The impact of the menstrual cycle and hormonal contraceptives on competitiveness

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Abstract

We examine whether competitiveness in women is influenced by biological factors. Female participants in a laboratory experiment solve a simple arithmetics task first under a piece rate and then under a competitive tournament scheme. Participants can then choose which compensation scheme to apply in a third round. We find that the likelihood of selecting into the competitive environment varies strongly and significantly over the menstrual cycle and with the intake of hormonal contraceptives. The observed patterns are consistent with a negative impact of the sex hormone progesterone on competitiveness. We show that the effect of the menstrual cycle and hormonal contraceptives on competitiveness is due neither to an an impact on performance, nor to an impact on risk aversion or overconfidence.

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1 Introduction

The literature on the impact of gender on economic decision making is extensive and gender differences in preferences are often identified as a potential source of the persisting wage gap between men and women. The potential importance of gender differences in preferences as a cause of the gender wage gap becomes clear when one considers to which extent the allocation of top executive jobs is skewed in favour of men.[1] Gender discrimination and conflicts between the long hours worked in such careers and family life are often identified as potential causes. More recently, the experimental economics literature has identified an additional explanation: women tend to dislike competition while men actively seek it. Promotions and wage increases are often conditional on prevailing in tournament-like competition and if fewer women enter competitive environments, less will come out on top. The aim of this paper is to determine whether biological factors, in particular the menstrual cycle and intake of hormonal contraceptives, have an impact on the competitiveness of women. Both the menstrual cycle and hormonal contraceptives lead to predictable hormonal fluctuations that exclusively affect women and such an impact would thus be an indication that the gender gap in competitiveness is at least partly caused by biological factors.

Most experimental studies concerned with competitiveness have subjects perform a simple task whereby the compensation scheme is varied between a non-competitive piece rate and a competitive tournament scheme. Overall, when subjects are given the choice of whether or not to enter the tournament, women tend to opt out while the majority of men chooses to enter. Niederle and Vesterlund (2007), using a simple maths task for which no gender differences in performance are observed, find that 73 percent of men prefer the tournament while only 35 percent of women choose to compete. Gneezy et al. (2003) moreover find that men significantly increase effort when the compensation scheme for a task becomes more competitive while women show no reaction.[2]

Whether this divergence in attitudes towards competition is mostly caused by innate factors or rather by differences in upbringing and culture is still largely an open question. Apicella et al. (2009) find no impact of either prenatal or current levels of testosterone on tournament entry in men, suggesting that testosterone is not a significant determinant of the gender gap in competitiveness. In other areas of economic behaviour, Burnham (2007) finds that higher testosterone levels are associated with a higher probability of rejection in the ultimatum game and Apicella et al. (2008) find testosterone levels to be correlated with financial risk taking. Treating subjects with nasal sprays, Kosfeld et al. (2005) show that the hormone oxytocin significantly increases giving in the trust game.[3] Sapienza et al. (2009) using a large sample of

[1] Using a dataset containing information on the five highest paid executives in large US corporations for the years 1992-97, Bertrand and Hallock (2001) find that the representation of women reaches a mere 2.5 percent.

[2] See Croson and Gneezy (2009) for a review of gender differences in lab and field experiments covering the areas of risk aversion, competitiveness, and social preferences.

[3] Fehr (2009) reviews further evidence of biological and other factors influencing trusting behaviour.

MBA students, find that testosterone levels are positively correlated with risk seeking and that the gender gap in the likelihood of seeking out a career in finance disappears when controlling for current and prenatal testosterone levels. Treating a sample of post-menopausal women with high doses of testosterone and oestrogen, Zethraeus et al. (2009), on the other hand, find no impact of hormonal levels in a range of games measuring altruism, trust, fairness, and risk aversion.

The economic literature also provides some evidence pointing towards nurture rather than nature being at the root of gender differences in competitiveness. Gneezy et al. (2008) investigate the impact of culture by conducting the same experiment, in which participants can choose between piece rate and tournament compensation for throwing balls into a basket, both with subjects stemming from a patriarchal society (the Maasai of Tanzania) and subjects from a matrilineal society (the Khasi of India). While the Maasai exhibit the same gender gap in competitiveness found in Western societies, the roles are reversed in the Khasi sessions, though the authors explicitly mention the possibility that nature, as well as nurture, may play a role in this reversal. Letting teenage subjects from all-girls, all-boys, and co-educational schools choose between piece rate and tournament compensation for solving mazes, Booth and Nolen (2009a) find that girls attending single-sex schools are significantly more likely to choose the tournament.[4]

In our experiment, we make use of the menstrual cycle and hormonal contraceptives to analyse to what extent the preferences of women concerning self-selection into competitive environments are affected by biological processes related to fluctuations in female sex hormones. If competitiveness is indeed related to these processes, we would expect it to fluctuate over the menstrual cycle and with contraceptive intake. Moreover, we would expect competitiveness to fall when sex hormone levels in the body are high and to rise when they are low. Such a finding would support the hypothesis that innate differences can explain a significant part of the gender gap in competitiveness. If the divergence between the competitive behaviour of men and women is due solely to nurture, on the other hand, we would expect to observe no effects. Our experimental design closely follows Niederle and Vesterlund (2007).

The impact of the menstrual cycle on economic decision making has so far only been analysed in the context of sealed bid auctions. Analysing bidding behaviour in first-price auctions, Chen et al. (2009) find that the gender gap in overbidding – women overbid significantly more than men – fluctuates over the menstrual cycle. The authors conclude that most of this variation is due to contraceptive users but this is based on a very small number of subjects as they have information on contraceptive use only for part of their sample. In a replication using a more straightforward auction design, Pearson and Schipper (2009) find significant fluctuations in bidding behaviour that are at odds with the findings of Chen et al. (2009). Since the first version

[4]In Booth and Nolen (2009b), the authors similarly show that the gender gap in risk aversion – girls are 36 percent less likely than boys to choose a risky gamble over a safe option – disappears completely for girls being raised in single-sex schools.

of this paper has been released, one other study concerned with the impact of the menstrual cycle on competitiveness has appeared (Wozniak, 2009). We will provide a comparison of results and further discussion in Section 5.[5]

We find that competitiveness fluctuates strongly and significantly over the menstrual cycle and with the intake of hormonal contraceptives. Moreover, these fluctuations follow the predicted pattern with subjects being significantly less competitive in times of high concentrations of sex hormones in the body. Making use of the diverging patterns of oestrogen and progesterone secretion over the menstrual cycle, we find that the fluctuations in competitiveness are strongly and significantly correlated with fluctuations in progesterone levels. We consider three possible indirect pathways for the effect of the menstrual cycle and contraceptives on competitiveness: via an impact on risk aversion, via an impact on maths performance, and via an impact on overconfidence. None of these hold up to the data.

The next section describes which variables we use to capture the relevant features of the menstrual cycle and of hormonal contraceptives. Section 3 provides further details about the experimental design, and Section 4 describes the sample. Section 5 presents the basic results and Section 6 reports the findings regarding possible pathways. Section 7 concludes.

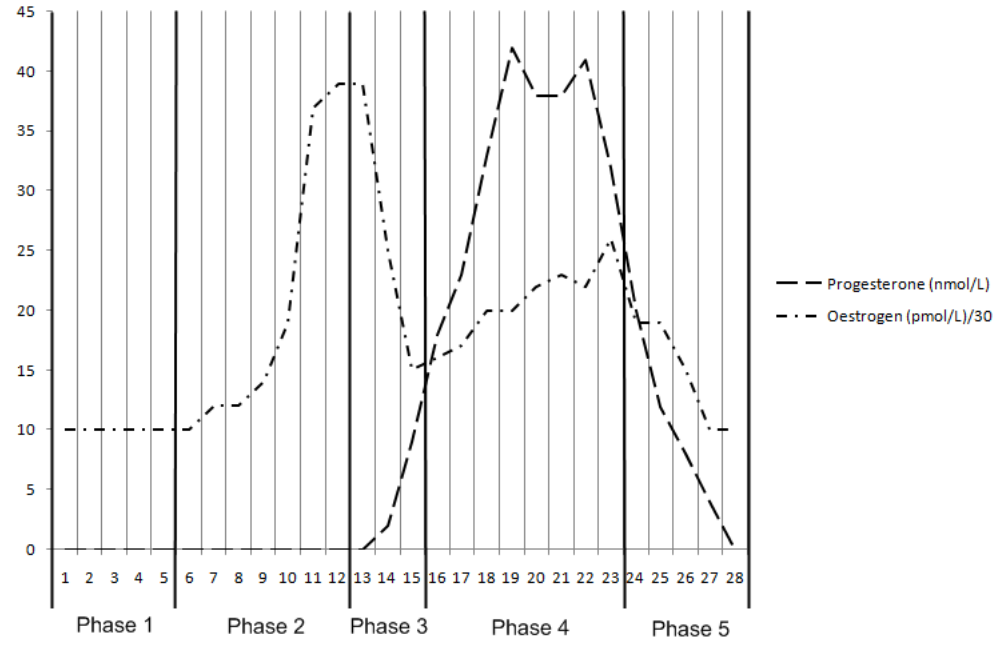
2 The menstrual cycle and hormonal contraceptives

Assuming a regular 28-day cycle, the levels of the female sex hormones oestrogen and progesterone fluctuate according to the following pattern, while levels of testosterone are virtually constant (see e.g. Richardson, 1992 or Owen, 1975):

- Phase 1: Menstrual phase (days 1-5 of the cycle): secretion of oestrogen and progesterone ceases.
- Phase 2: Follicular phase (days 6-12): oestrogen levels increase gradually, there is virtually no progesterone.
- Phase 3: Peri-ovulatory phase (days 13-15): oestrogen levels decrease, there is still little progesterone. This phase represents the fertile window of the menstrual cycle.
- Phase 4: Luteal phase (days 16-23): progesterone is secreted in large quantities, oestrogen levels reach a second peak.

[5]Contrary to the economic literature, the psychological and medical literature investigating the effects of the menstrual cycle is vast. Hampson and Kimura (1992) and Maki et al. (2002) find that during menstruation when hormone levels are low, women do better at male-oriented tasks such as spatial ability, while doing better at female-oriented tasks such as articulation during high-oestrogen phases. Others have found menstrual cycle effects on a wide range of behaviours and preferences including mood swings (Bäckström et al., 1983), risk taking behaviour (Chavanne and Gallup Jr, 1998), food intake (Gong et al., 1989), visual memory (Phillips and Sherwin, 1992), preferences for male body odour (Thornhill and Gangestad, 1999), preferences for male faces (Penton-Voak et al., 1999), and the likelihood of contracting soccer injuries (Möller-Nielsen and Hammar, 1989).

Figure 1: Hormone Levels over the Menstrual Cycle (Hormone levels are obtained from Chabbert Buffet et al. (1998); oestrogen levels have been reduced by a factor of thirty)



- Phase 5: Premenstrual phase (days 24-28): both oestrogen and progesterone levels decline drastically during this phase.

The fluctuations of sex hormones over the menstrual cycle are illustrated in Figure 1. We allocate subjects experiencing a natural menstrual cycle to one of the five menstrual cycle phases based on the cycle information collected through our post-experimental questionnaire. Assuming a regular 28-day cycle can be expected to lead to some measurement error when dividing subjects into the five menstrual cycle phases. However, most of the variability in cycle length between individuals stems from differences in the length of the follicular phase. The length of the ovulatory, luteal, and premenstrual phases on the other hand is relatively fixed (Hampson and Young, 2008). We construct a prospective measure of the menstrual cycle – i.e. we elicit information about the expected beginning of the next menstruation and then count backwards – and the distinction most affected by mis-classification should therefore be the one between the first and second phase. We also ask subjects whether they are currently menstruating or not and use this information to reallocate them between phases one and two, moving all menstruating subjects to phase one and all non-menstruating subjects to phase two. This should help to reduce the amount of mis-classifications.

In women using hormonal contraceptives such as the pill, vaginal rings, or contraceptive patches, which contain varying levels of artificial oestrogen and progestins[6], hormonal fluctuations are different. These contraceptives have in common that they are subject to a 28-day cycle wherein a 21-day intake period, which is characterised by constant daily doses of an artificial oestrogen and an artificial progestin, is followed by a 7-day break during which hormone intake levels drop to zero. Oestrogen excretion by the body is markedly reduced in women taking hormonal contraceptives and progesterone excretion ceases almost completely (Rivera et al., 1999). Hormone excretion levels do not recover during the 7-day break (Elstein et al., 1974) and levels of the artificial hormones contained in the contraceptives drop rapidly after the beginning of the break (Stanczyk et al., 1975). This leads to a regular pattern whereby hormone levels are high during the 21-day intake period and low during the 7-day pill break. We construct a binary variable indicating whether a subject is on the 7-day pill break. Hormone levels during the intake period depend on the strength of a given contraceptive and our dummy variable simply captures the effect of the average contraceptive in the sample. Given that a 28-day cycle is virtually assured for subjects taking the pill, we do not expect measurement error to be an issue.

For our statistical analysis, we finally divide subjects into high-oestrogen and low-oestrogen, as well as high-progesterone and low-progesterone individuals. For subjects not taking contraceptives, the high oestrogen phase corresponds to cycle phases two and four while the high progesterone phase coincides with the fourth phase of the menstrual cycle (see Figure 1). For subjects taking hormonal contraceptives, the high-oestrogen and high-progesterone phases are congruent and coincide with the pill-intake phase. For subjects experiencing a natural cycle, we also construct two continuous variables representing the expected oestrogen and progesterone levels given the day of the cycle a subject is currently in.[7] This measure will allow us to disentangle the effects of oestrogen and progesterone but, because we do not actually measure hormone levels, can be expected to be affected by measurement error to a higher degree than the simple dummy variables.

It might seem attractive at first sight to use the differing strengths of the oestrogen and progestin dosage of various contraceptive brands in order to disentangle the effect of the two hormones but there are a few important caveats. The hormonal contraceptives currently on the market contain a wide range of progestins with widely different properties.[8] The exact contraceptive brand prescribed to an individual – and therefore the oestrogen and progestin dosage – is likely

[6] A progestin is a synthetic hormone that has effects similar to progesterone.

[7] The average daily plasma hormone levels over the menstrual cycle are obtained from Chabbert Buffet et al. (1998).

[8] There is a large literature trying to estimate and compare the progestational and androgenic activity of different progestins, generally using rats or rabbits (see e.g. Muhn et al., 1995 and Kuhnz et al., 1995), but studies employing a uniform methodology to compare a large number of different progestins using human subjects are hard to come by. See Mansour (2006) for a summary of the research on the progestational and androgenic activity of most of the progestins found in currently available hormonal contraceptives

endogenous with respect to the outcome variable. We therefore favour the results stemming from the simple dummy variable which picks up the effect of the average hormonal contraceptive and which does not suffer from endogeneity issues. For the same reason it is also impossible to compare users of hormonal contraceptives with subjects experiencing a natural cycle: the choice of whether or not to take a hormonal contraceptive may be endogenous with respect to the outcome variable. When pooling samples, we therefore always introduce a contraceptive-takers dummy.

3 Experimental design

Data were collected in a series of lab experiments taking place in June 2009 in which subjects participated in four parts: a part eliciting their attitudes towards risk, a part related to choices regarding competition, a part measuring their social preferences, and a public goods part (in this order). Subjects were paid for only one of these four parts, which was randomly determined after the last part was played. This method to determine subjects' payoffs avoids that the different parts are connected through an endowment effect. In this paper, we only report results from the competition and risk attitudes part. Results obtained from the social preferences and public goods parts will be reported in a separate paper. The experimental instructions can be found in the appendix.

The design of the competition part closely follows the methodology of Niederle and Vesterlund (2007). Subjects are divided into groups of four and are asked to perform the simple task of solving as many sums of five two-digit numbers as they can during a five-minute interval. Subjects are presented with a randomly drawn sequence of five two-digit numbers which are presented on the screen in a row. Participants then enter their answer into a box and press a button. A new series of numbers appears immediately together with information on whether the previous answer was correct. Subjects are allowed to use scratch paper but no calculators. The total time per round is five minutes and subjects may solve as many sums as possible. Niederle and Vesterlund (2007) find no gender differences in ability for solving these simple arithmetic problems.

In a first round, subjects are compensated according to a non-competitive piece rate, receiving 1€ for each correct answer, and in a second round according to a competitive tournament scheme whereby the subject with the highest score of each group receives 4€ per correct answer while the rest receive nothing.[9] This design has the advantage that subjects experience both schemes before making a decision and enables us to determine whether ability has an effect on compensation scheme choice. Being informed about her absolute but not her relative performance, each subject then decides which of the two compensation schemes she wishes

[9] In case there are two or more winners, the money is split equally.

to apply in a third round. Subjects going for the tournament in round three receive 4€ per correct answer if they score higher than the best of their group mates did in round two. There are several reasons to proceed this way. First, while the performance of a subject opting for competition is still evaluated against performances obtained through a tournament, her beliefs about the decisions of others do not play a role. Second, a subject's choice does not affect the payments of others and social preferences can therefore be excluded as a source of bias. A random pick of one of the rounds is relevant for payment. Finally before informing subjects about their payment, we elicit their beliefs about their relative performances in rounds one and two by asking them to estimate their group rank for each task. Subjects receive 2€ for each correct guess. This enables us to determine whether (over)confidence plays a role in the choice of compensation scheme.

To measure attitudes towards risk, we conducted a simple objective probability lottery choice experiment which follows the methodology of Eckel and Grossman (2002). This will allow us to control for the impact of risk aversion on competitiveness and to test whether the impact of sex hormones on competitiveness is mediated by an impact on risk aversion. Subjects can choose between a sure payoff of 8 Euros and four 50/50 lotteries with linearly increasing riskiness and expected payoffs: 12/6, 16/4, 20/2, 24/0. The choice of lottery then serves as an indicator of the risk aversion of the subject, yielding a discrete variable ranging from 1 (sure thing) to 5 (highest expected payoff/highest risk option).[10]

All seven sessions were conducted at the computer lab of CREED (Center for Research in Experimental Economics and Political Decision-Making) at the University of Amsterdam in the Netherlands in June 2009. There were a total of 120 subjects, all of whom are female university students enrolled in various fields. On top of the task-specific compensation detailed below, subjects received a fixed fee of ten Euros. Subjects received task-specific instructions only immediately before the start of each round. The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007).

4 Sample

After the experiment but before being informed about their payment, subjects answered a short questionnaire eliciting details about their menstrual cycle, in particular in how many days their next menstrual cycle will begin and whether they are currently menstruating. The subjects were also asked which kind and brand of contraceptive they use. Finally, we also elicited their

[10]We also measured risk attitudes through the methodology designed by Holt and Laury (2002). The two risk measures are highly correlated. But since the Holt-Laury measure is a bit more complicated for subjects to grasp – leading some subjects to make inconsistent choices – we only use the results obtained with the Eckel-Grossman methodology in this paper. Using the Holt-Laury measure instead or eliminating the subjects who made inconsistent decisions does not change any of our conclusions concerning risk attitudes.

Table 1: Contraceptive Use

Contraceptive	Number of Subjects	Percentage
Pill	47	43.9
Other hormonal contraceptives	6	5.6
Condoms	31	29.0
Other methods	1	0.9
None	22	20.6
Total	107	100.0

age, nationality, and study major. The post-experimental questionnaire can be found in the appendix.

We drop thirteen subjects who state not to experience a menstrual cycle at all. Subjects gave a range of reasons including using contraceptives which completely suppress menstruation and pregnancy. Of the remaining subjects, 79.4 percent use some kind of contraceptive with 49.5 percent using hormonal methods (see Table 1). 43 out of 53 subjects using hormonal contraceptives remembered the exact brand so that we could obtain information on the content and dosage. Table 2 shows descriptive statistics. The subjects are on average 23.2 years old and 47.7 percent are of Dutch nationality with the rest being mainly of European origin. 42.1 percent of the students have a background in economics which includes students who picked economics, econometrics, business, or finance as their major. It is apparent from Table 2 that contraceptive takers and non-takers are different along most dimensions. This does not affect our results as we only compare high and low hormone subjects within each group.

Table 3 contains the actual and expected distribution of subjects across menstrual cycle phases and between the pill-intake and pill-break phases. Selective attrition due to menstruating subjects staying away is not a significant problem: a χ^2-test cannot reject equality of the observed distribution and the theoretical distribution, returning a p-value of 0.50. Only subjects in the premenstrual phase, which is also the phase in which premenstrual symptoms such as cramps occur, seem to be underrepresented. But this does not affect our main conclusions as our regression results are robust to the exclusion of phase five subjects. There is no attrition problem for subjects using hormonal contraceptives: the number of subjects on the pill-break, when withdrawal bleedings occur, is exactly equal to the expected number.[11]

The subjects are randomly distributed across the different phases of the cycle with respect to their age and nationality: the Kruskal-Wallis equality-of-populations rank test returns a p-value of 0.46 for the null hypothesis of no variation in age between subjects assigned to different menstrual cycle phases and Fisher's exact test yields a p-value of 0.48 with respect to the distribution of nationalities across the cycle phases. The same is true for users of hormonal

[11]Neither do subjects on the pill break differ from subjects in the pill-intake phase in the characteristics of the contraceptives they take: Fisher's exact test returns a p-value of 0.99 with respect to progestin type and the Wilcoxon rank-sum test returns a p-value of 0.90 with respect to oestrogen dosage.

Table 2: Descriptive Statistics

	Sample	Natural cycle	Pill takers
Age	23.2	24.0	22.5
Economics	42.1%	50.0%	34.0%
Female	100%	100%	100%
Nationality			
Dutch	*47.7%*	*29.6%*	*66.0%*
Other European	*43.0%*	*57.4%*	*28.3%*
Latin American	*3.7%*	*3.7%*	*3.8%*
Other	*5.6%*	*9.3%*	*1.9%*
N	107	54	53

Table 3: Subjects by Menstrual Cycle Phase

Menstrual Cycle or Pill Cycle Phase	Number of Subjects	Expected Number of Subjects
Menstrual Phase (5 days)	11	10
Follicular Phase (7 days)	15	13
Peri-Ovulatory Phase (3 days)	9	6
Luteal Phase (8 days)	15	15
Premenstrual Phase (5 days)	4	10
Pill Break (7 days)	13	13
Pill Intake Phase (21 days)	40	40

contraceptives when it comes to assignment to the pill break: the Kruskal-Wallis test return a p-value of 0.95 with respect to age and Fisher's exact test a p-value of 1.00 with respect to nationality.

This study uses a between subject design. A within subject design, with subjects participating in several consecutive sessions, would have the advantage of catching each subject on different parts of her cycle. There are, however, important caveats which convinced us that a between subject design is preferable. Apart from the obvious problems of attrition and substantially increased costs, it seems likely that subjects would be influenced by their previous choices if playing the same game (or similar games) repeatedly.

A placebo controlled trial whereby subjects receive testosterone or oestrogen shots would be an alternative to our methodology. While presenting the advantage of increased control over the hormonal treatment, this approach also comes with a number of disadvantages. Apart from the complications, sharply increased costs, and ethical issues that come with a medical procedure, we also believe that the results would be less relevant. It is the fluctuations naturally occurring over the cycle and induced by contraceptives which affect women in real life – and therefore possibly influence their decisions with respect to entering competitive environments – and not the effects of strong doses of administered hormones. Moreover, women have typically had many years to adapt to the effects of the menstrual cycle and hormonal contraceptives, something which is not the case with respect to the effects of hormone injections.[12]

Given that most experimental studies of competitiveness examine mixed gender tournaments it may seem more natural to use a mixed sample. This would also permit to measure gender differences directly. On the other hand, there is a vast literature showing that women react very differently to men at different points of their cycle.[13] The presence of male subjects and the resulting possibility of facing male opponents in the tournament would consequently introduce a confounding factor, making it less clear how to interpret fluctuations in behaviour over the cycle. This said, the difference between the fluctuations in competitiveness over the menstrual cycle when facing male opponents and those when facing female opponents would be an interesting topic for future research.

5 Results

Our results show large and significant effects of the menstrual cycle and hormonal contraceptives on competitiveness. Women experiencing a natural menstrual cycle are significantly less

[12] It is also not clear that directly measuring hormones using blood or saliva samples would provide more reliable results given the cross-sectional nature of our study. We are interested primarily in whether a subject is currently in a high or low phase of her menstrual cycle or pill cycle and not whether her hormone levels are high compared to those of other subjects.

[13] See for example Jones et al. (2005), Bellis and Baker (1990), and Penton-Voak and Perrett (2000). Also see Section 5 for a more detailed discussion.

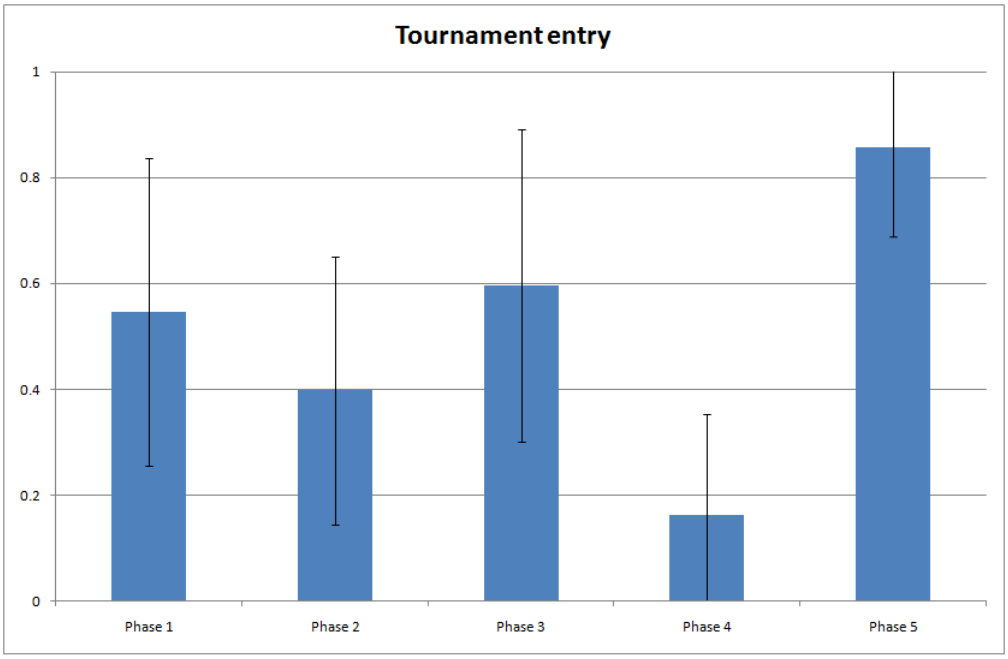
likely to choose the tournament – i.e. significantly less competitive – during the fourth phase of the menstrual cycle when progesterone is being secreted in large quantities and oestrogen secretion is strong too. Women taking hormonal contraceptives are significantly more competitive during the pill-break than outside of the pill-break. Pooling the two samples and dividing subjects into high and low hormone phases we find that low hormone subjects are roughly twice as likely to enter the tournament as high hormone subjects. Making use of the diverging fluctuation patterns of oestrogen and progesterone over the menstrual cycle, we attempt to disentangle the two hormones and show that tournament entry is very strongly correlated with progesterone fluctuations while evidence with respect to oestrogen is weaker. Keeping in mind that women are generally found to be significantly less competitive than men, we conclude that the behaviour of women shifts towards the behaviour of men when hormone concentrations are low. This gives support to the hypothesis of sex hormones being a cause of gender differences in competitiveness.

Average performance is in line with the findings of Niederle and Vesterlund (2007). The mean number of correct answers is 9.6 in round one and 11.5 in round two, the difference between the rounds being significant ($p<0.01$; one-sided t-test). This difference can be due either to learning effects or to the effect of increased competition on effort. Given that we observe a further significant increase from the second to the third round even for those subjects choosing the piece rate ($p<0.01$), there is more support for the hypothesis that learning effects are at play. The proportion of subjects opting for competition in round three is 44.9 percent.

If biological processes associated with fluctuations in female sex hormones have an impact we can expect to find significant variation in competitiveness across the five menstrual cycle phases. Additionally, we can expect competitiveness to be lower during the luteal phase when progesterone is secreted in large quantities while at the same time oestrogen secretion reaches a second peak, so that combined hormone concentration is particularly high. Indeed, we find that the likelihood of subjects choosing to enter the tournament varies strongly and significantly over the cycle. The predicted tournament entry rates across cycle phases are illustrated in Figure 2. It is evident that competitiveness is lower during the the follicular phase (phase 2) and the luteal phase (phase 4) than during the rest of the cycle. These are the phases in which the two peaks in hormone concentrations occur (see Figure 1). A one-way ANCOVA model controlling for age, educational background, and nationality returns a p-value of 0.03 for the joint significance of the five menstrual cycle dummies.

Competitiveness is particularly low for subjects in the luteal phase when the rush in progesterone excretion occurs. This difference between the luteal phase and the rest of the menstrual cycle is confirmed by the non-parametric Wilcoxon rank-sum test which returns a p-value of 0.02. Competitiveness is also lower in phases two and four combined, which represents the time period during which oestrogen secretion is particularly high, than during the rest of the cycle (Wilcoxon rank-sum p-value: 0.05). These differences are illustrated in the first and sec-

Figure 2: Tournament Entry Rates across Menstrual Cycle Phases (with 95%-confidence intervals)

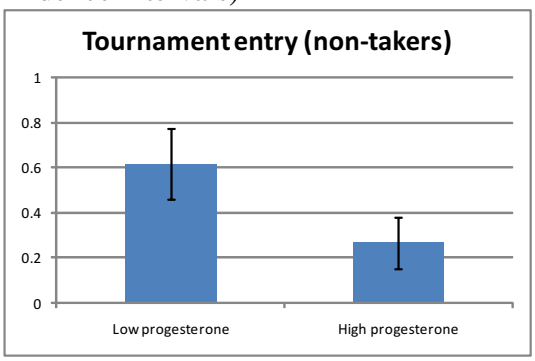


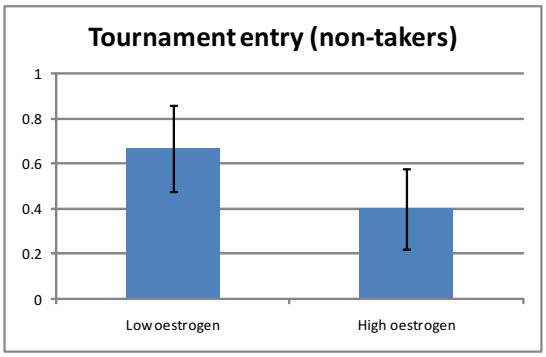
ond panel of Figure 3. Effects are equally strong for the sample of contraceptive users, who are significantly less competitive during the pill-intake phase than during the pill-break. This difference is illustrated in the third panel of Figure 3. A one-way ANCOVA model controlling for age, educational background, and nationality returns a p-value of 0.04 for the difference in competitiveness between subjects in the pill intake phase and those in the pill break as does a simple Wilcoxon rank-sum test.

Figure 4 shows the differences in competitiveness between the high and low hormone phases. Tournament entry levels and 95%-confidence intervals are obtained from simple regressions of treatment entry on phase dummies controlling only for a contraceptive-takers dummy. The regression coefficients are also reported in Columns (1) and (4) of Table 4. We can see that tournament entry is about twice as high during the low progesterone phase than during the high progesterone phase for the whole sample, with the tournament entry rate rising from roughly 28% to over 60%. The difference between the high and low oestrogen phases is similarly large. The same is also true for pill-takers and non-takers separately, as shown by Figure 3. The gap in tournament entry between non-pill takers in a high hormone phase and those in a low phase is similar in magnitude to the gap between pill-takers currently in the pill-break and those currently taking their hormonal contraceptive. Both samples approximately exhibit a doubling in the entry rate as they move from the high to the low hormone phase.

Table 4 also contains more detailed regression results. We can see that the difference in competitiveness between the high and low progesterone phases is robust to the inclusion of controls

Figure 3: Hormones and Tournament Entry Rates for Takers and Non-Takers (with 95%-confidence intervals)





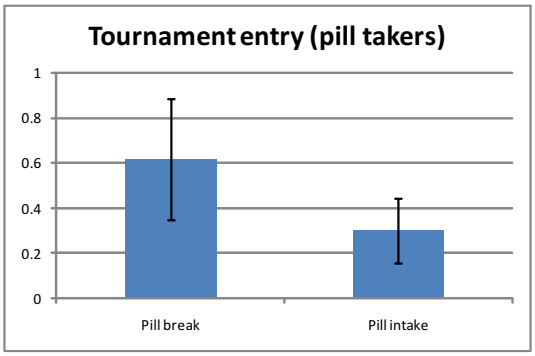
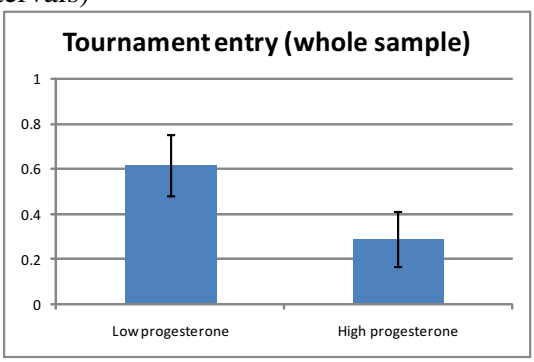


Figure 4: Hormones and Tournament Entry Rates for the Whole Sample (with 95%-confidence intervals)



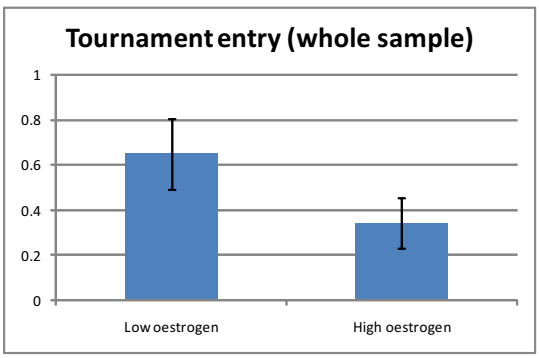


Table 4: Competitiveness Differences between High Hormone Subjects and Low Hormone Subjects

Competitiveness	(1)	(2)	(3)	(4)	(5)	(6)
High progesterone	-0.333***	-0.382***	-0.350***			
	(0.104)	(0.101)	(0.100)			
High oestrogen				-0.287***	-0.332***	-0.295***
				(0.101)	(0.099)	(0.099)
Contraceptive taker	0.018	0.100	0.135	-0.084	-0.007	0.036
	(0.104)	(0.099)	(0.091)	(0.096)	(0.097)	(0.091)
Risk aversion			0.087**			0.088**
			(0.036)			(0.036)
Performance			0.002			0.005
			(0.011)			(0.012)
Confidence			0.195**			0.182*
			(0.093)			(0.096)
Demographic Controls	no	yes	yes	no	yes	yes
Observations	107	107	107	107	107	107
R-squared	0.107	0.230	0.299	0.092	0.218	0.285

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

and significant at the 0.01-level throughout. The same is true for the difference between the high and low oestrogen phases. The regressions in Columns (2) and (5) introduce demographic controls which consist of age, nationality, and study background. In Columns (3) and (6), we additionally control for risk aversion as measured by the Eckel-Grossman scale, the average performance of subjects in rounds one and two, and confidence as measured by the belief to have been amongst the top two in one's group. These measures and their impact on tournament entry are discussed in greater detail in Section 6.

These results, however, do not enable us to distinguish whether the fluctuations in competitiveness correlate more strongly with oestrogen levels or progesterone levels. In order to obtain a clearer picture we will now take a closer look at day-to-day variations in hormone levels occurring in women who do not take hormonal contraceptives. Table 5 shows the results for linear probability models regressing tournament entry on daily expected oestrogen and progesterone levels and changes for the sample of subjects experiencing a natural cycle.[14] Columns (1) to (3) show the coefficients of average sex hormone levels. We can see that while the progesterone coefficient is significant and negative throughout, the oestrogen coefficient is never significant.

[14]Probit and logit estimation returns very similar results for all our regressions. The demographic controls consist of age, education, and nationality.

Table 5: Natural Hormone Fluctuations and Competitiveness

Competitiveness	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Oestrogen (level)	0.004	0.005	0.004				0.003
	(0.009)	(0.009)	(0.010)				(0.008)
Progesterone (level)	-0.009*	-0.011***	-0.011**				-0.008**
	(0.005)	(0.004)	(0.005)				(0.004)
Oestrogen (change)				-0.015	-0.018*	-0.018*	-0.017
				(0.010)	(0.010)	(0.010)	(0.011)
Progesterone (change)				-0.034***	-0.042***	-0.042***	-0.036***
				(0.012)	(0.008)	(0.008)	(0.008)
Risk aversion			0.037			0.025	
			(0.059)			(0.053)	
Performance			0.005			0.016	
			(0.017)			(0.016)	
Confidence			0.039			-0.0570	
			(0.194)			(0.182)	
Demographic controls	no	yes	yes	no	yes	yes	yes
Observations	54	54	54	54	54	54	54
R-squared	0.054	0.209	0.220	0.111	0.283	0.303	0.319

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Columns (4) to (6) contain the coefficients on changes in hormone levels (compared to the previous day). Changes in progesterone levels are highly significantly and negatively correlated with the likelihood of selecting into the tournament while changes in oestrogen concentrations are marginally significant and negative as well. This means that competitiveness is lower while hormone levels are increasing and vice versa. This result is consistent with recent findings in endocrinology suggesting that changes in hormone concentrations might matter as much or more than levels in triggering hormone-induced processes.[15]

Again, the hormone coefficients are robust to the inclusion of controls.[16] When levels and changes are included in Column (7), it becomes apparent that both levels and changes in progesterone concentration are significantly and negatively correlated with competitiveness. The changes in the oestrogen concentration are still marginally significant (p=0.12) while, as in

[15]Kol and Homburg (2008), for example, propose that "changes in hormone concentrations carry significant biological messages, much more than a given level at a given time point".

[16]As a further robustness check, we conducted the same analysis with the premenstrual phase subjects excluded. The under-representation of premenstrual phase subjects may be a consequence of selective attrition due to women being affected by premenstrual symptoms staying away which, given that premenstrual symptoms are hormone-driven, may cause bias. However, our main results carry through and our findings are therefore not an artifact of selective attrition of subjects in the fifth phase.

Columns (1) to (3), oestrogen levels are not significant. When checking for joint significance, it becomes apparent that the menstrual cycle fluctuations in competitiveness move in step with the progesterone concentration, for which the level and change coefficients are jointly highly significant ($p<<0.01$), rather than oestrogen concentrations, for which the level and change effects are not jointly significant. The four hormone coefficients are also jointly significant ($p<<0.01$) and we find no evidence for interaction effects between oestrogen and progesterone. One has to keep in mind though that the daily expected hormone levels are based on the assumption of a regular 28-day cycle and, given the strong day-to-day variations in hormone levels, are consequently affected by measurement error to a higher degree than the simple dummy variables used above.[17]

Expected plasma concentrations of progesterone vary from 0 nmol/L during the menstrual phase to 41 nmol/L at the luteal phase peak while oestrogen levels range from 300 pmol/L during the menstrual phase to 1170 pmol/L during the follicular phase peak.[18] This means that the predicted probability of entering the tournament is approximately fifty percent lower around day twenty of the menstrual cycle than during the menstrual phase when no progesterone and little oestrogen are secreted and hormone levels are flat.

Our results fit well with the wide variety of behavioural fluctuations over the menstrual cycle documented in the medical literature and the existing evidence on the behavioural effects of progesterone.[19] They are also consistent with an evolutionary explanation according to which competitiveness is less desirable during the infertile phase of the menstrual cycle and during pregnancy (when hormone levels are high) than during the fertile phase (when competition for male partners is most important and hormone levels are low). Jones et al. (2005) show that women's commitment to their romantic relationship and attraction to femininity in male faces are positively and significantly correlated with progesterone levels. The rush in progesterone occurring during the luteal phase signals the end of the fertile part of the menstrual cycle[20] during which women are more likely to engage in extra-pair copulations (Bellis and Baker, 1990),

[17] It is interesting to note that we find no impact of the menstrual cycle and contraceptives on the difference in arithmetic scores between round one (piece-rate) and round two (tournament) which, apart from learning effects, also incorporates the reaction of performance to the increase in the competitiveness of the compensation scheme. This is consistent with the finding of Niederle and Vesterlund (2007) that there is no gender gap in score improvement between rounds one and two.

[18] We divided the oestrogen levels by a factor of 30 in order to align the oestrogen coefficients with the progesterone coefficients.

[19] In a placebo controlled trial, de Wit et al. (2001) find that exogenous administration of progesterone leads to feelings of sluggishness and a decrease in vigor, as measured by the Profile of Mood States (PMOS), a psychological test consisting of 72 adjectives commonly used to describe momentary mood states. Concerning the behavioural effects of progesterone, see also Söderpalm et al. (2004), van Broekhoven et al. (2006), and Friess et al. (1997). Studies using rats suggest that these effects are due to progesterone acting as a modulator of neurotransmitter receptors (see e.g. Schumacher et al., 1990; Bitran et al., 1993; Frye and Duncan, 1994; and Picazo and Fernandez-Guasti, 1995).

[20] Conception can occur during roughly a six day period ending with ovulation (Wilcox et al., 1995). This means that the fertile period – when defined as the days during which a single act of intercourse can lead to pregnancy – ends as the luteal phase begins and the progesterone rush occurs.

have more frequent intercourse (Wilcox et al., 2004), and are more attracted to testosterone-related masculine facial features signalling immunity to infectious diseases (Penton-Voak and Perrett, 2000). A negative association between female sex hormone levels and competitiveness fits well with these findings as increased competitiveness is plausibly an important advantage when competing for genetically well-endowed males when fertility is high but much less so when trying to retain a long term partner with high child-rearing competence. In this context, it is interesting to note that hormonal conditions in the luteal phase are similar to those occurring during pregnancy (Jones et al., 2005). Evolutionary psychology states that women face higher costs of competitive behaviour compared to men because their death generally means the loss of their current offspring (Campbell, 2002), which is especially true during pregnancy.[21]

While our findings are consistent with results from the psychological and medical literature and with evolutionary theory, they are seemingly at odds with Wozniak (2009) who finds that women are more, rather than less, competitive during high hormone phases. There are some important differences in experimental design and analysis, however, which make the results difficult to compare. Instead of two possible choices, Wozniak (2009) offers his subjects a choice of three schemes – a piece rate, a tournament, and a group scheme in which proceeds are shared equally between group members – and introduces additional uncertainty by varying the number of competitors. He then orders these options according to ascending competitiveness – the group scheme being deemed the least competitive and the tournament the most competitive option – and uses ordered probit estimation. It is not evident, however, why sharing the proceeds with a group of others should be less competitive than working on one's own accord. In the piece rate scheme, a subject's results are not compared with or communicated to anyone else while in the group scheme subjects may feel compelled to live up to the expectations of the other group members or feel competitive pressure to perform better than them. Given that the group scheme provides relative feedback it is arguably more rather than less competitive than the piece rate.[22] The results in Wozniak (2009) are due mainly to a shift of subjects out of the group scheme and into the tournament scheme as they move from the low to the high phase. If the rank of the group scheme in the competitiveness ordering is changed, the results would obviously reverse.[23] Moreover, Wozniak (2009) does not introduce a contraceptive taker

[21] Our results are also consistent with a positive impact of testosterone on competitiveness. It has been shown for instance that exogenous administration of progesterone (for example through hormonal contraceptive intake) leads to a decrease in testosterone levels (see e.g. Alexander et al., 1990). Given that testosterone levels differ widely between men and women, testosterone also seems a plausible determinant of gender differences in economic behaviour. Moreover although testosterone levels are low in women compared to men, fluctuations in testosterone have strong behavioural effects in women, including on sexual desire (see e.g. Persky et al., 1978 and Bancroft et al., 1983).

[22] It is a stable finding of studies on gender and competitiveness that factors such as risk aversion cannot fully explain gender differences in competitiveness and it is plausible that one of the main reasons for women to avoid competitive situations is to avoid relative feedback.

[23] Moreover, it is impossible to know whether the majority of low hormone phase subjects who chose the group scheme would have picked the tournament (in which case results similar to ours would obtain) or the piece-rate if the group option was not available. Given the ordering and the ordered probit methodology, it is also not clear whether the hormone effect mainly picks up women moving from the group scheme to the piece rate, from the

dummy. As we have argued above, the decision (or prescription by a doctor) to take a hormonal contraceptive is likely endogenous with respect to competitiveness and it is therefore dangerous to compare takers and non-takers. Without a contraceptive taker dummy, one compares the decisions of contraceptive takers on the pill break with those of high-hormone phase non-takers and vice versa.

It is important to note that our results obtained for the subjects taking hormonal contraceptives and for those experiencing a natural cycle point in the same direction. The slump in competitiveness during the luteal phase is similar in magnitude to the negative effect of hormonal contraceptives. The gender gap in competitive behaviour thus widens during times of high concentration of (or rapid increase in) female sex hormones and the magnitudes of both the effect of natural hormonal fluctuations and of the fluctuations induced by hormonal contraceptives are substantial. Multiplying the estimated coefficients for menstrual cycle phases two to five with the expected fraction of days a woman spends in each phase over an average 28-day cycle, we find that women are 10.5 percentage points less likely to enter the tournament compared to a fictitious situation in which sex hormones are always at the low levels observed during the menstrual phase. This back-of-the-envelope calculation indicates that the effect of hormones can account for roughly a quarter of the gender gap in competitiveness estimated by Niederle and Vesterlund (2007). This suggests that hormonal differences between men and women provide a compelling partial biological explanation for observed gender differences in competitiveness.

6 Possible pathways

Our results show that the menstrual cycle and hormonal contraceptives have a significant impact on competitiveness. We will now investigate whether this effect is mediated by an impact on one of several possible determinants of competitiveness. We consider three possible indirect pathways: via an impact on risk aversion, via an impact on mathematical abilities, and via an impact on overconfidence. None of these hypotheses hold up to the data.

6.1 Risk aversion

Chen et al. (2009) hypothesise that the impact of the menstrual cycle on auction bids is mediated by an impact on risk aversion and Datta Gupta et al. (2005) show that women are strongly influenced by their degree of risk aversion when deciding whether to compete or not. Moreover, there is a long list of studies, including Eckel and Grossman (2002) and Powell and Ansic (1997), showing that women are significantly more risk averse than men.[24] The hypothesis that

piece rate to the tournament, or from group to tournament.

[24] See Croson and Gneezy (2009) for a full survey of studies investigating gender differences in risk attitudes. The vast majority of surveyed papers find either that women are more risk averse than men or find no significant difference.

the impact of the menstrual cycle and hormonal contraceptives on competitiveness is mediated by an impact on risk aversion seems therefore plausible.

Risk aversion as measured by our lottery choice experiment is indeed a strong and significant predictor of tournament entry. A one-way ANCOVA model controlling for age, educational background, and nationality returns a p-value of 0.03 for the null of equality of competitiveness across individuals with varying levels of risk aversion.[25] The regressions in Columns (3) and (6) of Table 4 show that an increase of one (on a five-point scale) in our risk indicator leads to an increase in the likelihood of competing of around nine percentage points.

But the second link in the chain, namely an impact of hormones on risk aversion, is missing. A one-way ANCOVA model with the usual demographic controls rejects an impact both of the menstrual cycle phases (p=0.64) and the pill-break (p=0.56). This result is confirmed by non-parametric tests.[26] We conclude that an effect on risk aversion does not represent a significant pathway for the impact of the menstrual cycle and hormonal contraceptives on competitiveness.

6.2 Mathematical ability

Given that the psychological literature has found some cognitive functions to vary over the menstrual cycle[27], one could imagine that the same is true for the ability to solve sums. If mathematical ability were significantly lower in times of high concentration of sex hormones, this could obviously have a negative impact on subjects' readiness to compete. But this hypothesis does not hold up on two accounts. On the one hand, average maths scores do not vary significantly across menstrual cycle phases or with contraceptive intake, and on the other hand, the performance of a subject in rounds one and two has no influence on her decision of whether or not to compete in round three.

A one-way ANCOVA model with demographic controls indicates that average mathematical performance shows no significant variation across the menstrual cycle phases (p=0.84) or between the pill-break and the pill-intake phase (p=0.17).[28] Moreover, absolute performance in rounds one and two, which is all the information subjects have at the moment of making the decision of whether or not to enter the tournament at the start of round three, has no impact on competitiveness. The regression results in Table 6 show that the effect of the mean score

[25]The nonparametric Kruskal-Wallis test returns a p-value of 0.01. Fisher's exact test yields a similar p-value. In what follows, where applicable Fisher's exact test and the Kruskal-Wallis test lead to the same conclusions.

[26]The Kruskal-Wallis test returns a p-value of 0.79 for equality of risk aversion across the menstrual cycle phases and a p-value of 0.18 for equality between the pill-intake phase and the pill-break. The same results also obtain when daily average hormone levels or changes are included as regressors in a linear probability model (this is also true for the ability and overestimation hypotheses).

[27]See for example the above-mentioned Hampson and Kimura (1992) and Maki et al. (2002). Epting and Overman (1998), on the other hand, find no performance fluctuations using a wide array of cognitive tasks.

[28]The Kruskal-Wallis test returns a p-value of 0.83 for the null of no variation in arithmetic performance over the menstrual cycle and of 0.10 for the difference between the pill-break and the pill-intake phase.

Table 6: The Effect of Performance in the Arithmetics Task on Competitiveness

Competitiveness	(1)	(2)	(3)
Mean Score (Rounds 1 and 2)	0.004	0.011	0.007
	(0.013)	(0.013)	(0.011)
Controls	no	yes	yes
Controls for cycle and contraceptives	no	no	yes
Observations	107	107	107
R-squared	0.001	0.186	0.295

from rounds one and two on the likelihood of competing in round three is both insignificant and negligibly small.[29]

6.3 Overconfidence

Niederle and Vesterlund (2007) find that (over)confidence plays a significant but limited role in explaining whether an individual chooses to compete and that men are significantly more overconfident than women. We will therefore test the hypothesis that the gender gap in overconfidence is related to differences in the hormonal balance and that this could be a mechanism by which the menstrual cycle and hormonal contraceptives affect competitiveness.

We use the beliefs of the subjects about their own rank in rounds one and two of the arithmetics task in order to test this hypothesis. We find some evidence that differences in confidence are related to tournament entry. Subjects are clearly overestimating their own performance in the round two tournament: 67 percent believe to be either first or second amongst their group mates. Also, 41 percent of subjects overestimate their rank while only 21 percent underestimate their relative performance. A one-sided t-test indicates that individuals who believe that they are amongst the two best in their group in round two (the tournament round) are 16 percent more likely to enter the tournament in round three (p=0.06) and that subjects who overestimate their performance in round two are 13 percent more likely to compete (p=0.10) than the rest. The coefficients on the confidence measure in Columns (3) and (6) of Table 4 are even larger.[30]

[29]Other measures of performance yield the same result when added as regressors (regression results are not reported): scores from round two only and group ranks in rounds one and two are not significant in any specification when used to replace actual performance. The same is true for dummies indicating an individual was the best or amongst the two best of his group. The Kruskal-Wallis p-values for equality in competitiveness across individuals of differing group ranks are 0.74 for round one ranks and 0.62 for round two ranks.

[30]No such effects can be found for overconfidence and beliefs concerning performance in round one (the piece-

But two ANCOVA models with demographic controls make clear that an effect of the menstrual cycle and hormonal contraceptives on overconfidence cannot be a pathway by which hormonal fluctuations affect competitiveness: conditional on absolute performance in round two, neither the menstrual cycle phase dummies (p=0.69) nor the contraceptive intake dummy (p=0.80) significantly affect the belief of subjects to be amongst the two best in their group.[31]

7 Conclusions

The labour market decisions of men and women are strikingly different, especially when it comes to the competitiveness of the chosen work environment. Simply put, men seem to actively seek competition while women tend to avoid it – a fact that is corroborated by several controlled experiments in the lab. This difference is very likely one of the causes of the gender gap in wages, especially since the gender wage gap has been shown to be increasing across the wages distribution (Arulampalam et al., 2007) and thus to be highest for those positions where competition is especially fierce. It is therefore an important question whether these differences are purely a consequence of upbringing and education or whether biological differences between women and men play a role as well. Which policies we should adopt if we wish to tackle the gender imbalances in the labour market crucially depends on whether nature or nurture is at play.

Our results point towards biological differences playing an important part in explaining gender differences in competitiveness. Women are significantly less competitive both when taking contraceptives containing oestrogen and progesterone and during the parts of the natural menstrual cycle when secretion of these hormones is especially strong. This points towards fluctuations in female sex hormones being at the root of our findings. Taking advantage of the differing fluctuation patterns of oestrogen and progesterone, we show that the variations in competitiveness over the menstrual cycle are most strongly correlated with progesterone. Our findings are compatible with an evolutionary explanation according to which competitiveness is less desirable during the infertile phase of the menstrual cycle and during pregnancy, when hormone levels are high, than during the fertile phase, when they are low. The hormonal effects are strong enough to explain a substantial part of the gender gap in competitiveness observed in previous lab experiments. We also find that the impact of the menstrual cycle and hormonal contraceptives on competitiveness is mediated neither by an effect of sex hormones on risk aversion, nor by an effect on overconfidence or performance.

rate task).

[31] Results do not change when not controlling for round two performance or when overestimation of rank is the outcome variable. These results are confirmed by non-parametric test results. The Kruskal-Wallis p-values for the null of no variation over the menstrual cycle are 0.59 for the belief of being amongst the top two of one's group and 0.51 for the likelihood of overestimating one's rank. The picture is the same for variation caused by hormonal contraceptives with p-values of 0.34 and 0.55 respectively.

This shows that next to the cultural factors identified by Gneezy et al. (2008) amongst others, biological factors play an important role in explaining gender differences in competitiveness. An interesting direction for future research could be to directly measure the concentration of hormones in the body of subjects by taking blood or urine samples. Closer attention to progesterone seems particularly warranted. This hormone has so far been largely ignored in the literature on the effects of hormones on economic decision making but our results suggest the possibility that it could play an important role in explaining gender differences in competitiveness and possibly other areas as well. The results of Apicella et al. (2009) notwithstanding, future experiments could also take a closer look at the link between testosterone and competitiveness. Sapienza et al. (2009) find that testosterone levels influence career choice and conclude that this effect works through an impact on risk preferences. Given our results, it is plausible that an effect of testosterone on competitiveness could be another pathway by which testosterone levels are correlated with career decisions. Further research into the exact mechanisms underlying the hormonal effects on competitiveness also seems warranted. This includes the open question of whether it is the preferences of individuals or rather their perceptions of competitive situations which are influenced by hormones.

References

Alexander, Gerianne M., Barbara B. Sherwin, John Bancroft, and David W. Davidson, "Testosterone and sexual behavior in oral contraceptive users and nonusers: A prospective study.," *Hormones and Behavior*, 1990, *24* (3), 388–402.

Apicella, Coren L., Anna Dreber, Benjamin Campbell, Peter B. Gray, Moshe Hoffman, and Anthony C. Little, "Testosterone and financial risk preferences," *Evolution and Human Behavior*, 2008, *29*, 384–390.

_ , _ , Peter B. Gray, Moshe Hoffman, Anthony C. Little, and Benjamin C. Campbell, "The role of androgens on competitiveness in men," unpublished manuscript, Institute for Financial Research (SIFR) 2009.

Arulampalam, Wiji, Alison L. Booth, and Mark L. Bryan, "Is There a Glass Ceiling over Europe? Exploring the Gender Pay Gap across the Wage Distribution," *Industrial and Labor Relations Review*, 2007, *60* (2), 163–186.

Bancroft, John, Diana Sanders, David Davidson, and Pamela Warner, "Mood, Sexuality, Hormones, and the Menstrual Cycle. III. Sexuality and the Role of Androgens.," *Psychosomatic Medicine*, 1983, *45* (6), 509–516.

Bäckström, Torbjorn, Diana Sanders, Rosemary Leask, David Davidson, Pamela Warner, and John Bancroft, "Mood, sexuality, hormones, and the menstrual cycle. Hormone levels and their relationship to the premenstrual syndrome.," *Psychosomatic Medicine*, 1983, *45* (6), 503–507.

Bellis, Mark A. and R. Robin Baker, "Do females promote sperm competition? Data for humans.," *Animal Behaviour*, 1990, *40* (5), 997–999.

Bertrand, Marianne and Kevin F. Hallock, "The Gender gap in top corporate jobs," *Industrial and Labor Relations Review*, 2001, *55* (1), 3–21.

Bitran, Daniel, Robert H. Purdy, and Carol K. Kellog, "Anxiolytic effect of progesterone is associated with increases in cortical alloprenanolone and GABAA receptor function.," *Pharmacology Biochemistry and Behavior*, 1993, *45* (2), 423–428.

Booth, Alison L. and Patrick J. Nolen, "Choosing to Compete: How Different Are Girls and Boys?," IZA Discussion Papers 4027, Institute for the Study of Labor (IZA) 2009.

_ and _ , "Gender Differences in Risk Behaviour: Does Nurture Matter?," IZA Discussion Papers 4026, Institute for the Study of Labor (IZA) 2009.

Burnham, Terence C., "High-testosterone men reject low ultimatum game offers.," *Proceedings of the Royal Society*, 2007, *274*, 2327–2330.

Campbell, Anne, *A mind of her own: the evolutionary psychology of women*, Oxford University Press, 2002.

Chabbert Buffet, N., C. Djakoure, S. Christin Maitre, and P. Bouchard, "Regulation of the Human Menstrual Cycle," *Frontiers in Neuroendocrinology*, 1998, *19* (3), 151–186.

Chavanne, Tara J. and Gordon G. Gallup Jr, "Variation in Risk Taking Behavior Among Female College Students as a Function of the Menstrual Cycle.," *Evolution and Human Behavior*, 1998, *19* (1), 27–32.

Chen, Yan, Peter Katuscak, and Emre Ozdenoren, "Why Can't a Woman Bid More Like a Man?," 2009.

Croson, Rachel and Uri Gneezy, "Gender differences in preferences," *Journal of Economic Literature*, 2009, *47* (2), 448–74.

de Wit, Harriet, Laura Schmitt, Robert Purdy, and Richard Hauger, "Effects of acute progesterone administration in healthy postmenopausal women and normally-cycling women.," *Psychoneuroendocrinology*, 2001, *26* (7), 697–710.

Eckel, Catherine C. and Philip J. Grossman, "Sex Differences and Statistical Stereotyping in Attitudes toward Financial Risk.," *Evolution and Human Behavior*, 2002, *23* (4), 281–95.

Elstein, Max, P. G. Briston, M. Jenkins, D. Kirk, and H. Miller, "Effects of a Low-oestrogen Oral Contraceptive on Urinary Excretion of Luteinizing Hormone and Ovarian Steroids," *British Medical Journal*, 1974, *1* (5896), 11–13.

Epting, L. Kimberly and William H. Overman, "Sex-sensitive tasks in men and women: a search for performance fluctuations across the Menstrual Cycle," *Behavioral Neuroscience*, 1998, *112* (6), 1304–1317.

Fehr, Ernst, "On The Economics and Biology of Trust," *Journal of the European Economic Association*, 2009, *7* (2-3), 235–266.

Fischbacher, Urs, "z-Tree: Zurich toolbox for ready-made economic experiments," *Experimental Economics*, 2007, *10* (2), 171–178.

Friess, E., H. Tagaya, L. Trachsel, F. Holsboer, and R. Rupprecht, "Progesterone-induced changes in sleep in male subjects.," *American Journal of Physiology - Endocrinology And Metabolism*, 1997, *272* (5), 885–891.

Frye, Cheryl A. and Jennifer E. Duncan, "Progesterone metabolites, effective at the GABAA receptor complex, attenuate pain sensitivity in rats.," *Brain Research*, 1994, *643* (1-2), 194–203.

Gneezy, Uri, Kenneth L. Leonard, and John A. List, "Gender Differences in Competition: Evidence from a Matrilineal and a Patriarchal Society," NBER Working Papers, National Bureau of Economic Research 2008.

_ , Muriel Niederle, and Aldo Rustichini, "Performance In Competitive Environments: Gender Differences," *The Quarterly Journal of Economics*, 2003, *118* (3), 1049–1074.

Gong, Elizabeth J., Dominique Garrel, and Doris Howes Calloway, "Menstrual cycle and voluntary food intake," *American Journal of Clinical Nutrition*, 1989, *49*, 252–258.

Gupta, Nabanita Datta, Anders Poulsen, and Marie-Claire Villeval, "Male and Female Competitive Behavior: Experimental Evidence," IZA Discussion Papers 1833, Institute for the Study of Labor (IZA) 2005.

Hampson, Elizabeth and Doreen Kimura, "Sex Differences and Hormonal Influences on Cognitive Function in Humans," in Jill B. Becker, S. Marc Breedlove, and David Crews, eds., *Behavioral Endocrinology*, MIT Press, 1992, pp. 357–398.

_ and Elizabeth A. Young, "Methodological issues in the study of hormone-behavior relations in humans: Understanding and monitoring the menstrual cycle," in Jill B. Becker, Karen J. Berkley, Nori Geary, Elizabeth Hampson, James P. Herman, and Elizabeth Young, eds., *Sex differences in the brain. From genes to behavior.*, Oxford University Press, 2008, pp. 63–78.

Holt, Charles A. and Susan K. Laury, "Risk Aversion and Incentive Effects," *American Economic Review*, 2002, *92* (5), 1644–1655.

Jones, B.C., A.C. Little, L. Boothroyd, L.M. DeBruine, D.R. Feinberg, M.J. Law Smith, R.E. Cornwell, F.R. Moore, and D.I. Perrett, "Commitment to relationships and preferences for femininity and apparent health in faces are strongest on days of the menstrual cycle when progesterone level is high," *Hormones and Behavior*, 2005, *48* (3), 283–290.

Kol, Shahar and Roy Homburg, "Change, change, change: hormonal actions depend on changes in blood levels.," *Human Reproduction*, 2008, *23* (5), 1004–1006.

Kosfeld, Michael, Markus Heinrichs, Paul J. Zak, Urs Fischbacher, and Ernst Fehr, "Oxytocin increases trust in humans.," *Nature*, 2005, *435* (2), 673–676.

Kuhnz, Wilhelm, Karl-Heinrich Fritzemeier, Christa Hegele-Hartung, and Rolf Krattenmacher, "Comparative Progestational Activity of Norgestimate, Levonorgestrel-Oxime and Levonorgestrel in the Rat and Binding of these Compounds to the Progesterone Receptor.," *Contraception*, 1995, (51), 131–139.

Maki, Pauline M., Jill B. Rich, and R. Shayna Rosenbaum, "Implicit memory varies across the menstrual cycle: estrogen effects in young women," *Neuropsychologia*, 2002, *40*, 518–529.

Mansour, Diana, "Use of the new progestogens in contraception and gynaecology.," *The Obstetrician & Gynaecologist*, 2006, (8), 229–234.

Möller-Nielsen, Jesper and Mats Hammar, "Women's soccer injuries in relation to the menstrual cycle and oral contraceptive use.," *Medicine & Science in Sports & Exercise*, 1989, *21* (2), 126–129.

Muhn, Peter, Rolf Krattenmacher, Sybille Beier, Walter Elger, and Ekkehard Schillinger, "Drospirenone: A Novel Progestogen with Antimineralocorticoid and Antiandrogenic Activity. Pharmacological Characterization in Animal Models.," *Contraception*, 1995, (51), 99–110.

Niederle, Muriel and Lise Vesterlund, "Do Women Shy Away from Competition? Do Men Compete Too Much?," *The Quarterly Journal of Economics*, 2007, *122* (3), 1067–1101.

Owen, John A., "Physiology of the menstrual cycle.," *American Journal of Clinical Nutrition*, 1975, *28*, 333–338.

Pearson, Matthew and Burkhard C Schipper, "Menstrual cycle and competitive bidding," Technical Report 16784, University Library of Munich, Germany 2009.

Penton-Voak, I. S. and D. I. Perrett, "Female preference for male faces changes cyclically: Further evidence.," *Evolution and Human Behavior*, 2000, *21* (1), 39–48.

_ , _ , D. L. Castles, T. Kobayashi, D. M. Burr, L. K. Murray, and R. Minamisawa, "Menstrual cycle alters face preference," *Nature*, 1999, (6738), 741–742.

Persky, Harold, Harold I. Lief, Dorothy Strauss, William R. Miller, and Charles P. O'Brien, "Plasma Testosterone Level and Sexual Behavior of Couples.," *Archives of Sexual Behavior*, 1978, *7* (3), 157–173.

Phillips, Susana M. and Barbara B. Sherwin, "Variations in memory function and sex steroid hormones across the menstrual cycle.," *Psychoneuroendocrinology*, 1992, *17* (5), 497–506.

Picazo, O. and A. Fernandez-Guasti, "Anti-anxiety effects of progesterone and some of its reduced metabolites: an evaluation using the burying behavior test.," *Brain Research*, 1995, *620* (1-2), 135–141.

Powell, Melanie and David Ansic, "Gender differences in risk behaviour in financial decision-making: An experimental analysis," *Journal of Economic Psychology*, 1997, *18* (6), 605–628.

Richardson, John T.E., "The Menstrual Cycle, Cognition, and Paramenstrual Symptomatology," in John T.E. Richardson, ed., *Cognition and the Menstrual Cycle*, Springer-Verlag, 1992.

Rivera, Roberto, Irene Yacobson, and David Grimes, "The mechanism of action of hormonal contraceptives and intrauterine contraceptive devices.," *American Journal of Obstetrics & Gynecology*, 1999, *181*, 1263–1269.

Sapienza, Paola, Luigi Zingales, and Dario Maestripieri, "Gender differences in financial risk aversion and career choices are affected by testosterone," *Proceedings of the National Academy of Sciences*, 2009.

Schumacher, Michael, Hector Coirini, Donald W. Pfaff, and Bruce S. McEwen, "Behavioral Effects of Progesterone Associated with Rapid Modulation of Oxytocin Receptors.," *Science*, 1990, *50* (2), 691–694.

Söderpalm, Anna H. V., Sommer Lindsey, Robert H. Purdy, Richard Hauger, and Harriet de Wit, "Administration of progesterone produces mild sedative-like effects in men and women.," *Psychoneuroendocrinology*, 2004, *29* (3), 339–354.

Stanczyk, Frank Z., Masahiko Hiroi, Uwe Goebelsmann, Paul F. Brenner, Mary E. Lumkin, and Daniel R. Mishell Jr., "Radioimmunoassay of serum d-norgestrel in women following oral and intravaginal administration," *Contraception*, 1975, *12* (3), 279 – 298.

Thornhill, Randy and Steven W. Gangestad, "The Scent of Symmetry: A Human Sex Pheromone that Signals Fitness?," *Evolution and Human Behavior*, 1999, *20* (3), 175–201.

van Broekhoven, F., T. Bäckström, and R.J. Verkesa, "Oral progesterone decreases saccadic eye velocity and increases sedation in women.," *Psychoneuroendocrinology*, 2006, pp. 1190–1199.

Wilcox, A.J., Donna Day Baird, David B. Dunson, D. Robert McConnaughey, James S. Kesner, and Clarice R. Weinberg, "On the frequency of intercourse around ovulation: evidence for biological influences," *Hum. Reprod.*, 2004, *19* (7), 1539–1543.

Wilcox, Allen J., Clarice R. Weinberg, and Donna D. Baird, "Timing of Sexual Intercourse in Relation to Ovulation – Effects on the Probability of Conception, Survival of the Pregnancy, and Sex of the Baby," *New England Journal of Medicine*, 1995, *333* (23), 1517–1521.

Wozniak, David, "Choices About Competition:Differences by gender and hormonal uctuations, and the role of relative performance feedback," unpublished manuscript, University of Oregon 2009.

Zethraeus, Niklas, Ljiljana Kocoska-Maras, Tore Ellingsen, Bo von Schoultz, Angelica Linden Hirschberg, and Magnus Johannesson, "A randomized trial of the effect of estrogen and testosterone on economic behavior," *PNAS*, 2009, *106*, 6535–6538.