7712***	-0.7222**	-0.7384**	-0.6794**
	(0.2515)	(0.2584)	(0.2811)	(0.2754)
Asian/Asian American	-1.3131	-1.6614*	-1.5858*	-1.9109*
	(0.8563)	(0.8957)	(0.8665)	(0.9172)
Other Ethnicities	1.2088	1.3586	1.3569	1.5072
	(0.9906)	(0.9922)	(1.0618)	(1.0427)
Math and Stats Courses		0.0231		0.0094
		(0.1606)		(0.1660)
Science and Engineering Courses		-0.0685*		-0.0534
		(0.0370)		(0.0358)
Economics and Business Courses		-0.0069		0.0118
		(0.0806)		(0.0780)
Other Social Science Courses		-0.0910*		-0.1051*
		(0.0504)		(0.0581)
Humanities and Other Courses		-0.0349		-0.0357
		(0.0338)		(0.0320)
Menstrual Phase			2.3938	2.2392
			(1.4955)	(1.5158)
Follicular Phase			6.3230***	6.1773***
			(1.0891)	(0.9045)
Peri-Ovulatory Phase			2.7842**	3.0832**
			(1.1150)	(1.2825)
Luteal Phase			2.7817**	3.0492**
			(1.0749)	(1.0803)
Premenstrual Phase			2.3544**	2.2073**
			(0.8759)	(0.9522)
Observations	3,463	3,463	3,463	3,463
R-squared	0.83	0.83	0.83	0.83

Notes:

1: Clustered (at session level) standard errors in parentheses.

2: Significant at: * 10% level; ** 5% level; *** 1% level.

3: Cubic polynomial in value and reserve price is controlled for.

4: Period indicator variables are used to control for learning.

Table 5: Demographics, Education and Menstrual Cycle on Dominant Strategy Play in the Second-Price Auction.

Dependent variable (estimation method):	Playing Dominant Strategy in SPA (Logit)			
	(1)	(2)	(3)	(4)
Female	-0.3688	-0.2456		
	(0.3597)	(0.3265)		
Age	0.0452	0.0555	0.0361	0.0454
	(0.0293)	(0.0364)	(0.0308)	(0.0357)
Number of Siblings	-0.1140	-0.1362	-0.1307	-0.1602
	(0.1112)	(0.1144)	(0.1129)	(0.1128)
Asian/Asian American	-0.3307	-0.5335	-0.3884	-0.6130*
	(0.2792)	(0.3254)	(0.2846)	(0.3326)
Other Ethnicity	-0.7799**	-0.8087**	-0.8029**	-0.8457**
	(0.3607)	(0.3692)	(0.3624)	(0.3617)
Math and Stats Courses		-0.0968		-0.0984
		(0.0777)		(0.0751)
Science and Engineering Courses		0.0187		0.0205
		(0.0200)		(0.0198)
Economics and Business Courses		0.0730*		0.0757*
		(0.0377)		(0.0398)
Other Social Science Courses		-0.0436*		-0.0477*
		(0.0257)		(0.0256)
Humanities and Other Courses		-0.0117		-0.0120
		(0.0204)		(0.0200)
Menstrual Phase			-0.4503	-0.2864
			(0.5003)	(0.4959)
Follicular Phase			-0.6765	-0.6562
			(0.5535)	(0.5910)
Peri-Ovulatory Phase			-0.6881	-0.6305
			(0.6468)	(0.4475)
Luteal Phase			-0.0313	0.1817
			(0.5046)	(0.4884)
Premenstrual Phase			-0.3913	-0.2783
			(0.5228)	(0.5114)
Observations	3,081	3,081	3,081	3,081
Log-likelihood	-1,988.69	-1,942.11	-1,977.34	-1,925.45

Notes:

1: Clustered (at session level) standard errors in parentheses.

2: Significant at: * 10% level; ** 5% level; *** 1% level.

3: Period indicator variables are used to control for learning.

Table 6: Demographics, Education and Menstrual Cycle on Overbidding in the Second-Price Auction

Dependent variable (estimation method):	Overbidding (Logit)			
	(1)	(2)	(3)	(4)
Female	-0.2391	-0.3865		
	(0.2768)	(0.2687)		
Age	-0.0822	-0.0791	-0.0727	-0.0672
	(0.0517)	(0.0529)	(0.0536)	(0.0548)
Number of Siblings	0.0990	0.1201	0.1125	0.1383
	(0.1060)	(0.1013)	(0.1021)	(0.0937)
Asian/Asian American	0.4673*	0.6293**	0.5934**	0.7942***
	(0.2692)	(0.3027)	(0.2585)	(0.3022)
Other Ethnicities	0.4801	0.4534	0.5167	0.5029
	(0.3233)	(0.3485)	(0.3181)	(0.3368)
Math and Stats Courses		0.0918		0.0993
		(0.0721)		(0.0687)
Science and Engineering Courses		-0.0209		-0.0232*
		(0.0138)		(0.0138)
Economics and Business Courses		-0.0592**		-0.0615**
		(0.0284)		(0.0280)
Other Social Science Courses		0.0250		0.0317
		(0.0273)		(0.0267)
Humanities and Other Courses		0.0210		0.0252
		(0.0213)		(0.0217)
Menstrual Phase			-0.2096	-0.4049
			(0.4479)	(0.4506)
Follicular Phase			0.0804	0.0217
			(0.4176)	(0.4282)
Peri-Ovulatory Phase			-0.3215	-0.4624
			(0.3721)	(0.3619)
Luteal Phase			-0.6735*	-0.9438**
			(0.3974)	(0.3723)
Premenstrual Phase			0.3837	0.3040
			(0.4507)	(0.3823)
Observations	3,081	3,081	3,081	3,081
Log-likelihood	-2060.18	-2021.64	-2038.42	-1991.58

Notes:

1: Clustered (at session level) standard errors in parentheses.

2: Significant at: * 10% level; ** 5% level; *** 1% level.

3: Period indicator variables are used to control for learning.