Female physiology meets psychology

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Menstrual cycle and contraceptive pill effects

Kelly Denise Cobey

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Chapter 1

General Introduction

There is convergent evidence for shifts in female psychology across the menstrual cycle. Specifically, women have been shown to display distinct shifts in their preferences and behaviour as they transition from fertile to non-fertile cycle phases (reviewed in Gangestad & Thornhill, 2008). Such shifts correspond to fluctuations in levels of naturally occurring hormones. However, the use of hormonal contraceptives (henceforth HC's), which is indeed widespread, is known to modify hormone levels. I will argue that, because HC's suppress normal hormonal fluctuation, their use disrupts natural female preferences and behaviours which occur across the menstrual cycle. In doing so, I will provide indication which suggests that this disruption may have psychological consequences for the dynamics of actual relationships.

The HC pill is the most widely studied form of medication in the world (Hather et al., 2007). There is, without question, a valuable body of existing research on the impact of HC use. However, to date much of this research has focused on the physical risk factors associated with use (for reviews see for example Smith et al., 2003, cervical cancer; Vandenbroucke et al., 2001, venous thrombosis; Martins et al., 2006, bone health) or on the social political influence that the introduction of reliable and reversible contraception has had on the role of women within society (e.g., Goldin & Katz, 2002). It is no surprise that such vital and immediately relevant topics have received so much attention. However, remarkably relatively few studies have examined the psychological effects associated with HC use. Examining how the use of HC's impacts behaviour in social relationships may contribute to women's ability to make more informed decisions to use HC's.

I approached the study of HC effects on female psychology from an evolutionary psychology perspective. Evolutionary psychology attempts to study human behaviour from an adaptive perspective. Evolution by natural selection is the source through which all physiological systems are structured. Consequently, evolutionary psychology uses a selectionist approach which considers how traits may help an organism to survive and/or reproduce. The use of an evolutionary approach

provided pertinent theoretical insights into what behavioural changes one might expect to see as a result of HC use. Research in this area conducted without thought for how and why traits evolve would lead to uninformed functional theorizing which in turn would generate fruitless scientific theories (Daly & Wilson, 1999).

In the subsequent sections of this introduction I will present an overview of the physiology of the female menstrual cycle and describe the pattern of psychological changes known to occur at fertile versus non-fertile cycle stages. I will then outline the history of HC's and their method of action. Together, these sections aim to provide readers with a basic foundation of medical and consumer expectations of HC's. Finally, I will briefly summarize the current psychological literature on HC effects before concluding with an outline of the empirical chapters contained within this thesis.

Physiology of the female reproductive cycle

The female reproductive cycle, commonly referred to as the menstrual cycle, lasts approximately one month and results in changes to a woman's ovaries and uterus. Among Dutch women the onset of the menstrual cycle, known as menarche, takes place at approximately age 13 (e.g., a median of 13.15 years was reported Mul et al., 2001). However, age at menarche among the Dutch has been shown to be influenced by additional factors including height and body mass index (BMI) (Mul et al., 2001). Other research has shown that age at menarche varies as a function of a number of other variables including nutritional status (Tena-Sempere, 2008), ethnicity (Wu et al., 2001) and geography (Morabia et al., 1998).

Broadly speaking, changes occurring at the ovaries during the reproductive cycle can be divided into three main stages: the follicular phase, the ovulatory phase and the luteal phase. The length of the reproductive cycle varies between women. An average of 28 days is typical (e.g., Cole et al., 2009 report an average cycle length

of 27.7 days ± 2.4 days), however anywhere between 21 to 45 days is considered normal (Hornstein & Schwerin, 2013)[1].

At the start of the reproductive cycle, during the follicular phase, due to an increasing level of the gonadotropin follicle-stimulating hormone (FSH) several follicles will begin to grow. Growing follicles produce estrogen. Typically, one follicle will grow at a faster rate than the others. This follicle is known as the "dominant follicle" as it produces more estrogen than the smaller competing follicles (Mihm & Evans, 2008). The production of estrogen from the dominant follicle, in combination with high existing levels of FSH triggers the development of luteinizing hormone (LH) binding sites. Concurrently, the dominant follicle develops an antrum and becomes a mature secondary follicle. When this occurs, inhibin, a peptide hormone, is secreted which suppresses previous FSH secretion from the pituitary gland. In the absence of high FSH the smaller competing follicles soon die off. This process ensures that only one follicle matures in a given month (Hornstein & Schwerin, 2013)[2].

The dominant follicle then produces increasing levels of estrogen in an accelerated fashion, creating a further increase in LH binding sites, which in turn, through a positive feedback loop with the pituitary gland, increases levels of LH. Mid-cycle estrogen surges resulting in a corresponding surge in LH and FSH (See Figure 1 and Figure 2). It is at this time that ovulation, the discharge of the ovum from the ovary, occurs. In an average cycle ovulation occurs around day 14. After ovulation, during the luteal cycle phase, the granulosa cells (the inner layer of the follicle) left behind begin to secrete progesterone and some estrogen, and through a series of metabolic

[1] Variation in cycle length between women can occur as a result of numerous factors that influence hormone levels such as differences in age or weight, or social environmental factors such as stress levels and smoking (Harlow & Matanoski, 1991; Rowland et al., 2002).

[2] In rare cases when two or more follicles develop the possibility for multiple births occurs (e.g., fraternal twins).

changes become the corpus luteum. The corpus luteum continues to secrete estrogen and progesterone. While this is occurring FSH and LH drop dramatically. Typically around day 21 the corpus luteum begins to degenerate causing a sudden drop in estrogen and progesterone hormones. These processes cause the endometrium, a mucus lining of the uterus, to shed. This shedding, termed menses, or more commonly, the menstrual period, results in the flow roughly 50 ml of blood and tissue from the uterine cavity out of the vagina. A typical menses lasts two to seven days. In the absence of negative feedback loops with estrogen and progesterone (due to cyclical changes in the ovary), FSH and LH begin to increase and a new cycle starts (Hornstein & Schwerin, 2013). The female reproductive cycle re-occurs from menarche until menopause and marks the reproductive period in a woman's life.

Importantly, conception is only possible during specific stages of the reproductive cycle. Conception risk is the highest just prior to ovulation in the late follicular phase. The LH surge is typically used as an indicator of the fertile phase, since LH levels increase dramatically just prior to ovulation. For example, ovulatory detection kits, used by women trying to get pregnant, work through measuring LH levels in the urine (e.g., Nielsen et al., 2001). With the exception of the brief window of time between the LH surge and ovulation, throughout the rest of the menstrual cycle a woman's conception risk is extremely low.

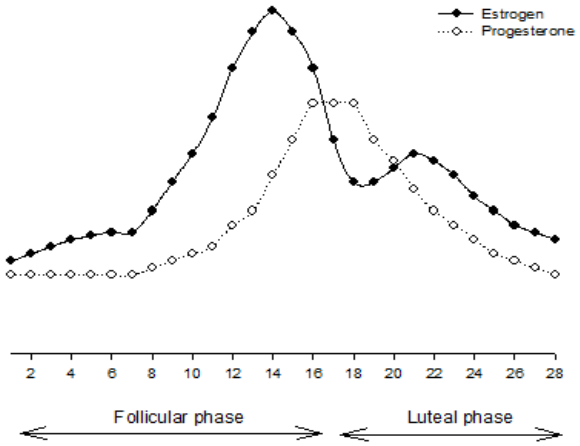


Figure 1. Pattern of hormone blood levels of estrogen (filled) and progesterone (empty) across a typical 28-day menstrual cycle. Estrogen peaks mid-cycle around day 14 when ovulation generally occurs.

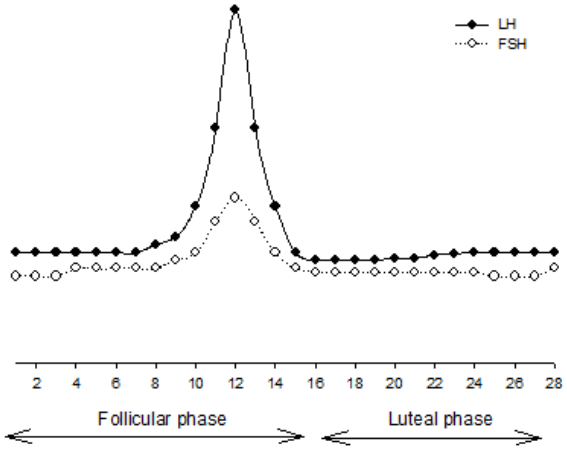


Figure 2. Level of gonadotropic hormones of FSH (empty) and LH (filled) across a typical 28-day menstrual cycle. Both LH and FSH peak mid-cycle.

Evolutionary psychology and the reproductive cycle

To begin this section, for clarity, I will explicitly outline key terminology pertinent to this discussion. Herein, I will use the term *fitness* to refer to the ability of an organism to survive and reproduce offspring into the next generation. The term *adaptation* will be used to describe a trait which helps an organism to enhance its fitness. An adaptation is therefore a trait which by virtue of its presence provides an organism with a survival advantage or enables it to reproduce healthy offspring at a higher rate than it otherwise would in the absence of the trait. The term *costly trait* refers to a feature which requires a lot of energy or time to maintain and in some way enhances the possessors fitness. Finally, *'good gene traits'* refer to costly traits which may signal underlying health (Folstad & Karter, 1992).

Recall from the previous section on the physiology of the female reproductive cycle that fertility only occurs during a brief window each month just prior to ovulation. At this time, in a range of species, females undergo overt physical changes that clearly signal their conception risk. This phenomenon is known as *oestrus*. For example, chimps and baboons display prominent sexual swellings when fertile (Dixson, 1983). Moreover, the actual quality of these sexual swellings has been shown to directly correlate with fitness outcomes, clearly indicating their value as honest cues of health and reproductive potential (Domb & Pagel, 2001). For many years human behavioural ecologists assumed that changes akin to these did not exist among human females (e.g., Etkin, 1964; Jolly, 1972; Alexander & Noonan, 1979; Burley, 1979; Spuhler, 1979; Symons, 1979). This conclusion was asserted based on the fact that women are sexually receptive throughout the entire cycle. That is, in humans sex is not restricted to phases of high fertility where conception is possible.

However, in the past 15 years a growing body of evidence has disproven this idea. The *ovulatory shift hypothesis*, which was first proposed by Gangestad and Thornhill (1998; 2008), argues that women undergo systematic shifts in mating psychology across the reproductive cycle in relation to conception risk. That is, they

argued that women display a *dual sexuality* akin to *oestrus* in which female preferences and behaviours diverge in stages of high and low fertility. Gangestad and Thornhill (2008) stress that while women are receptive to sex throughout the cycle (known as extended sexuality) they exhibit distinct differences in mating related psychology when fertile. *Dual sexuality* is argued to function adaptively to enhance female fitness similarly to *oestrus* changes which occur in a number of non-human species (e.g., chimpanzees; Spritzer et al., 2005).

Prior to elaborating on *dual sexuality*, a basic understanding of sex differences in reproductive investment is necessary. The small size and cheap cost of producing male sperm, relative to the large size and cost of producing female follicles, means that fewer females to males are able to reproduce at any given time. Accordingly, while each successive mating has the potential to increase male reproductive fitness, this is not true to the same extent for females (Bateman, 1948). This results in sex differences in 'choosiness' and fitness benefits with respect to engaging in sexual relationships. A full discussion of these differences is beyond the scope of this thesis. Most simply stated, based on the notion that women are the 'limiting factor' for reproduction and that males differ in their genetic quality, it makes little sense for women to indiscriminately mate with males. Thus women are selective in their mate choice and consider what benefits they can achieve from their partners. Broadly speaking, benefits can be direct or indirect. Direct benefits may come in the form of parental care, resource provisioning, and protection from parasites (given that men who are able to display costly traits are more likely to have lower parasite loads). Obtaining direct benefits has an immediate effect on reproductive fitness and is relevant to women throughout the cycle. Indirect benefits are acquired by pairing with males who have costly traits indicative of good genes. Indirect benefits come in the form of offspring health and survival. That is, females can benefit from mating with men who possess costly traits because the underlying good genes required to display costly traits will be inherited by any subsequent offspring. Women can therefore make use of phenotypic traits believed to signal underlying good genes to be discriminating their mate choice (Roberts & Little, 2008).

However, the potential value in acquiring indirect benefits varies across the cycle with conception risk. That is, the only time that pairing with an individual with good genes can provide indirect benefits is when conception is possible. Thus, a cycle-contingent shift in mating preferences for indicators of good genes would be adaptive. This is particularly true given that men with indicators of good genes have been shown to be less likely than other men to provide investment (e.g., Gangestad & Simpson, 2000) and are more sexually promiscuous (Boothroyd et al., 2008). This suggests that men who offer indirect benefits tend not to provide direct benefits. Of course, I acknowledge, the two need not be mutually exclusive.

Based on these differential benefits, the *ovulatory shift hypothesis* argues that phases of fertility should therefore not be characterized as times of generalized sexual motivation or excitement, but rather as times of increased sexual motivation and excitement to specific male traits associated with good genes (Gangestad & Thornhill, 2008). The *ovulatory shift hypothesis* also argues that women's increased fertile phase preference for these good genes should be specific to short-term, but not long-term, mating contexts (Gangestad & Thornhill, 1998). Research shows, for example, that when fertile, as compared to non-fertile, women demonstrate an increased preference for masculinity. This is considered adaptive because masculinity is thought to be a costly trait (Folstad & Karter, 1992). For example, when fertile women show increased preference for masculinity in male faces (e.g., Penton-Voak et al., 1999; Penton-Voak & Perrett, 2000; Johnston et al., 2001; Jones et al., 2005; Welling et al., 2007; Little & Jones, 2012), bodies (Little et al., 2007a; Gangestad et al., 2007), voices (e.g., Puts, 2005; Feinberg et al., 2006) and scents (e.g., Havlíček et al., 2005). Apart from physical preference shifts, research has also shown that near to ovulation women prefer greater degrees of behavioural masculinity. For example, women have been shown to prefer men who display greater levels of intrasexual (same-sex) competition and social presence more during fertile relative to non-fertile cycle stages (Gangestad et al., 2004).

Low levels of fluctuating asymmetry are likewise considered to be an indicator of good genes which reflect underlying quality, or at the very least, developmental stability. Findings related to symmetry preferences across the reproductive cycle are consistent with those with respect to masculinity: increased preference for symmetry as assessed in faces (e.g., Little et al., 2007b, but see also Koehler et al., 2002; Koehler et al., 2006), bodies (Thornhill et al., 2003) and from scent (e.g., Gangestad and Thornhill, 1998; Thornhill & Gagestad, 1999; Rikowski & Grammer, 1999; Thornhill et al., 2003) has been found during fertile cycle phases. In addition to these traits, studies have shown that a limited number of good gene indicators believed to be related to mental fitness are preferred more by women when fertile as compared to when non-fertile. One example includes creative intelligence (Haselton & Miller, 2006).

A woman's ability to attract a male partner also varies with her conception risk. For example, female faces (Roberts et al., 2004; Bobst & Lobmaier, 2012) and voices (Bryant & Haselton, 2009; Pipitone & Gallup, 2008) are judged to be more attractive during fertile relative to non-fertile cycle stages. Similarly, men have been shown to rate scents of women in the fertile stage of the cycle as least intense and most attractive (Singh & Bronstad, 2001; Thornhill et al., 2003; Kuukasjärvi et al., 2004; Havlíček et al., 2006; Gildersleeve et al., 2012). A variety of other features which are known to be important markers of attractiveness are also enhanced during fertility, for example, women become more symmetrical (Manning et al., 1996), have lower waist-to-hip ratios (Kirchengast & Gartner, 2002) and more appealing gaits (Gueguen, 2012). Preliminary evidence exists which suggests that, at least to some degree, women are cognizant of their increased physical attractiveness: women report greater self-perceived attractiveness or feelings of 'sexiness' when fertile as compared to when non-fertile (Haselton & Gangestad, 2006). However, this finding is made somewhat less clear when one considers research by Hill and Durante (2008) that shows that female self-esteem decreases when fertile.

Shifts in self-perception, whether conscious or not, could however explain the finding that women's behaviour also varies as a function of fertility. For example, women are known to dress more attractively when fertile as compared to non-fertile (e.g., Grammer et al., 2004; Haselton et al., 2007; Durante, Li & Haselton, 2008). Likewise research tracking female product use and spending has shown that women are more likely to use appearance enhancing products when fertile (Durante et al., 2011; Saad & Stenstrom, 2012). Interestingly, at the same time as they focus increased effort on physical appearance, women also report increased desire to visit social venues such as nightclubs (Haselton & Gangestad, 2006). Frequenting social venues may place women at increased odds of meeting new men, which is consistent with that they are more interested in extra-pair men when fertile. For example, women are more likely to accept a courtship solicitation from a male when fertile (Geugeun, 2009). This is in line with other findings which show that women experience greater sexual desire and fantasies when fertile (Bullivant et al., 2004), and that, among women in a relationship, these fantasies are directed towards extra-pair mates rather than the primary partner (Gangestad, Thornhill & Garver, 2002). Perhaps the most compelling support for the notion that cyclical changes in female preferences and behaviour function adaptively to obtain fitness benefits is found in research which shows that extra-pair sexual desire when fertile is particularly strong when a woman perceives her primary partner to lack indicators of genetic quality such as symmetry (Gangestad, Thornhill & Garver-Apgar, 2005) or physical attractiveness (Haselton & Gangestad, 2006; Pillsworth & Haselton, 2006). This implies that, when fertile, changes in a woman's own physical attractiveness and altered preferences for features in men, motivates increased behavioural attention to mating-relevant stimuli particularly in instances when a woman is not already paired with a man she perceives to have costly good gene traits.

The aforementioned fertile phase shifts in mate preferences, attractiveness and social behaviour beg the question of whether or not such changes are noticeable outside of the laboratory to social or romantic partners (Cobey & Buunk, 2012). To

date this possibility has been approached from two perspectives. In one line of research investigators have been testing the influence of fertility status on female-female relationships. Since women vary in their quality, it is possible that fertile phases of the cycle are associated with increased female-female competition. A study by Fisher (2004) has indeed shown that women are more likely to derogate the faces of female competitors when fertile as compared to when non-fertile.[3] This may be explained by the fact that women place a greater emphasis on mating effort at this time and are therefore more salient of, and degrading to, potential rivals. Research has yet to examine variation in women's reactions to fertile versus non-fertile rivals, and this therefore provides an interesting avenue for future research. In a second line of research, the possibility that male partners may adjust their behaviour as a response to cyclical changes in female attractiveness and behaviour is being studied. Current research on this theme shows that women report increased mate guarding when fertile as compared to non-fertile (Gangestad, Thornhill & Garver, 2002). Interestingly, perceptions of partner jealousy have been shown to be enhanced in circumstances where women perceive their male partner to be low in sexual desirability (Haselton & Gangestad, 2006). A recent study using male self-reports of mate guarding has validated this idea: men self-report to be more vigilant of their partner when she is fertile as compared to non-fertile (manuscript in prep, communication with Thornhill 2012). Similarly, this study indicated that women report higher levels of self-assertive mate guarding behaviours towards their partner when fertile, while at the same time (especially when strongly attracted to extra-pair men) engaged in more behaviours which are unobservable to males that resist male vigilance or mate guarding. Miller and Maner (2010) suggested a proximate explanation for the link between female fertility status and male behaviour. These researchers showed that men exposed to the scents of fertile women maintained higher testosterone levels afterwards than men exposed to odours of women who were non-fertile. This finding may be explained in context to the challenge

[3] Note that I have been unable to replicate this finding either as a direct replication or through use of survey measures as I present in Chapter 6.

hypothesis (reviewed in Archer, 2006) which describes how testosterone helps to facilitate a trade-off between male reproductive and parenting effort. High, or increased, testosterone is associated with mating activity. Therefore, higher relative testosterone levels after exposure to fertile female odours may represent an adaptation to seek sex when female conception risk is highest. Within a committed relationship, heightened testosterone in response to fertile scent might also serve to enhance male mate guarding ability since testosterone has been implicated in male competitive behaviour. However, a more recent study by Roney & Simmons (2012) has failed to replicate the work of Miller and Maner (2010) when using a crossover design in which men were unaware of the source (e.g., gender) of the odours they smelt. This suggests that mental imagery of women may impact the findings obtained by Miller and Maner (2010), and that scent alone does not fully explain the reported effects. In other work which measured changes in male behaviour, men have been shown to increase their use of non-conforming words when conversing with a fertile as compared to a non-fertile woman. Non-conforming words are thought to be associated with creativity or intelligence and therefore considered to be potential signals of male genetic quality (Coyle & Kascak, 2012).

The aforementioned studies suggest that female fertility, while subtle, is not concealed. Instead, fertility is observable through shifts in mating preferences, increased same-sex competitive behaviour and changes in opposite sex mating behaviour. If cyclical shifts in these areas impact fitness outcomes, then use of HC's may generate presently unrecognized negative consequences. Before discussing theses potential consequences, I will briefly provide a historical overview of the development of HC's and their method of action.

History of hormonal contraception

Human females are somewhat unique in the animal kingdom in that they do not restrict sex to periods of fertility as is common in many non-human species. That is, women display an extended sexuality in which they are receptive to sex during both

fertile and non-fertile cycle stages. Women are even receptive to sex in instances where they are fertile but in which pregnancy is outwardly not desired. The prevention of pregnancy through the use of contraception is therefore, not surprisingly, an ancient practice. Women and midwives have passed on their knowledge of both hormonal and barrier methods for preventing pregnancy for centuries. For example, one of the first records of condom use by a man is from the 16th century, when an Italian physician named Gabriele Falloppio devised a linen condom that was soaked in a chemical solution and then dried prior to use. Falloppio developed this device in an effort to protect against syphilis (Collier, 2007). This may sound peculiar relative to today's techniques, but traditions of contraception were widespread, and varied a great deal, long before the invention of the condom. In 1900 BC ancient Egyptian women made vaginal suppositories from plants, honey and acacia gum to prevent pregnancy (Riddle et al., 1994), while Indian women made suppositories from animal dung of elephants or crocodiles (Skuy, 1995). Women residing in Cyrene, on the coast of Libya, who created a potion which contained the resin of a plant, *Silphium*, from the giant fennel family, which was believed to have contraceptive properties. It was used locally by women, but also exported to nearby Greece and Syria to such an extent that it became extinct by 300 BC (Riddle et al., 1994). In other areas of the world women ingested extract from prayer bead seeds to obtain contraception that was understood to last for 13 months (Iwu, 1993).

The HC pill, today's most widely used form of contraception, differs substantially from methods used historically. However, an understanding of the antiquity of HC's and contraception more generally is imperative to understand modern day HC's. The political climate during the time HC's were developed and introduced had a direct bearing upon how they were formulated and marketed. HC's were first introduced in America on May 9th, 1960; however, work began on their development many decades prior. In many respects, HC's were not solely an American invention (Marks, 2001). For example, by 1921 Ludwig Haberlandt, an Austrian physiologist, had already acknowledged from his research that it would be

possible to generate an oral contraceptive comprised of hormones (reviewed in Simmer, 1975). At the time, this notion was entirely novel. Existing methods of contraception made use of physical barriers (e.g., condoms or diaphragms) which required mechanical application at the time of sex. The idea that effective contraception could be obtained hormonally and that use could be decoupled from the act of sex was tremendously innovative. In the aftermath of the First World War Heberlandt acknowledged that families would benefit from being able to space their births and reduce family size due to severe unemployment and supply problems. By 1927, Haberlandt had conducted a number of animal studies which indicated that insertion of ovarian and placental extracts into female animals delivered contraceptive protection (Goldzieher, 1993).

From that point onward however, Haberlandt encountered great obstruction politically by colleagues who felt his desire to create a HC was both morally and ethically unsound. This resistance made it problematic for him to initiate clinical trials of his natural hormone preparation. Eventually, in the 1930's after encountering so much resistance Haberlandt registered his HC with the company G. Richter based out of Budapest, Hungary. In spite of acquiring this contract his work was still considered taboo. For example, Haberlandt was denied an academic promotion at his Catholic university. In response to his struggle with political pressures Haberlandt eventually committed suicide in 1932. Years later his drug would eventually be clinically tested (Haberlandt, 2009) and subsequent changes led to the development of the first Hungarian HC pill, Infecundin, in 1966 (Marks, 2001). In the years that followed Heberlandt's death other researchers began exploring recently developed synthetic hormones. European research groups led this chase: CIBA of Switzerland, Schering and Bohringer of Germany, Roussel of Paris and Organon of The Netherlands held a monopoly on production (Bullough, 1994). Researchers who saw the potential of using synthetic hormones to achieve reliable contraception were limited by high purchasing costs. Worse still, when researchers could obtain synthetic hormones to test in clinical trials the political climate often prohibited them from doing so. At the time, the notion of medicating healthy

women, solely for contraceptive purposes, was considered precarious[4]. The birth control pill was the first prescribed form of medicine designed to be used daily by those who were not sick (Marks, 2001).

A key political figure in the history and ultimate development of HC's was Margaret Sanger, an American nurse and activist for women's rights. Sanger befriended Katherine McCormick a wealthy educated woman who gave her the necessary financial means to pursue the development of HC's (reviewed in Burrows et al., 2012). In 1941, a break came to scientists who could not afford to purchase expensive European synthetic hormones for research. At this time Russell Marker, an American chemist at Penn State, found that the wild yam, *Dioscorea*, of Mexico could be used to create large quantities of synthetic progesterone at high rates (Marks, 2001). Following Marker's discovery, Sanger introduced McCormick to physiologist Gregory Pincus, and together with the backing of McCormick's capital they then commissioned John Rock, an obstetrician and gynaecologist, to lead the first ever HC trials with human subjects.

Eventually, G.D. Searle (where Rock was associated) became the first company to patent and market HC's in 1960. The first HC, Enovid, contained 10 mg norethynodrel and 150μg mestranol, an astonishing dose by today's standards (Edgren, 1991). Enovid had proven effective in clinical trials with 5 mg and 2.5 mg norethynodrel, but the Food and Drug Administration (FDA) originally denied approval of these lower doses for (unsubstantiated) fear of contraceptive failure (White Junod & Marks, 2002).[5] Enovid, and the HC's which followed, were initially hailed as miracle drugs. This was reflected in their rapid uptake: within five

[4] In 1933, the Dutch company Organon permitted testing of a hormonal preparation, Menformon, for mitigation of menstrual issues; however, refused to test the same product as a contraceptive (Oudshoorn, 1994).

[5] Interestingly, prior to its release as a form of HC, Enovid had been in use for nearly 3 years by over nearly half a million American women as a prescription used to treat irregular menstrual cycles (White Junod & Marks, 2002).

years of their launch over 11 million women worldwide were using the pill (Guttmacher, 1966). HC's transformed the way women viewed sex, freeing them of fears of pregnancy while allowing them to pursue education and careers. Supporters of HC's also claimed they strengthened marriages through enabling sexual activity in the absence of the fear of pregnancy and the subsequent financial and emotional burden of raising an unwanted child. In the early 1960's women began asking their doctors for HC's to treat what they viewed as a medical problem (conceiving a child). This practice was unusual for doctors, who at the time, were used to first diagnosing and then dictating to patients what prescriptions they would take. It also revolutionized who had control of contraception. Previously, the responsibility fell on men to consider contraception through use of condoms or the rhythm method. HC's allowed women full control over their bodies, and could be used in the absence of one's partner (Marks, 2001).

In spite of the initial positive appraisal, the introduction and use of HC's was soon plagued with controversy. Initial possibilities of potential ties to thrombosis and to cancers were prominent and needed to be addressed urgently in further research (e.g., Donayre & Pincus, 1965; Neistadt et al., 1966; Gruenstein et al., 1964; Welshe & Meites, 1969). Still, many women were willing to risk these serious medical complications to avoid pregnancy. Coupled with the potential physical risks, the Catholic Church had deemed use of the pill immoral and against the will of God: "The moment has not come for man to entrust to his reason and his will, rather than to the biological rhythms of his organisms, the task of regulating birth" (Text of Humanae Vitae; Pope Paul VI, 1968). Opponents of HC's also claimed use would generate increased promiscuity which they then feared could destroy the traditional family structure. It is worthwhile to note, contrary to the popular belief held by many, the sexual revolution of the 1960's that followed the introduction of HC's, cannot be explained due to the emergence of reliable contraception[6]. This is

[6] 'The Woodstock Generation' of the 1960's which is commonly associated with sexual openness can thus not be explained by access to reliable hormonal contraception.

because, in the years following the introduction of HC's it was prescribed solely to married women and thus not available to young single women (Marks, 2001). In spite of this, the view that the introduction of HC's resulted in sexual liberalism was (and remains) common. Perhaps, in fact, the relationship may be reversed: while the introduction of HC's coincided with the sexual revolution, the liberalization of attitudes which occurred proceeding the 1960's may have been necessary to see their development and the subsequent marketing. In 1953, The Kinsey Institute reported that over half of unmarried women had reported having (vaginal) sex - it seems, given this information, that the sexual revolution was well underway by the time that HC's were introduced in 1960 (Kinsey et al., 1953). The sexual revolution may also be explained by other factors, including, for example, the uneven sex ratio after the war (e.g., Hesketh & Xing, 2006). The benefits afforded to married women who used newly introduced HC's are highlighted in a 1975 song sung by the country music singer Loretta Lynn entitled 'The Pill' seen below.

You wined me and dined me when I was your girl
Promised if I`d be your wife you`d show me the world
But all I`ve seen of this old world is a bed and a doctor bill
I`m tearing down your brooder house `cause now I`ve got the pill

All these years I`ve stayed at home while you had all your fun
And every year that`s gone by another baby`s come
There`s gonna be some changes made right here on Nursery Hill
You`ve set this chicken your last time `cause now I`ve got the pill

This old maternity dress I`ve got is going in the garbage
The clothes I`m wearing from now on won`t take up so much yardage
Miniskirts hotpants and a few little fancy frills
Yeah I`m making up for all those years since I`ve got the pill

I`m tired of all your crowing how you and your hens play
While holding a couple in my arms another`s on the way
This chicken`s done tore up her nest and I`m ready to make a deal
And you can`t afford to turn it down `cause you know I`ve got the pill

This incubator is overused because you`ve kept it filled
The feeling good comes easy now since I`ve got the pill
It`s getting dark it`s roosting time tonight`s too good to be real
Aw but Daddy don`t you worry none `cause Mama`s got the pill
Oh Daddy don`t you worry none `cause Mama`s got the pill

Interestingly, this song helped to access hard to reach populations of rural women in North America, who, upon hearing of Loretta's song, began to take interest in HC. Loretta Lynn helped 'the pill' to gain acceptance in popular media and brought the discussion of issues surrounding contraception and unwanted pregnancy, which were initially considered unmentionable, into mainstream discussion (Sicoli, 1994). In the 50 years that have elapsed since the introduction of the pill, substantial formulation changes have occurred to alleviate many of the aforementioned health risks while maintaining contraceptive efficiency. Today, modern HC's contain different forms of synthetic hormones altogether, in far lower doses than those first marketed, and this has greatly reduced the occurrence of adverse physical effects. In spite of these changes the study of psychological side effects of HC use has still not yet been fully addressed. Studies to date tend to be limited to the areas of general mood or libido (e.g., Oinonen & Mazmanian, 2002; Sanders et al., 2001). Why might this be?

Since HC's were first introduced the political struggles associated with its availability have not waned, but rather simply shifted to new topics. HC is now, for instance, often a major political campaign issue in the Western world with views for and against HC's often now seen at the heart of conflict in the Liberal-Conservative ideological divide[7]. Similarly, the Catholic Church remains a vocal proponent against HC's and has therefore been a powerful force in limiting its use and access worldwide (e.g., Goldzieher, 1991). This suggests that HC's remain, to some extent, unaccepted in society which may consequently overshadow the investigation of psychological side-effects.

An additional possible explanation for the omission of psychological research on this topic is that, when HC's were introduced, women had a deep desire to

[7] In the most recent American presidential election Barak Obama and Mitt Romney disputed this topic constantly. For example, a focus of the second debate on October 16th, 2012 was on whether contraceptive access should be included in the healthcare bill (Tanne, 2012).

independently control their family size and birth intervals. In particular, HC's provided ailing women with a reprieve from the impact of multiple successive pregnancies and lessened the economic burden of raising additional children. Many accounts from women who obtained some of the first prescriptions for Enovid suggest that they were willing to incur physical health costs in order to avoid the problem of unwanted pregnancy (described in Marks et al., 2001). This desperation may have meant that women were less likely to report subtle behavioural changes as they were willing to accept and cope with what were minor adjustments when compared to the outcome of having an additional child. This feeling may have amplified further during The Great Depression when extra economic constraints may have meant that restricting family size influenced personal survival.

Now that physical side effects have lessened, women are becoming more vocal of potential psychological concerns associated with pill use. A quick browse through popular magazines and newspapers will reveal a plethora of articles on this issue. Recent titles such as 'How the pill messes with women's minds' (Daily Mail, Oct 20th, 2011) and 'Does the pill affect relationships?' (Cosmopolitan, Nov 1st, 2012) reflect a growing acknowledgment and interest within society of potential psychological effects associated with HC's. The time has come for studies to investigate these anecdotal tales and determine what unrecognized psychological consequences may be associated with HC's and how they might subsequently be mitigated.

Physiology of HC's

Today contraception can be attained hormonally via orally ingested pills, via injections, via insertion of intrauterine devices (IUD's), via external skin patches and through implanted devices (Rivera et al., 1999; Delavande, 2008). A woman's choice of her preferred method of hormonal contraception is an individual decision based on differences in lifestyle factors. Furthermore, a woman may choose to use a variety of different types of HC's at different stages of her life to meet her current

needs. The most common form of HC currently in use is the combined oral contraceptive pill, with over 100 million women worldwide currently using "the pill" for contraceptive purposes (Trussell, 2007). Since combined oral contraceptives are the most commonly used form of HC, the research contained within this thesis is centred on their psychological effects. Therefore, while our results may also apply to other forms of HC's (e.g., injections, patches, IUD's and implants), these methods were not tested within our research and will therefore not be described in detail here. The need to examine psychological effects of these other forms of administration thus remains.

Alike Enovid, the first ever combined oral contraceptive pill, contemporary HC's are composed of a synthetic estrogen and progesterone: ethinyl estradiol (EE) and progestin (South-Paul et al., 2008). A wide variety of pill types are available on the market and they typically vary in their progesterone component and its concentration, as well as the corresponding concentration of EE (Hornstein & Schwerin, 2013). Interestingly, there is no clear medical guideline for administering the variety of brands presently available on the market[8]. That is, there are no standardized criteria for prescribing one form of combined oral contraceptive over another form to a particular type of woman. It is common for general practitioners to prescribe one specific brand of combined oral contraceptive to virtually all their patients (typically at the advice of a drug sale representative). Should a patient encounter difficulties or experience negative symptoms on a particular brand they often undergo a period of trial and error until they find a brand which suits them better. It should also be noted that while hormonal profiles of women varying in BMI as well as ethnicity have been shown to differ (Taioli et al., 1996; Coker et al., 1997; Randolph Jr et al., 2004) these are not factors explicitly relevant in a general practitioners criteria for prescribing HC's.

[8] In some countries, such as The Netherlands, where women must pay for their HC's, the lack of clear guidelines often result in women simply choosing the cheapest brand available.

Relative to the first combined oral contraceptives today's pills all contain very low doses of synthetic hormones. Current literature classifies pills with an EE dose of 20 μg as an 'ultra-low dose', while a 'low dose' pill is typically considered to have an EE concentration between 30 μg and 35 μg (e.g., Poindexter, 2000; Rosenberg et al., 2000). Pills containing greater than 35 μg of EE are not common. There is also a variety of HC pills which contain no synthetic estrogen. These pills, known as progestin-only pills, are not typically prescribed unless patients are estrogen contradicted as breakthrough bleeding tends not to be as reliably controlled and contraceptive efficiency is more dependent upon timely administration (Amy & Tripathi, 2009).

The most common method of administration of combined oral contraceptives is in a 21-7 regime. In this format women swallow one pill per day for 21 days followed by a seven day pill free break in which they experience a withdrawal bleed. This format mimics the typical 28-day regular menstrual cycle. Newer versions of combined oral contraceptives come in formats with shorter pill free intervals. For example, HC pills now exist in a 24-4 regime, in which pills are swallowed for 24 consecutive days followed by a four-day pill free interval. These regimes are thought to increase contraceptive efficiency while maintaining low hormone doses (e.g., Bachmann et al., 2004). At first glance, it may seem odd that one can vary regime lengths while still maintaining contraceptive efficiency. As stated previously, hormonal contraception was developed in an era where altering natural biology was considered taboo. This climate had a direct bearing on the formulation of the pill: researchers used a seven-day pill free interval in the initial combined oral contraceptives in an attempt to mimic the natural menstrual cycle and menses length. It was thought that this consideration would lead to the pill being viewed as more natural and that it would therefore gain greater acceptance from women and the Catholic Church (Marks, 2001)[9]. Typically combined oral contraceptive pills are

[9] Today, much evidence suggests that shorter pill-free intervals (which generate shorter menstrual bleeds) are actually more effective (e.g., Spona et al., 1996; Sullivan et al., 1999; Archer et al., 2006).

of the same dose strength each day during the pill taking phase; however, newer formulations such as biphasic and triphasic pills step up the dose two and three times, respectfully, at intervals.

Combined oral contraceptives prevent fertility through a number of methods, though primarily they interfere with the hypothalamic-pituitary-ovarian axis. For instance, the estrogen component inhibits FSH production which in turn inhibits follicular growth. The progestin component works to actually prevent ovulation through inhibition of the mid-cycle LH surge (van Heusden & Fauser, 1999; Frye, 2006). These processes suppress natural estrogen and progesterone production, meaning that women that use HC's have lower serum estrogen and progesterone levels (see Figure 3) (e.g., Hatcher & Namnoum, 2004; Basu et al., 1992).

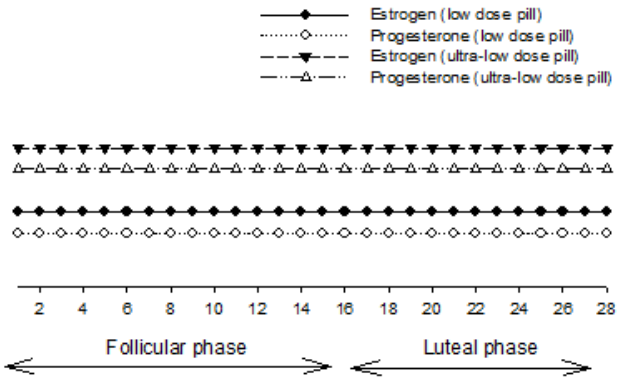


Figure 3. Pattern of estrogen (filled) and progesterone (empty) in women using low dose pills (diamonds) and ultra-low dose pills (triangles). Women on HC's containing higher doses of hormones have their natural hormones suppressed to a greater extent.

The progestin component also provides secondary contraceptive prevention through the thickening of cervical mucus and altering the endometrium making it difficult for sperm to penetrate into the uterus and implant (Rivera et al., 1999; Hornstein &

Schwerin, 2013). During the pill free interval, when the monthly menstrual bleed takes place, pituitary hormone activity resumes. This means that follicles begin to grow. Upon the initiation of the next active pill phase inhibition of growth occurs (van Heusden & Fauser, 1999).

Given that the pituitary ovarian axis recovers function so quickly, correct pill taking practices are very important to ensure contraceptive protection. Pills must therefore be taken at the same time every day to help maintain a consistent level of hormones in the body, and on time after a pill free interval. Failure to do so can result in contraceptive failure. When taken properly, contraceptive efficiency of combined oral contraceptives is very high. The pearl index, a measure of contraceptive failure, shows that HC's are among the most effective means of attaining reliable contraception.[10] High levels of efficiency are typical of all of today's HC's (for comparisons with other forms of contraception see Trussell et al., 2004).

In spite of successfully achieving contraceptive efficiency with lower hormone doses, use of even today's most modern combined oral contraceptives is associated with health risks. Potential risk factors as diverse as cancers (e.g., reviewed in Smith et al., 2003; Kumle et al., 2002), osteoporosis (e.g., Prior et al., 2001), disrupted lipid and carbohydrate metabolism (e.g., Godsland et al., 1990; Klipping & Marr, 2005), and stroke and cardiovascular problems (e.g., Lidegaard et al., 2009; Baillargeon et al., 2005) have been identified and studied. Additionally, psychological studies have shown links to depression (e.g., Kulkarni, 2007) and changes in sexual function (e.g., Wallwiener et al., 2010). However, psychological studies conducted on HC's have not yet adequately addressed the impact of contraceptive use within a wider context. Accordingly, at present a number of interesting questions with respect to the consequences of HC use remain

[10] For example, in a study of Alesse, a very commonly used combined oral contraceptive, a Pearl index of 0.84 was reported in a study which examined over 7720 cycles in a sample of 792 women who were tracked for six months. From this group only 5 women experienced an unintended pregnancy (Archer et al., 1997).

unanswered (Cobey & Buunk, 2012). For example: Does starting or stopping HC use alter the dynamic of an existing relationship?; Do women feel (and therefore behave) differently than they otherwise would while using hormonal contraception?; How might behavioural changes brought about through HC use impact female social relationships and well-being? In the next section I will outline research findings informed by an evolutionary psychology perspective that have attempted to answer these sorts of questions.

Evolutionary psychology and HC's

Women who use HC's do not show cyclical shifts in preferences for indicators of good genes or changes in their behaviour or attractiveness (reviewed in Alvergne & Lummaa, 2010). For example, HC users show weaker preferences for male vocal masculinity (Feinberg et al., 2008), no preference for either scents of symmetrical or asymmetrical men (Gangestad & Thornhill, 1998; Thornhill & Gangestad, 1999), and do not exhibit cyclical changes in perception of attractiveness as evaluated in voices (Pipitone & Gallup, 2008) and scent (Kuukasjärvi et al., 2004). This can be explained by the fact that they do not experience phases of fertility or hormonal shifts across the cycle (Figure 3).

Such changes may impact partner choice and subsequent outcomes in relationships. The most compelling evidence in support of this idea comes from research on the major histocompatibility complex (MHC). MHC genes influence immune processing and are thus responsible for the recognition of foreign proteins through activation of T-cells (reviewed in Havlíček & Roberts, 2009). Genes of the MHC are highly polymorphic even within a single population and this polymorphism has been the centre of investigation for decades (e.g., Brown & Eklund, 1994). It has been argued that the maintenance of MHC variation within a population can be explained by a preference for MHC dissimilar partners and is therefore a product of sexual selection. Animal studies, typically on rodents, show support for this idea: individuals prefer MHC-dissimilarity in their partners (e.g., Jordan & Bruford,

1998; Piertney & Oliver, 2006). Selecting a partner who is MHC dissimilar means that resulting offspring will inherit a greater degree of MHC heterozygosity, which is (generally), associated with higher rates of pathogen resistance. Therefore, this decreases the chance that offspring will be homozygotes at a deleterious allele. Preferences for MHC dissimilar partners may therefore also reflect an inbreeding avoidance mechanism (e.g., Penn & Potts, 1999; Penn et al., 2002).

MHC heterozygosity can be evaluated via odour. Wedekind and colleagues (1995) provided the first evidence of MHC-dissimilarity preferences in humans and on the subsequent effect of using HC's on these preferences. They showed that when asked to rate odours obtained from T-shirts which had previously been worn by men that, on average, regularly cycling women rated men who were less similar in their MHC as more attractive. These women also stated that the scents which were less MHC similar reminded them more of their previous romantic partners. Interestingly, those women who were using HC's rated the T-shirts of men who were more MHC-similar as most attractive. Results therefore suggested that HC use may alter MHC preferences. A subsequent study by Roberts and colleagues (2008) built on this finding through prospectively testing MHC preferences among a sample of women who transitioned from regularly cycling to using HC's. This allowed for control of potential between-subject differences among women using HC's versus those who were non-users. Roberts and colleagues (2008) did not find a significant effect for MHC dissimilarity preference among regularly cycling women; however, they showed that after initiation of HC's users showed a shift in preference towards MHC similar men. A similar shift was not observed among a control group of participants who did not alter HC use status. These results therefore suggest that HC's may interfere with potentially adaptive human mate preferences leading users to choose different partners than they otherwise would.

A recent study by Little and colleagues (2013) suggests this is indeed that case. These researchers tested masculinity preferences in a group of women prospectively as they transition to HC use and showed that relative preferences for masculinity

decreased. In a second study, they extended this laboratory based finding by showing that women who met their partner while using HC's were paired with men who had lower levels of facial masculinity than those who met their partner while regularly cycling. This compelling result suggests that the absence of cyclical shifts in preferences has a genuine outcome on partner choice. What consequences, if any, this change in mate choice has on relationship dynamics or subsequent offspring outcomes remains to be determined.

Based on the evidence that women's preferences and attractiveness differ when regularly cycling as compared to when using HC's, one might predict that initiating HC use within an existing relationship may cause changes in levels of satisfaction. Recent research by Roberts and colleagues (2012) provides preliminary support for this idea. They showed that women who met their partner while using HC's reported to be more satisfied with their partner emotionally; however, these women reported lower sexual satisfaction with their partner (controlling for current pill use) than women who met their partner off of the pill. This may be explained in relation to the framework of Little and colleagues (2013) who provide evidence that women on HC's are paired with less masculine (i.e., more investing) men.

The brevity of this section relative to the section of cyclical shifts across the menstrual cycle accurately reflects the current state of literature on this topic: little is known about HC effects on mate choice and social relationships. There are several possible reasons why this may be the case. I have previously discussed the idea that women may have been willing to accept psychological symptoms in order to prevent pregnancy or how physical symptoms may have overshadowed psychological ones. However, practically speaking the cost of conducting this sort of psychological research presents a further barrier. Additionally, while researchers would ideally track large groups of women's romantic and social relationships longitudinally as they switch on and off the pill, there are both medical and ethical concerns in assigning women to use HC's (as well as placebos) which must be considered. As a result of these practical limitations, research conducted to date, on

psychological effects of HC, with few exceptions, typically makes use of between-subject samples in which women using the pill are compared to women not using the pill on a variety of dimensions. This is, of course, not a rigid means to sufficiently test the questions at hand, and therefore herein I intended to improve (to the extent it was possible) upon the typical methodological shortcomings of research in this area.

Thesis Outline

The empirical work contained within this thesis has been structured in two parts which I now provide a summary of. Part One investigates HC and menstrual cycle effects on female romantic jealousy. Part Two of this thesis attempts to contextualize the findings documented in Part One with respect to jealousy. In this latter section I present research investigating intrasexual competition and attractiveness.

Part One

In Chapter Two, I present results from a study that examined the effect of HC's and the menstrual cycle on female jealousy. This study is unique to the literature in that it is one of the first studies in this area to be conducted using a within-subjects design in which the same women are tested when they are regularly cycling and using HC's. Similarly, it uses transvaginal ultrasonography to detect fertility status as opposed to one of the more crude methods (e.g., forward counting from onset of menses) that are typically employed in this line of work. At the outset of this research the prevalent view within the literature was that female jealousy increased when a woman was fertile as compared to non-fertile and similarly that jealousy is higher among women using the pill than among women who were regularly cycling (Geary et al., 2001). However, as all studies to date were conducted using between-subjects samples, a study using a within-subjects design remained necessary to validate these findings. In line with previous research I predicted that when sampled

within-subjects women would report higher levels of jealousy when fertile as compared to non-fertile. In addition, I predicted that HC use would be associated with higher levels of jealousy than when regularly cycling since estrogen, which is greatly suppressed by synthetic hormones during use, has been shown to be intimately related to emotional behavioural outcomes (Fink et al., 1995; Steiner et al., 2003).

In Chapter Three, I present a cross-cultural study which examined the influence of female menstrual cycle stage on jealousy response. This study aimed to replicate a portion of the results presented in Chapter Two, that is, that women experience higher levels of jealousy when fertile than when non-fertile. The study is unique to the literature in that it is one of the first studies to my knowledge which examines menstrual cycle effects on female behaviour in an African Caribbean sample. Moreover, this study also benefited from the use of a relatively older population of women of which many were non-students. I predicted that, while baseline levels of jealousy may differ in this population, Curaçao women would report higher levels of jealousy when fertile than when non-fertile.

In Chapter Four, I present a study which more closely examines the effect of HC use on female jealousy. In Chapter Two, I tested overall effects of HC use on jealousy and found, among other results, that women report higher levels of jealousy when using the pill as compared to when non-fertile. In Chapter Four, I assessed how specific HC formulations might differentially influence female jealousy. Based on the fact that combined HC's come in different doses I examined whether higher concentrations of synthetic hormones in the pill were associated with higher levels of jealousy. I predicted that the higher concentrations of synthetic estrogen, known to suppress natural female estrogen, would invoke greater levels of jealousy. I also tested for effects of synthetic progesterone concentration, since some evidence has shown that progesterone regulates affiliation behaviour (e.g., Maner et al., 2010; Taylor, 2006) which may subsequently influence levels of jealousy.

In Chapter Five, I present results of a study which examined how jealousy within romantic relationships may be influenced by different contexts of HC use. Specifically, I examined how congruency between present use/non-use of HC's and use/non-use at the start of the relationship might influence current levels of jealousy. This study was derived from research which indicates that female mate preferences change when women initiate HC's (reviewed in Alvergne & Lummaa, 2010). Based on this, I expected that if a woman chose her partner when she was not using HC's and then later began use, she may find that her new preferences are no longer satisfied by her mate and subsequently express jealousy in reaction to her relationship uncertainty. To do this, I examined the independent effect of current contraceptive use, contraceptive use at the start of the relationship and the congruency between current use and use at the start of the relationship of levels of jealousy. I predicted that in instances where current contraceptive use was incongruent to use at the start of the relationship, levels of relationship jealousy would be higher since preferences would have shifted since the time of partner choice.

Part Two

The motivation for Part Two of this thesis came from critical evaluation of specific findings obtained in Part One. In Part One we found that women reported increased jealousy when fertile as compared to when non-fertile (Chapter Two and Chapter Three). However, it is not directly obvious why this might be: expressing jealousy when fertile is not likely to aid women in siring more children or children of better quality and it certainly does not appear that such shifts would be overtly linked to survivorship. Based on this, I aimed to conduct a series of studies in Part Two which more directly specified the underlying processes involved in increased jealousy when fertile. This was done in an effort to augment my explanation of the mechanism behind the findings. I sought to examine other factors which are likely to be related to jealousy or which jealousy may be a by-product of. I tested if intrasexual (same-sex) competition or self-perceptions of attractiveness varied

across the menstrual cycle. Shifts in competitive behaviour or competitive ability can be understood as directly advantageous to fitness and may therefore contribute to shifts in jealousy.

In Chapter Six, I present the results of a study which considered shifts in intrasexual competition across the menstrual cycle and during use of HC's. As in Chapter 2, this study used a within-subjects design and transvaginal ultrasonography to assess fertility. Here, I predicted that levels of intrasexual competition would be higher when fertile than when non-fertile as in Fisher (2004). Also, speculatively, based on the assumption that intrasexual competition may relate to jealousy, I predicted that during HC use levels of intrasexual competition would be higher. As you read on, you will see that the results of this study diverged a great deal from these predictions, and I will discuss why this might be the case and what explanation I put forward for the initially unexpected findings.

In Chapter Seven, I present a study on self-perceived attractiveness across the menstrual cycle and during use of HC's. Again, as in Chapter Two and Chapter Six, this study used a within-subjects design. However, in this study I also tracked female participant's male partners when the women were both regularly cycling and using HC's. I had no concrete predictions for the anticipated direction of shift of self-perceived attractiveness among women because previous results have indicated both positive and negative self-evaluations when fertile as compared to non-fertile (e.g., Haselton & Gangestad, 2006; Hill & Durante, 2009). However, I predicted that should females indicate a shift in their attractiveness at any of their measures, male self-reports would shift in the same direction. You will see that these predictions also did not hold, again failing to provide a mechanism for cyclical shifts in jealousy. However, results provide other important insights into the impact of fertility status on relationship dynamics. To finish, in Chapter Nine I will re-summarize all of my findings and discuss their implications and limitations.

Chapter 2

Reported jealousy differs as a function of menstrual cycle stage and contraceptive pill use: a within-subjects investigation

Cobey, K.D., Buunk, A.P., Roberts, S.C., Klipping, C., Appels, N., Zimmerman, Y., Coelingh Bennink, H., & Pollet, T.V. (2012). Reported jealousy differs as a function of menstrual cycle stage and contraceptive pill use: a within-subjects investigation. *Evolution and Human Behavior, 33, 395-401.*

Abstract

Previous research suggests that female jealousy is sensitive to hormonal variation and, more specifically, potentially moderated by estrogen levels. Here, we tracked self-reported jealousy using a within-subjects design, comparing jealousy when the same women were regularly cycling and using hormonal contraceptives. Results show that fertile cycle phases are associated with higher levels of jealousy than non-fertile cycle phases in both single and partnered women. However, patterns of jealousy reported when using hormonal contraceptives, as compared to when regularly cycling, differed between single and partnered women. In single women, levels of jealousy while on the pill fell between those reported when fertile and non-fertile but were not significantly different from either. In partnered women, levels of jealousy while using the pill were significantly higher than those reported during the non-fertile cycle phase and similar to those during the brief period of fertility. We discuss possible reasons for differences between single and partnered women in reported jealousy while using the pill. This research is among the first to definitively show that a psychological characteristic, for example, jealousy, may be influenced differentially by endogenous hormones vs. exogenous hormones administered via hormonal contraceptives.

Introduction

A growing body of literature suggests that women have evolved subtle changes in behaviour and preferences across the menstrual cycle as a function of conception risk (e.g., Penton-Voak et al., 1999; Jones et al., 2008). To reiterate from the general introduction many of these studies focus on testing cyclical shifts in preferences for indicators of male genetic quality (reviewed in Garver-Apgar, Gangestad & Thornhill, 2008). For example, masculinity and body odour are argued to function as honest signals of health (e.g., Thornhill & Gangestad, 1999; Roberts et al., 2005; but see also Getty, 2002). Female attraction towards these good gene traits is said to increase during fertile phases of the cycle because during this time obtaining genetic benefits for future offspring is most relevant (e.g., Thornhill & Gangestad, 1999).
Research has also documented shifts in female attractiveness across the menstrual cycle. For instance, female faces (Roberts et al., 2004), voices (Pipitone et al., 2008), and choice of dress (Haselton et al., 2007) are judged to be most attractive when women are at fertile cycle stages. Heightened attractiveness during fertility could be seen as adaptive as it may allow women to attract a larger pool of potential partners, or partners of higher quality, when conception risk is highest. Evidence indicating that men show increased mate guarding towards fecund female partners suggests that menstrual shifts in attractiveness have consequences for male behaviour as well (Gangestad et al., 2002; Flinn, 1988). Similarly, the literature suggests that male mate guarding of fecund partners is moderated by female attractiveness: with more attractive women experiencing higher degrees of mate guarding (Haselton & Gangestad, 2006). In line with these findings, women in relationships, particularly those who assess their male partner not to have good genes traits, are more likely to report extra-pair flirtation when fertile.

Taken together the plethora of recent studies documenting female menstrual cycle shifts prompts a key question: do cyclical shifts in preferences or behaviour have an adaptive function? If this reasoning is correct, then use of HC's, which suppress

cyclical variation, may lead to less adaptive mate preferences and behaviours than those found within non-users.

Indeed, there is some evidence in support of this notion. Relative to non-users, women who use HC's demonstrate decreased preferences for indicators of genetic quality in males (e.g., Little et al., 2002; Roberts et al., 2008; Wedekind et al., 1995) and overall decreased attractiveness in their behaviour (Miller et al., 2007). If menstrual cycle shifts play a meaningful role in allowing women to select quality partners or to obtain, attract, or retain mates, then the use of hormonal contraception may have consequences for the selection of new partners as well as for the stability of existing pair bonds (Alvergne & Lummaa, 2010; Roberts et al., 2012).

Apart from influencing partner preferences and attractiveness, research also suggests that HC use and menstrual cycle shifts in hormones may influence relationship jealousy. Relationship jealousy can be defined as thoughts, emotions, or behaviours which occur as a result of the perceived threat of losing a potential mate to an actual or imagined rival (Buunk, 1991). Jealousy can be adaptive in that it allows women to monitor their partner and to foresee any potential threats to her monopolization of his resources or direct paternal care. Using a within-subjects design Geary and colleagues (2001) correlated estimated levels of estrogen in regularly cycling women to jealousy. While they found no mean differences in jealousy scores across cycle weeks, relative periods of high estrogen (increased conception risk) in week two of the cycle were associated with higher levels of jealousy. The benefit of cyclical shifts in jealousy is not entirely clear. Geary and colleagues (2001) hypothesized that this finding might be explained as a result of increased sexual desire during times of high estrogen. It remains an empirical question as to whether such shifts in jealousy are adaptive, or if they are indeed a by-product of other processes such as sexual desire. In a second study Geary and colleagues (2001) reported that women who used oral contraceptives had higher levels of sexual jealousy than non-users. Taken together, these findings suggest a role for estrogen in female jealousy responses.

Using a within-subjects design I test how female relationship jealousy varies, firstly as a function of fertility status across the menstrual cycle, and secondly as influenced by the use of HC's. The vast majority of research on pill-induced behavioural effects, including that of Geary and colleagues (2001), is limited by the fact that it draws conclusions based on between-subjects designs. The use of between-subjects designs is problematic in that there may be pre-existing differences in culture, personality, sexual experience, relationship status, socio-economic status, and conscientiousness between those women who choose to use hormonal contraception and those who do not (Roberts et al., 2008; Alvergne & Lummaa, 2010). To address these methodological issues, here I use a within-subjects design in which participants are tracked both while they are regularly cycling and after they have commenced oral contraceptive use.

This study also benefits from an accurate process of detecting, and therefore defining, periods of fertility. Previous menstrual cycle studies have typically made crude estimates of the timing of ovulation, in many instances relying on female self-reports of menstrual onset, from which researchers count forward or backwards to establish an estimate of fertility. Beyond the potential for errors in self-report, the timeframe for which fertility is defined is highly inconsistent across studies (e.g., backward counting to day fifteen, Garver-Apgar et al., 2008; forward counting to days nine-fifteen, Miller et al., 2007; forward counting to days six-fourteen, Penton-Voak & Perrett, 2000). More recently, luteinizing hormone (LH) test strips have been used in an effort to better estimate fertility (e.g., Pillsworth & Haselton, 2006). However, this method is limited by the fact that it fails to account for anovulatory cycles in which luteinized follicles remain unruptured (Metcalf & Mackenzie, 1980; Qublan et al., 2006). Further, there is variation in the definition of the duration and timing of the fertile period with reference to the detection of an LH surge (e.g., one day prior and five days after, Gangestad et al., 2002; two days prior and three days after, Haselton et al., 2007). Use of transvaginal ultrasonography allowed us to improve on this aspect of previous research.

Based on previous results reported by Geary et al., (2001) I predicted that, when regularly cycling, fertility (e.g., phases relatively high estrogen), will be associated with significantly higher levels of jealousy relative to the non-fertile cycle stage. Similarly, based on previous research I predicted that HC use would be associated with increased levels of jealousy as compared to scores obtained during non-use.

Methods

Subjects

Participants were twenty-nine females of white European descent aged between 20 and 33 (M = 22.59 years; SD = 2.63 years). Participants were taking part in one of two clinical drug trials that tracked the inhibition of ovulation when using HC's. Participants were not given placebos or any other medication during their participation in either of the trials. Both trials had been ethically approved by an independent medical ethics committee. Criteria for participant exclusion included: pregnancy, lactation, irregular menstruation (cycle length greater than forty-two days), a history of drug or alcohol abuse, the use of depot progestogen preparations, injectables, or biodegradable implants (within the past six months), clinically relevant abnormal cytology within the past three years as assessed by a cervical smear, or clinically significant abnormalities in routine hematology, serum biochemistry, and urinalysis at screening.

Women were recruited for the purpose of the present study via advertisements and word of mouth. This research was approved by the University of Groningen Ethics Committee. Participants were paid for their participation, or alternatively, entered into a draw to win an iPhone (or its equivalent in monetary value) in compensation for their time taking part. Of those who chose to take part, thirteen women were presently in a relationship, while sixteen reported to be presently single.

Measures

The study consisted of three sessions: two that occurred when participants were regularly cycling (first at a high and then at a low-fertility period) and one when participants were using HC's. During each of the three scheduled sessions participants were asked to complete a computer-based survey**.** Seventeen of the participants, those recruited from trial one, completed the surveys on their home computer. They were specifically instructed to complete the online survey in private and in the absence of potential distractions. The remaining twelve participants, those who were recruited from the second trial, completed their surveys on a PC in a laboratory of a Psychology Department at a large European University.

The survey was completed in Dutch (by native Dutch speakers) and contained basic demographic measures and the original Dutch version of a Jealousy Scale (Buunk, 1997) (Cronbach's alphas = .86 (fertile), .89 (non-fertile), .87 (pill use)). This is a fifteen-item questionnaire in which answers are reported on a one to five scale with higher scores indicating higher levels of jealousy. Example items include: *"I am concerned that my partner finds someone else more attractive than me*", "*It is unacceptable to me that my partner has friends of the opposite sex*"; "*How would you feel if your partner would dance intimately with someone of the opposite sex?*".

Session Scheduling

To accurately schedule participants for their three sessions each individual was tracked for a period of at least four months. Participants were tracked for one month while spontaneously cycling. Participants who had been using HC's underwent a washout cycle in which no measurements were taken prior to being observed for a full menstrual cycle. Previous research has shown that hormone levels return to baseline well before two months after ceasing contraceptive use (e.g., Duijkers et al., 2005). Ovarian function is restored within a few days of stopping HC's. Moreover, ethinyl estradiol and progestogens have half-lives of ten hours and eight to twenty-four hours respectfully, and will thus have been eliminated well before we

took our regularly cycling measures (Goldzieher, 1989; Täuber, Tack & Matthes, 1989).

During this time participants underwent transvaginal ultrasonography (GE Voluson E8 device, with a 4-8 MHz vaginal transducer) readings every 3 ±1 days, starting on day nine of the menstrual cycle, to determine their proximity to ovulation. As indicated in Duijkers et al., (2004) follicles were measured in two directions and a mean size was calculated. Participants were instructed to complete their 'fertile' survey within 48 hours of their regular transvaginal ultrasonography measurements indicating that they had a follicle that was greater than or equal to 13 mm in size, demonstrating that the dominant follicle had developed, and therefore the fertile phase was entered. We then continued to monitor participants via transvaginal ultrasonography to ensure that ovulation took place. Fertility was also confirmed by the measurement of serum progesterone levels. In line with Hoogland and Skouby's (1993) classification system for measuring ovarian activity using ultrasound technology, all participants were observed to have a progesterone level greater than 5nmol/L at the time they completed their fertile survey. According to the Hoogland scoring system this indicates either a luteinized follicle or a ruptured follicle suggesting that risk of conception is high.

The second survey, the 'non-fertile' survey measure, was completed during the luteal cycle phase. Participants were instructed to complete this survey six days or more after it had been observed, via transvaginal ultrasonography, that they had ovulated. For the purpose of the HC survey, participants had to have been using contraceptives for a minimum duration of three months. Participants were using a wide variety of different brands of combined oral contraceptives all of which were low dose formulations administered through a twenty-eight day regime with twenty-one days of active pills followed by a seven-day pill free week. Participants completed the 'pill use survey' on an active pill day at least fifteen days into the third month of consistent HC use.

The order in which the surveys were administered was not completely randomized, as this was constrained by the clinical trial. However there was, variation in the order of completion based on which of the two trials participants were recruited from. Twelve women completed the surveys in the order 'pill use survey', 'fertile survey', 'non-fertile survey'; while, seventeen women completed the surveys in the order 'fertile survey', 'non-fertile survey', 'pill use survey'.

Data Analysis

Results were analyzed using hierarchical linear mixed modeling (SPSS, 15.0) with measurements nested for each subject. Data was log transformed to obtain a normal distribution (Raw data: *skewness statistic*: 1.06, *SE* = .26; Transformed data skewness: .363, *SE* = .26). Results reported are consistent to those found when analysed with the non-transformed data.

I first analysed the model with jealousy as the dependent variable, fertility status (fertile, non-fertile, pill use), relationship status, and the order in which participants completed their surveys as fixed factors, and age as a covariate. I also included the interaction of fertility status and relationship status in this model. Parameters were estimated by Maximum Likelihood and the model had absolute convergence in terms of loglikelihood, parameter and Hessian convergence. A random intercept was included at participant level. I report F-test and t-tests for the post-hoc comparisons. After this overall model, I report the same test conducted independently among single and partnered women.

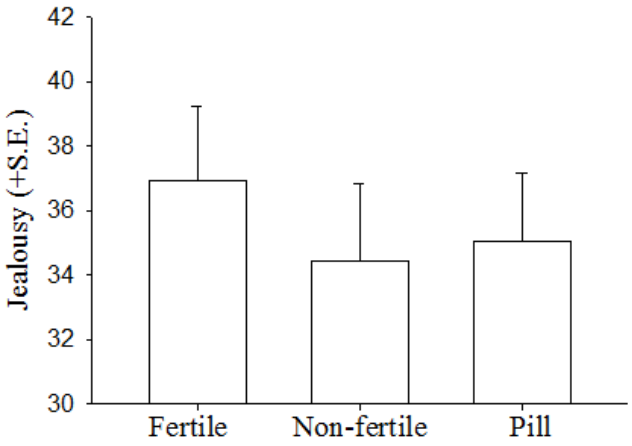
Results

The overall model indicated a significant effect of fertility status of jealousy scores (F (2, 58) = 4.02, p = .02). Relationship status, order surveys were competed in, and the interaction of fertility and relationship status were all non-significant (all F < 2.81, all p > .26). Age had a marginal influence on the model (.10). Pairwise comparisons revealed that levels of jealousy reported when fertile were significantly

higher than those reported when non-fertile (Mean difference = .068, *SE* = .026, *p* = .01). Levels of jealousy reported when using the pill were not significantly different from those reported when fertile (Mean difference = -.013, *SE* = .026, *p* = .61) but were significantly higher than those found when non-fertile (Mean difference = .055, *SE* = .026, *p* = .035).

A priori relationships status was considered to be an important factor which may differentially influence the expression of jealousy. Therefore, although the interaction between fertility status and relationship status in the overall model was non-significant, given our small sample size I chose to consider single and partnered women distinctly. When analyzed in individual tests, results for single and partnered women differed somewhat in spite of the non-significant interaction between fertility status and relationship status in the overall model (see Figure 4). Among single women jealousy scores were significantly higher when fertile than non-fertile (Mean difference = .074, *SE* = .035, *p* = .04); however, there was no difference between levels of jealousy reported when regularly cycling and when using the pill (fertile versus pill: Mean difference = .053, *SE* = .035, *p* = .14; non-fertile versus pill: Mean difference = -.021, *SE* = .035, *p* = .55). Similarly, although marginally significant, among partnered women levels of jealousy were higher when fertile than non-fertile (Mean difference = .063, *SE* = .037, *p* = .10). However, levels of jealousy reported by partnered women were higher when using the pill than when non-fertile (Mean difference = .089, *SE* = .037, *p* = .02), but not different when using the pill versus being fertile (Mean difference = .026, *SE* = .037, *p* = .48). In neither the model for single or partnered women was there a significant effect of age or order of completing the surveys (all $p > .1$).

(a) Single



(b) Partnered

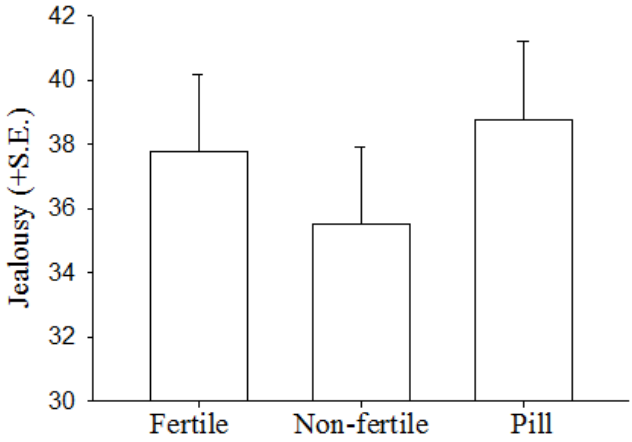


Figure 4. Mean jealousy scores (+*SE*) for women across survey measures. (a) Single women reported significantly higher jealousy when fertile as compared to non-fertile. (b) Partnered women reported marginally significantly higher levels of jealousy when fertile as compared to non-fertile. Levels of jealousy when on the pill were significantly higher than when non-fertile.

Discussion

Via a within-subjects design I investigated if self-reported female jealousy varies across the menstrual cycle and what effect HC pill use had on this behaviour. Results indicate that jealousy varies as a function of menstrual phase, with higher levels of jealousy reported when fertile than when non-fertile in both single and partnered women. To date, research documenting cyclical effects in behaviour and preferences is typically framed within the *ovulatory shift hypothesis* (e.g., Durante et al., 2008; Gangestad et al., 2004). The *ovulatory shift hypothesis* argues that women can benefit from engaging in extra-pair sex to obtain genetic benefits for offspring, but that this comes at a cost of potentially losing a long-term partner. Therefore, selection is assumed to have shaped women to express pronounced preferences for genetic indicators in men that they evaluate as short-term sex partners only when conception risk is high (Gangestad & Thornhill, 1998; Gangestad et al., 2002). While substantial evidence exists in support of the *ovulatory shift hypothesis*, I do not feel the present results are best explained within this framework.

While I believe jealousy may be adaptive to ensure monopolization of partner resources and paternal care, I do not see how cyclical shifts in jealousy could be advantageous to women. That is to say, the size of potential threats in a relationship does not differ for women when fertile versus non-fertile. In men it is clear that shifts in jealousy with respect to partner fertility serve an adaptive function. Given the fitness loss associated with cuckoldry, and the high cost (e.g., time) of remaining vigilant of one's partner at all times, it is adaptive for men to display more jealousy during times when female conception is possible. By contrast, for women, who risk being deserted by their partner and left with the burden of parenting in the absence of male resource investment, the costs of jealousy are equal irrespective of fertility status. Moreover, our findings seem at odds with previous literature on cyclical effects which suggests that fertile periods are associated with

increased extra-pair interest rather than fear of partner infidelity (e.g., Jones et al., 2005; Pillsworth & Haselton, 2006).

For a trait to be considered an adaption it must enhance the fitness of its possessor relative to individuals that do not possess the trait. There is no reason to believe that women who possess strong cyclical shifts in jealousy gain a fitness benefit. Likewise, it is unlikely that in the absence of cyclical variability in jealousy women would suffer a fitness disadvantage and sire fewer offspring. However, it may be that our scale for jealousy taps into some other aspect of mate choice processes which is indeed adaptive. For example, jealousy may be involved in the process of selecting and competing to obtain a mate. Previous research has shown that women increase levels of female-female competition when fertile (Fisher, 2004). Such shifts are adaptive in that they allow women to obtain a partner of higher quality than they otherwise would. It may be that women find themselves feeling more jealous when fertile because mating competition is most salient at this time. A limitation to our study is that the items on the scale used to measure jealousy are specific to a real or imagined partner. It may be that overall levels of jealousy, or specifically jealousy towards attractive females, are driving the effects I report. Future research is needed to explore this hypothesis.

Geary and colleagues (2001) suggested a possible explanation for cyclical shifts in jealousy is that they are a by-product of higher levels of sexual desire when fertile as compared to when non-fertile. This does not appear to be an entirely consistent explanation for our results as it has previously been shown that HC use lowers overall levels of sexual desire (e.g., Graham & Sherwin, 1993). Our finding among partnered women which shows that levels of jealousy are similar when fertile and when using HC's suggests that levels of sexual desire are not likely to explain our effects unless the relationship between the two variables is more complex.

One might also argue that female shifts in jealousy are a by-product of male shifts in jealousy. That is to say, women may respond to increases in partnered male

jealousy through increasing their own expression of jealousy. This however, appears not to be an adequate explanation given that I find similar effects among single and partnered women. Given that both single and partnered women shift levels of jealousy across the menstrual cycle suggests that this shift is unlikely to be adaptive as it would be costly to evoke in situations which are not appropriate. At this stage it is difficult to specify a strong causal interpretation of what cyclical variation in jealousy may be a by-product of. Nonetheless, I find that periods of high estrogen are associated with higher affective responses to partner jealousy, a finding which is consistent with previously reported data (Geary et al., 2001).

Two important implications arise from our results. Firstly, the demonstration that there are clear temporal changes in jealousy across the menstrual cycle in both men and women hints that fertility may correspond to periods of relationship conflict. Future research in which couples are tracked on features such as relationship satisfaction and jealousy across the menstrual cycle may help to disentangle temporal changes in jealousy even further. Secondly, I show that among partnered women HC use increases levels of jealousy from the non-fertile baseline which occurs across the menstrual cycle. Higher overall levels of jealousy in women on the pill may have negative consequences on their relationships, but also perhaps on self-esteem and upon overall individual wellbeing. That I only find a pill effect among partnered women may suggest that pill use initiation has altered the dynamics of the partnership, causing increased tension between partners. Men may be responding to changes in their female partner, which occur as a result of contraceptive use, causing jealousy among women. Future work is needed to explore the real world implications of these findings in more detail. It remains an empirical question as to whether or not the shifts in jealousy documented are indeed noticeable to male partners, and if or how they might influence relationship dynamics, or levels of male partner investment.

There are several limitations to our findings. Firstly, our design was not fully randomized. Future research should aim to completely randomize the fertile, non-

fertile, and pill measures, so as to avoid the possibility of any order effects. Further, as alluded to previously, the scale I used to asses jealousy asked participants to respond to items that required them to imagine their partner in a variety of different contexts. Our study included both single and partnered women. Research conducted within the Netherlands shows that 91% of Dutch individuals between the ages of 20-24 report having had at least one romantic relationship (De Graaf et al., 2005). While I feel it is unlikely (mean age: 22.59 years), it is possible that single women in our sample have no previous relationship experience. Alternatively, women who were recently partnered may have been better able to imagine how they would react to the scale items than those who have been single for a longer period of time. It is therefore somewhat unclear how single women answered the jealousy questions. For example, I do not know whether they were imagining a love rival for a current love interest or recalling a love rival. Future research should seek to collect information with respect to previous partnerships to account for these limitations.

As they stand, our results suggest that jealousy may be influenced differentially by endogenous and exogenous hormones. Yet, it is difficult to specifically distinguish between the effects of the hormones contained within HC's, and the resulting effect of suppressing natural hormones. What is clear is that there may be more variables than often assumed that are involved in explaining cyclical shifts as well as HC-induced behavioural changes. Future research on this topic could consider the effects of HC use based on differences in concentrations or derivative forms of synthetic hormones used (see Chapter Four). Finally, our study is limited by the fact that participants chose to take part in a clinical trial and may therefore differ in some way from women within the general population. Although participants were unaware of the predictions of the study, they may have been cognizant of the fact that I was interested in HC induced behavioural changes. A future study using a double-blind placebo control design could get around this issue (see for example Yonkers et al., 2005).

In summary, this study shows that regularly cycling women report higher levels of jealousy during fertile phases as compared to non-fertile phases, and it indicates that use of HC's results in significantly higher absolute levels of jealousy than when non-fertile. If either temporal shifts in jealousy or increased baseline levels of jealousy have consequences on relationship quality or mate choice, then use of HC's may be disrupting these processes.

Acknowledgements

I wish to thank the staff of Dinox for all of the time and effort they invested into informing participants of the present study, and for conducting all transvaginal ultrasonography measurements. I am also grateful to Rob Kurzban and two anonymous reviewers for their comments on a previous version of the manuscript. A. P. Buunk provided funding for the participant prize and payments.

Chapter 3

Reported jealousy differs as a function of menstrual cycle stage: A study of Afro-Caribbean women living in Curaçao

Cobey, K.D., Girigori, O., Buunk, A.P. (Submitted). The influence of menstrual cycle phase on jealousy response: Data from an African-Caribbean sample.

Abstract

The vast majority of literature which has tested for changes in female behavior and mating preference across the menstrual cycle has been conducted using student samples comprised of largely white undergrads from Western populations. The present study examined cyclical shifts in female jealousy among a sample of 71 African-Caribbean women from Curaçao. Results suggest, in line with previous findings, that women experience higher levels of relationship jealousy when fertile as compared to when non-fertile. We discuss possible explanations for the usefulness of cyclical shifts in jealousy in context to how jealousy may relate to female-female mating competition.

Introduction

As we have seen from the Introduction and Chapter Two, a great deal of literature, from both human and non-human species, has provided evidence that female mating preferences and behaviour are systematically influenced by fertility status. Among humans, several studies have shown that women are rated as more attractive when fertile than when non-fertile: males indicate a stronger preference for fertile female faces (Roberts et al., 2004), voices (Pipitone & Gallup, 2008; Bryant & Haselton, 2009), and scents (Singh & Bronstad, 2001; Havlíček et al., 2006; Gildersleeve et al., 2012). In addition to shifts in attractiveness, heightened female attraction to 'good gene' males and increased sexual interest are known to occur during fertile phases of the menstrual cycle (reviewed in Gangestad & Thornhill, 1998). Women have been shown to prefer increased facial masculinity (Penton-Voak et al., 1999; Penton-Voak & Perrett, 2000), vocal masculinity (Puts, 2005; Feinberg et al., 2006) and more dominant male scents (Havlíček et al., 2005) during fertility. Increased fertile preference for non-physical traits, including preferences for dominant male behaviour (Gangestad et al., 2004), creativity (Haselton & Miller, 2006), and intelligent appearance (Gangestad et al., 2007) have likewise been documented.

What survival value or reproductive advantages lie in such shifts? As described in the General Introduction, changes in female preferences and mating behaviour across the menstrual cycle are typically explained within the framework of the *ovulatory shift hypothesis* (Gangestad & Thornhill, 1998; Gangestad & Thornhill, 2008). The *ovulatory shift hypothesis* is based on two primary assumptions: (1) that the risk or cost of being abandoned by ones male partner is consistent across the cycle, but that (2) the potential benefits of extra-pair sex are higher when fertile as compared to when non-fertile. Accordingly, this theory posits that women may benefit from employing a mixed strategy in which they selectively seek out extra-pair copulations (with high quality partners) when fertile, but not when non-fertile since in general men of high genetic quality tend to be less inclined to invest paternal effort than are men who are of comparably lower quality (Gangestad &

Thornhill, 2008). As a result, greater sexual interest during times of fertility is explained as an adaptation which allows women to pair with a partner they otherwise could not obtain or from whom resource investment would be unlikely.

As in Chapter Two, the present research investigated menstrual cycle shifts in female jealousy. Before delving into the methods of this study, I will first expand on the previous discussion of jealousy. Recall that jealousy is a basic human affect that is aroused in situations where there is a loss, or perception of a potential threat to lose, a valuable relationship (Symons, 1979; Daly et al., 1982; Buunk et al., 1996). The experience of jealousy in such situations subsequently motivates behaviour that aims to thwart potential losses. Previous research has shown that jealousy is experienced differently for men and women (e.g., Buss et al., 1992; Buunk et al., 1996). That is, the triggers for both psychological and physical jealousy vary between the sexes. For example, when asked to report whether a mate's sexual or emotional infidelity would be more upsetting, women are more likely to report greater upset to emotional infidelity, while men are more likely to report greater upset to sexual infidelity (e.g., Buss et al., 1992; Buunk et al., 1996; Buss et al., 1999; Wiederman and Kendall, 1999; Pietrzak et al., 2002; Sagarin et al., 2003; Schützwohl, 2007). Moreover, participants of both sexes who choose these respective forms of infidelity as most upsetting were quicker to make this decision than are those who choose the reverse (Schützwohl, 2005). Sex differences in jealousy can be explained as the result of differences in parental certainty (Trivers, 1972). For example, unlike women who bare the reproductive cost of gestation, men have no paternal certainty. As such, a woman's sexual infidelity may burden her male partner into investing in an unrelated child. Given that investing in non-kin is costly in terms of time and resources, it is alleged that men who successfully attend to and thwart off potential incidences of female infidelity would have higher reproductive success than those who do not. It has been asserted that male sexual jealousy evolved to solve this adaptive problem (Daly et al., 1982; Buss et al., 1992). Previous research which has shown that women report increased mate guarding from their male partners when fertile supports this idea (Gangestad et al.,

2002; Flinn, 1988). Further, male mate guarding of partners during fecund periods has been shown to be moderated by female attractiveness: with more attractive women experiencing higher degrees of mate guarding (Haselton & Gangestad, 2006).

Females face a different adaptive problem. The cost of raising an infant is substantially higher in the absence of bi-parental investment (Alexander & Noonan, 1979). Accordingly, a man's sexual infidelity poses the risk that a woman may be abandoned by her partner who begins to invest in pursuing a new woman, or alternatively, siring and investing in new offspring. Such loss of investment is particularly costly to women in environments where investment from only one parent may incur survival costs to children. As a result, females are particularly threatened by the possibility that their partner will leave them for someone else. However, as set forth in the *ovulatory shift hypothesis* and discussed in Chapter Two, this loss is of equal significance irrespective of fertility status. That is, the costs of losing one's partner or them siring another woman's child, does not differ for a woman when fertile versus non-fertile. In spite of this, a variety of findings suggest that levels of relationship jealousy reliably fluctuate across the menstrual cycle. The first to address this potential was the work of Gaulin and colleagues (1997) who, using between-subjects design, showed that estrogen levels, but not progesterone levels, were positively correlated with female jealousy response. In an extension of this work, Geary and colleagues (2001) later showed that jealousy response correlated with measured estrogen concentration in cycle week two. This suggests that periods of high fertility are associated with increased levels of jealousy. In Chapter Two I found the same pattern of results using a within-subjects sample from a Dutch population. This study was unique in that it examined cyclical shifts in jealousy among single and partnered women separately. Interestingly, the degree of shift in jealousy documented was larger among single women than among partnered women.

The function of increased jealousy during fertility is not however directly obvious. It is possible that jealousy is a manifestation of increased levels of intrasexual competition (this is tested in Chapter Six). Previous research has shown that women are more intrasexually competitive when fertile (Fisher, 2004) suggesting that fertility may be a time where competition for mates is more salient. Accordingly, jealousy may increase as a consequence of the fact that women are more conscious of rivals. Indeed, this interpretation is in line with the fact that cycle shifts in jealousy have been documented in both single and partnered women (Chapter Two; Geary et al., 2001).

To date, all studies investigating menstrual cycle effects on jealousy have been conducted within what appears to be largely white undergraduate student populations from the Western world. In fact, only a small minority of studies investigating the potential for cyclical changes in any preference or mating behaviour, has been conducted within a non-white or non-Western population (e.g., Flinn, 1988; Penton-Voak, 1999). In a compelling *Nature* paper Heinrich and colleagues (2010) have called to attention to the fact that 70% of all papers published in psychology come from studies with participants who are largely white American students. With this staggering statistic in mind, in the present research I examined cyclical shifts in jealousy among a group of women recruited from Curaçao. Curaçao is an island in the South Caribbean Sea off the coast of Venezuela which is ethnically comprised of an African-Caribbean majority. In Curaçao racial, economic and gender stratification is obvious, with considerable unemployment found among the Afro-Caribbean population (Abraham-van der Mark, 2003). Matrifocal households are the norm and men tend not to share responsibility for their children long-term (Ministerie van Binnenlandse Zaken en Koninkrijsrelaties, 2010). Given this situation one might predict that loss of investment from an initially contributing male partner may be particularly costly to a woman in this setting. Therefore, I predicted that competition to maintain mates may be stronger in Curaçao than other Western populations. I also predicted, in line with previous

evidence, that fertile cycle phases would be associated with higher levels of jealousy than non-fertile phases.

Replication is essential for the verification and generalization of previous findings (Muma, 1993). The replication of results previously found in predominantly white Western societies within Curaçao would lend support towards the notion that female menstrual cycle shifts, specifically in jealousy, are a universal. Further, the mean age of this study sample is substantially older (about ten years) than that which is typically used in most previous investigations and a considerably larger proportion of the sample consisted of non-students (for comparisons see Chapter Two; Gaulin et al., 1997; Geary et al., 2001) which offers further distinctiveness to this research.

Methods

Participants

Participants were recruited via word of mouth between November 2010 and February 2011 from the capital of Curaçao, Willemstad. A total of 76 women were initially recruited, however one participant was excluded from analysis because she indicated that she had a reproductive disorder. A second individual was excluded because she indicated that she had not been born in Curaçao. A further three women reported cycles greater than 40 days, prompting the possibility of pregnancy, and were therefore also excluded. As a result of these exclusions the data of 71 women were used for analysis. Participants were aged between 18-45 (M = 29.13, SE = 1.08) and none were using any form of hormonal contraception, pregnant, or reported to have been lactating at the time of the survey. All participants reported to be of Curaçao descent and half of the sample indicated that they were non-students who were presently working.

Fertility scheduling

Given our cross-sectional design, I employed the crude, albeit commonly used (e.g., Havlíček et al., 2005), forward counting method to assign participants conception risk. Participants who were recruited on days 9-14 of the cycle were presumed to be in a stage of high conception risk, while those outside this window were presumed to be in a stage of relatively low conception risk. Based on this classification it was determined that 20 participants were in a high conception risk stage, while 51 participants were in a low conception risk stage at the time of recruitment. While our methodology is expedient, and researchers on this topic should aim to improve the quality of assigning conception risk (see Chapter Two, Chapter Six and Chapter Seven), our study is unique in that it examines menstrual cycle effects within an older, non-western, and partially non-student population.

Measurement of dependent variables

Participants completed a short pen and paper questionnaire containing basic demographic measures as well as a 15-item scale for jealousy (Buunk, 1997) used in the previous chapter. Participants were asked to respond to items using a one to five point scale, with higher scores indicating higher levels of jealousy. Again, example items from this scale include: "your partner danced intimately with someone of the opposite sex" and "I am afraid that my partner is sexually interested in someone else". In a slight modification from the instructions offered in Chapter Two, participants who were single at the time of participation were asked to imagine how they would feel in each of the situations based on previous relationship experience. Participants could choose to complete the questionnaire in Papiamentu or in Dutch, the two official languages of Curaçao. Papiamentu is an African-European creole language, which has Portuguese and Castilian elements.

Results

The mean summed score on the jealousy scale was 54.45 (*SD* = 11.76) and 47.78 (*SD* = 10.84) for fertile and non-fertile participants, respectfully. To examine the

effect of fertility status on jealousy response I conducted an independent-samples t-test (see Figure 5). Results indicated that jealousy was significantly higher among the sample of fertile women than among the sample of non-fertile women (t = -2.28, p = .026, df = 69, Mean difference = 6.66). When entered into a univariate model neither age nor relationship status significantly influenced jealousy scores (all p > .31, F < 1.04). Note that when the rates of jealousy among participants in this study are compared to the rates of jealousy among the sample of Dutch women used in Chapter Two (collapsing across fertile and non-fertile measures), that Curaçao women show significantly higher levels of overall jealousy (F = 5.05, p = .026), yet we see cycle shifts in both populations (see Figure 6).

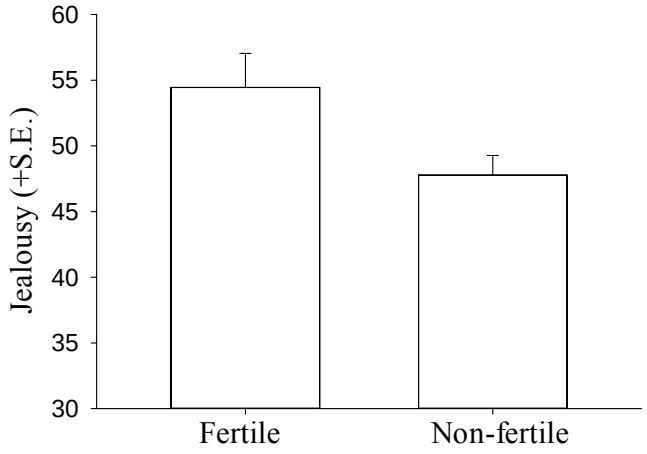


Figure 5. Mean scores (+SE) of participant jealousy scores when fertile and non-fertile among women from Curaçao

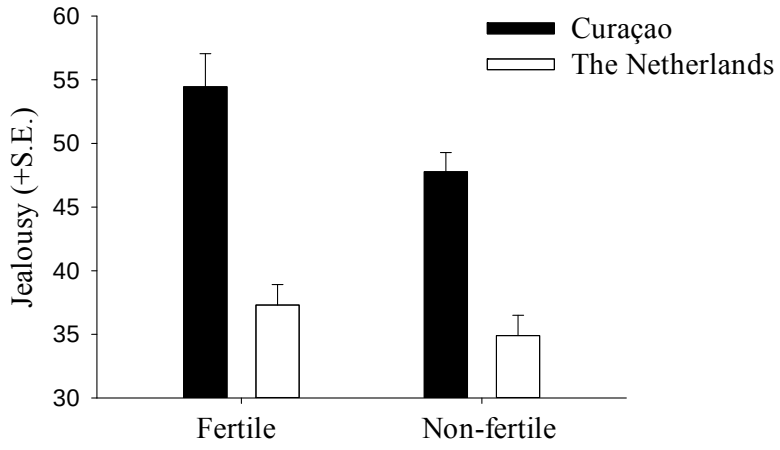


Figure 6. Mean scores (+SE) of participant jealousy scores when fertile and non-fertile among women from both Curaçao and The Netherlands

Discussion

The present results demonstrate cyclical shifts in the expression of female jealousy, with higher levels of jealousy reported when fertile than when non-fertile. With the exception of work by Flinn (1988), this study is unique to the literature in that it investigates cyclical variation in an Afro-Caribbean population. Further, many participants were non-students and the mean age of the sample was older than what has been typical in previous research. Previous research has shown that fertile periods are associated with increased extra-pair flirtation and mating effort (Pillsworth & Hasleton, 2006; Jones et al., 2005). These findings seem at odds with the present result: that women show increased fear of in-pair partner fidelity when fertile. Assuming that the expression of jealousy carries some cost (e.g., the time and energy required to stay vigilant) one could speculate that its expression involves a trade-off; otherwise jealousy would function at a maximum ideal level at all times.

However, this begs the question of what, if any, advantage women gain from increasing jealousy when fertile.

To extend the discussion from Chapter Two, one possible explanation is that shifts in jealousy may be the by-product of another adaptive systematic change which occurs across the female menstrual cycle. For example, jealousy may shift across the cycle as a result of shifting levels of intrasexual competition. Increased competitive behaviour when fertile could aid a woman to obtain a mate or potentially to secure an individual of higher quality than they typically would, thereby enhancing their reproductive fitness. Fisher (2004) has previously shown that women derogate female faces more when fertile than when non-fertile. This finding suggests that women may be more conscious of rivals when fertile and are thus more critical in their assessment of them. The finding that levels of jealousy increase when fertile may therefore be the result of the fact that our scale tapped in to some form of female-female competition. It may be that increased salience of mating competition when fertile influences female jealousy response in some way; however at present this remains speculative. This possibility will be addressed in Chapter Six, so I will not elaborate further here. You will soon see that intrasexual competition does not appear to be an adequate interpretation of the present findings.

A second possibility is that during times of increased conception risk women will be particularly salient of continued investment from their male partner. That is, if a woman is going to have sex with a man, given the costs associated with rearing an infant as a single parent, they may be conscious of the likelihood of continued male support. This consideration is most pertinent when conception is possible (i.e., “If I am going to have sex with you when I can get pregnant, you really better support me”). This explanation is supported by the fact that results suggest that cyclical shifts in jealousy occur irrespective of relationship status. In fact, previous results described in Chapter Two indicate that cyclical shifts in jealousy were more robust among single women than among partnered women.

Future research should seek to uncover the specific endocrine mechanism underlying these results. Estrogen is an obvious etiological candidate, given the pattern of results with respect to hormone shifts across the menstrual cycle and the results of Geary and colleagues (2001). However, it remains plausible that the pattern is the result of more complex hormonal change, including, for example, the relative ratio of estrogen to progesterone. Researchers should also aim to specify the target of shifting jealousy: does jealous shift overall or are shifts more specific? In our study all items on the jealousy questionnaire asked participants to react to their partner (or imagined partner) in a variety of settings. It therefore remains necessary to examine shifts in jealousy which are not specific to this target (e.g., to female rivals).

Further, while I specifically asked that single women imagine themselves in a relationship; again it is not entirely clear how this was interpreted. For example, I cannot disentangle if these participants imagined a previous partner, a hypothetical partner, or even an ideal partner. It should also be acknowledged that the use of a within-subjects design, as in Chapter Two, would have been preferable to the between-subjects design utilized herein for convenience in sampling. Future research measuring jealousy behaviourally is also warranted to confirm these questionnaire based findings.

An important implication arising from our results is that, among women not using HC's, levels of jealousy shift in a predictable fashion across the menstrual cycle. Increased jealousy, when fertile, may alter relationship dynamics in partnered women. It may be, for example, that temporal shifts in jealousy are associated with shifting levels of conflict within partnerships. As it stands, it remains to be determined whether or not shifts in jealousy reported are conscious to women themselves, or moreover, if they are picked up upon by male partners. Studies investigating how shifts across the menstrual cycle influence relationship satisfaction for both female and male partners are likely to prove to be an interesting avenue for future research.

Acknowledgements

I am grateful to the student volunteers from The University of The Netherlands Antilles who collected and organized our survey response data from within the Willemstad community. Without the help of these students we could not have conducted our research within this population.

Chapter 4

Hormonal birth control use and relationship jealousy: Evidence for estrogen dosage effects

Cobey, K.D., Pollet, T.V., Roberts, S.C., & Buunk, A.P. (2011). Hormonal birth control use and relationship jealousy: Evidence for estrogen dosage effects. *Personality and Individual Differences*, 50, 315-317.

Abstract

Women who use hormonal contraceptives have been shown to report higher levels of jealousy than women who are regularly cycling. Here, we extend these findings by examining if self-reported levels of jealousy vary with the dose of synthetic estrogen and progestin found in combined oral contraceptives in a sample of 275 women. A univariate ANOVA analysis revealed that higher levels of ethinyl estradiol were associated with significantly higher levels of self-reported jealousy. There was, however, no relationship between combined oral contraceptive progestin dose and reported jealousy levels. When controlling for age, relationship status, mood, and combined oral contraceptive progestin dose the results for ethinyl estradiol were maintained. A test for the interaction between the jealousy sub-scale items (reactive, possessive, and anxious jealousy) was however non-significant: ethinyl estradiol dose thus does not affect one type of jealousy more than another but rather affects overall jealousy. The implications of these findings are discussed in the context of their evolutionary consequences on mate choice and relationship dynamics.

Introduction

Relationship jealousy is a central affect that is experienced by both men and women (Shackelford et al., 2000; Bringle & Buunk, 1991). Cross-cultural research suggests that men are more distressed by sexual infidelity, while women are more distressed by emotional infidelity (e.g., Buunk et al., 1996; Geary et al., 1995; Buss et al., 1992). However, agreement over these findings is not robust (Harris, 2003), and both positive (Buss, 2000; Barelds & Dijkstra, 2006) and negative (Shackelford & Buss, 2000; Buunk, 1991) associations with jealousy and relationship quality have been reported.

Interestingly despite the dispute within the literature to establish or refute the existence of sex-specific differences in jealousy, surprisingly little focus has been directed towards considering the potential mediating role of individual differences in sex hormones on jealousy response. The fact that HC's are widely used (Groves, 2009) and come in different doses presents a unique opportunity to study the effects of hormones on female jealousy. It is well-documented that women who use HC's do not exhibit the same patterns of behaviour or preferences as regularly-cycling women (e.g., Roberts et al., 2008; Miller et al., 2007). I have outlined a great deal of this evidence in the preceding Chapters and General Introduction. To date, little research has focused on how such HC use might affect patterns of jealousy. In Chapter Two, I have provided evidence that among partnered women HC use is associated with higher levels of jealousy than when regularly cycling (at least when non-fertile). As discussed previously, this finding is in line with Geary and colleagues (2001) who showed that the intensity of jealousy response of women using HC's was higher than that of non-users. Relative to women not using the HC's, a larger percentage of women on HC's also reported that their partner's sexual infidelity would be more upsetting than their partner's emotional infidelity. In a separate study, which examined women who were regularly cycling, Geary and colleagues (2001) found that high absolute levels of estrogen in cycle week two

predicted higher levels of sexual infidelity. Together these findings suggest a role for estrogen in facilitating jealousy response.

In this Chapter I aim to extend these findings by testing if there are differences in patterns of jealousy based on the use of different concentrations of combined oral contraceptives (COC's). COC's are a form of HC which is composed of a combination of a synthetic form of ethinyl estradiol (EE) and progestin (South-Paul et al., 2008). They are the most common form of HC's in use. The current medical literature classifies COC's with an EE dose of 20 µg as an 'ultra-low dose', while a 'low dose' pill is typically considered to have an EE concentration between 30 µg and 35 µg (e.g., Poindexter, 2000; Rosenberg et al., 2000). I used the existing medical classification 'ultra-low' and 'low' dose as categories for comparison within this research project. I predicted that affective jealousy response, although certainly influenced by a wide variety of factors, may be moderated by individual estrogen levels and that the use of HC's with higher concentrations of EE would be associated with higher affective jealousy response.

To examine this possibility as in Chapter Two and Chapter Three, I used Buunk's typology for jealousy. Buunk (1991, 1997) distinguishes between three types of jealousy: reactive, possessive, and anxious. While in Chapter Two and Three I present the overall results for jealousy, in this chapter given differences across sub-scales I have chosen to present overall effects in addition to sub-scale findings. Reactive jealousy refers to the degree to which an individual experiences negative emotions as a result of their partner's emotional or sexual infidelity. Possessive jealousy refers to the degree of effort an individual invests to prevent their partner from coming into contact with opposite-sex individuals. Lastly, anxious jealousy refers to cognitively generated experiences of anxiety, worry, and distrust which relate to one's partner's infidelity. I used Buunk's typology because, in contrast to many of the other dichotomous definitions of jealousy, it places jealousy response on a continuum from healthy to unhealthy.

Methods

Participants

Participants in the study were 275 women aged 17-35 (M = 22.56, SD = 2.89) who had been using hormonal oral contraceptives for at least three months. Participants were recruited by word of mouth and from a large European university. Those from the university took part in exchange for course credit. All research was conducted via an online website set up using Qualtrics survey software.

Measures

Participants were first asked to report their age, relationship status, and to complete the PANAS-X mood scale (Watson et al., 1994). They then were asked to report the brand name of their HC pill, the duration of time they had been using it (in months), and to report the precise dose of synthetic hormones in each pill.

Participants then completed the jealousy scale developed by Buunk (1997). Again, this scale contains 15-items, 5 for each of the respective sub-types of jealousy (overall jealousy scale Cronbach's alpha = .87; anxious sub-scale Cronbach's alpha = .90; sexual sub-scale Cronbach's alpha = .70; preventative sub-scale Cronbach's alpha = .79). Participants responded on a one to five point scale.

Statistical analyses

A mean score for the jealousy scale and each of the sub-scales was computed for each of the participants. The relationship between EE dose and jealousy score was then assessed by means of an ANOVA. Given that there are no clear medical classification for COC progestin dose classification, progestin was analyzed as a continuous variable.

Finally, I used a GLM to test the specific between-subject effects of EE concentration on the three jealousy domains. In this analysis participant PANAS-X

mood scale score was used as a control variable, as was participant age, relationship status and oral contraceptive pill progesterone.

Results

Overall jealousy

The relative influence of estrogen concentration on mean overall jealousy response was examined via an ANOVA. This revealed a significant effect ($F = 6.81$, $p < .001$) of ultra-low versus low EE concentrations on jealousy response (see Figure 7). This effect was maintained when controlling for age, relationship status, mood, and COC progestin concentration. In contrast to EE, COC progestin dose was not a significant predictor of self-reported jealousy ($p > .05$).

Jealousy sub-scales

Mean participant scores for jealousy response to each of the three sub-scales were then calculated (see Table 1). A GLM controlling for mood score on the PANAS-X, participant age (each entered as covariates), and relationship status (entered as a fixed factor) was used to investigate the potential role of contraceptive EE dose on each of these three types of jealousy. This analysis revealed a significant effect of contraceptive EE dose on mean reactive responses ($t = 3.35$, $p = .001$) and on mean possessive jealousy responses ($t = 2.10$, $p = .012$). Scores for anxious jealousy were in the predicted direction with respect to increasing EE dose, but were not statistically significant ($t = 1.49$, $p = .06$).

Table 1. Mean and standard deviation of jealousy response scores by jealousy type and dose of EE

	Ultra-low dose EE		Low dose EE	
Jealousy Item	Mean	SD	Mean	SD
Sexual	3.59	.086	3.91	.044
Anxious	1.97	.093	2.21	.071
Preventative	1.61	.075	1.86	.052

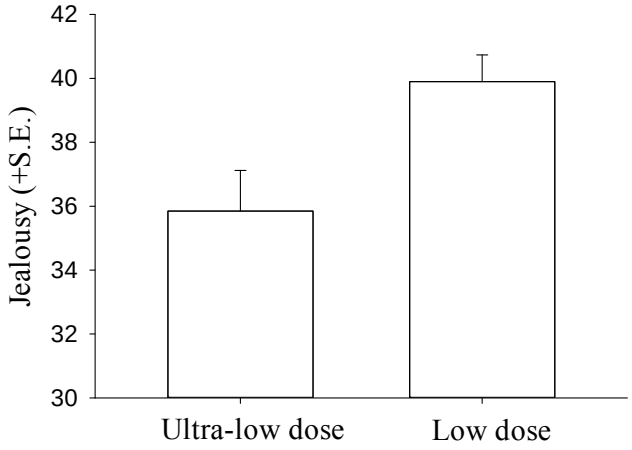


Figure 7. Difference in raw jealousy scores (+SE) for participants using oral contraceptives with ultra-low and low EE doses[11].

[11] Again, these means (based on a Dutch sample) are significantly lower than those observed in Chapter Three (using a Curaçao sample).

Discussion

Our findings demonstrate that COC EE dose directly influences women's self-reported jealousy. This result supports ideas by Geary and colleagues (2001), stating that high levels of circulating estrogen play a role in behavioural jealousy outcomes. It is also in line with the findings presented in Chapter Two and Chapter Three of this thesis, suggesting that estrogen, whether synthetic or natural, influences female jealousy response. The other key finding of this study is the lack of a relationship between synthetic progesterone dose and reported jealousy. This finding is in line with previous research and suggests that estrogen is most intimately involved in emotional behavioural outcomes (Fink et al., 1995; Steiner et al., 2003).

These findings are important for three reasons. The first is a practical point: when considering designs for future research on, for example, female mate choice and preferences, it may be important not just to distinguish between HC users and non-users, but also between those pill-users on ultra-low and low EE concentrations. Furthermore, our result draws attention to the effect size of the many studies which have been conducted by simply comparing pill and non-pill users without reference to EE dose: depending on the proportion of ultra-low versus low dose users within such studies, effect sizes may have been under- or overestimated.

Secondly, increased jealousy response could be seen as a negative side-effect of estrogen which has received little attention. Although there is an existing push towards developing COC's with lower levels of EE, this is largely due to the physical side-effects which result from higher EE concentrations (Poindexter, 2000). With the exception of studies focusing on female mood changes (e.g., Oinonen & Mazmanian, 2002; Joffe et al., 2003) and effects on mate preferences (see below), studies which document additional behavioural variables associated with COC have lagged behind those investigating physical outcomes. Although this study does not speak towards the benefits of HC use, of which there are many, it

seems that women, and perhaps pharmaceutical providers, are not fully aware of the range of potential behavioural side-effects associated with pill use and more specifically brand choice.

Thirdly, this study supplements the existing literature which suggests that HC pill use may influence female mate choice preferences and relationship dynamics. For example, evidence indicates that, relative to non-pill users, women on COC's show no or weaker preferences for masculine faces and voices (Little et al., 2002; Feinberg et al., 2008), and altered preference for genetic dissimilarity in partners (Roberts et al., 2008; Havlíček & Roberts, 2009). It may be that pill-associated changes in preferences for masculinity and genetic dissimilarity are mediated not just by the absence of an estrus phase but also by COC concentrations. Finally, the levelling effect that oral contraceptives provide compared with hormonal fluctuations across normal cycles may alter important temporal patterns in jealousy and responsiveness within pair-bonds. Since I find that women using low-dose COC report higher levels of jealousy compared to those using ultra-low doses, it may mean that these women suffer to a greater extent in forming and maintaining a pair bond.

One might argue that the causation of these findings is difficult to deduce. However, despite the potential for self-selecting differences between women using low and ultra-low concentrations, women in our sample did not differ in age or relationship status. Moreover, there are no clear medical guidelines according to which doses of COC's should be prescribed. However, following Roberts and colleagues (2008) and Chapter Two's methodology for attributing cause to behavioural consequences of COC use, future studies that make use of a within-subjects design (e.g., measuring changes in behaviour as women switch from one brand of COC to another) may be useful in fully disentangling this possibility.

Chapter 5

Hormonal contraceptive congruency: Implications for relationship jealousy

Cobey, K.D., Roberts, S.C., & Buunk, A.P. (in press). Hormonal contraceptive congruency: Implications for relationship jealousy. *Personality and Individual Differences.*

Abstract

Research shows that women who use HC's differ in their mate preferences from women who have regular cycles. It has been proposed that when a partnered woman either begins to use or ceases to use HC's, she may experience changes in her relationship since her preferences become incongruent with those prevalent at the time of her partner choice. This has not yet been directly tested. Here, in doing this, we aim to specifically test whether current and past HC use contributes to present levels of relationship jealousy. We find a significant interaction in levels of jealousy based on current HC use and HC use at the start of the relationship. When current HC use is incongruent with that at the start of the relationship, women report significantly higher levels of jealousy. Results are the first to suggest that both current and past HC use may influence relationship outcomes.

Introduction

A number of divergent factors influence female partner preferences at the initiation of a romantic relationship. Research from an evolutionary perspective, for example, has shown that women experience shifts in mating preferences across the menstrual cycle (reviewed in Gangestad & Thornhill, 2008). To reiterate from the General Introduction, when fertile as compared to non-fertile, women have been shown to prefer increased levels of relative masculinity in faces (Penton-Voak et al., 1999), bodies (Little et al., 2007), voices (Feinberg et al., 2006; Puts, 2005), scents (Grammer, 1993; Havlíček et al., 2005) and behaviours (Gangestad et al., 2007; Gangestad et al., 2004). Likewise, women are known to increase their preference for men with bilaterally symmetric traits when fertile (e.g., Gangestad & Thornhill, 1998; Rikowski & Grammer, 1999; Thornhill et al., 2003). Masculinity and symmetry are argued to be costly traits, which are difficult to maintain, and therefore are thought to index physical quality (e.g., Schieb et al., 1999). Cyclical shifts in female mating psychology may therefore function, in part, to aid women in choosing a partner of high physical quality when conception risk is highest (Gangestad & Thornhill, 2008; Little & Jones, 2012).

In contemporary populations however, the use of HC's among young women desiring reliable and reversible contraception is widespread. At present, more than 100 million women worldwide are currently using "the pill" for contraceptive purposes (Trussell, 2007). Recent evidence suggests that use of HC's interferes with the aforementioned cyclical shifts in female mating preferences (reviewed in Alvergne & Lummaa, 2010). This is because HC's suppress female fertility and flatten hormonal shifts which occur across the cycle (Frye, 2006). This may suggest that women who use HC's may be less attuned to indicators of male physical quality than women who have regular cycles and therefore that they may subsequently actually choose partners of lower physical quality than they otherwise would. This concept is best supported by evidence obtained from studies examining preferences for genetic dissimilarity at the Major Histocompatibility Complex

(MHC). The MHC codes for proteins involved in immune self/non-self-recognition, and increasing consensus for a link between overall MHC-heterozygosity and fitness has been established across a range of species including humans (e.g., Penn & Potts, 1999; Penn et al., 2002; Roberts et al., 2005). MHC-dissimilarity may be assessed via odour, and regularly cycling women appear to prefer the scent of MHC-dissimilar men, and relatively more often find that these odours remind them of their actual or former real-life partners (Wedekind et al., 1995). However, on initiation of HC's, women show a shift in preference towards the scent of men who are MHC-similar, suggesting that such use may interfere with adaptive mate choice (Roberts et al., 2008).

Little and colleagues (2013) have recently provided additional support for the idea that HC use interferes with natural female mating preferences. First, in a laboratory based study, they tracked women's facial masculinity preferences prospectively as they initiated use of HC's. They showed that preferences for masculinity in opposite-sex, but not same-sex, faces decreased following initiation of HC's. These shifts were not observed in a control group. Further, using real-world couples, they showed that women who met their partner while using HC's were more likely to be paired with men who were rated lower in overall facial masculinity than those who met their partner when they had regular cycles. This finding is in line with other research which has shown that women who use HC's show no shift, or a very weak shift, in preferences for increased masculinity across the cycle (Feinberg et al., 2008; Little et al., 2002). Somewhat less intuitively related to these findings, is the result of Jones and colleagues (2005) showing that women display a greater relative preference for health in the non-fertile phase of the menstrual cycle, and similarly, that HC users have higher overall preferences for health in faces than non-HC users. Taken together this suggests that masculinity and perceived health are judged distinctly from one another since preferences shift in opposite directions across the cycle and during HC use (e.g., Little et al., 2002; Little et al., 2008). Finally, in contrast to women with regular cycles, women using HC's also do not exhibit a mid-cycle peaks in attractiveness (e.g., Kuukasjarvi, et al., 2004; Miller et al., 2007)

or changes in symmetry preferences (Gangestad & Thornhill, 1998; Thornhill & Gangestad, 1999).

In the current study, I sought to expand on previous research which has examined HC pill effects on mate preferences through investigating if there are consequences of HC use for romantic jealousy. Jealousy is a basic affect which is aroused in situations where there is a loss, or a perception of loss, of a valuable relationship (Buunk, 1991). Jealousy can be seen as adaptive in that it may help to allow an individual to control and monopolize reproductive access and investment from their partner. I examined two possible ways in which contraceptive use might influence jealousy. First, in a replication of previous work (Geary et al., 2001; Chapter Two, Chapter Three) I tested the possibility that current contraceptive use increases levels of jealousy. Secondly, I tested the possibility that jealousy is mostly influenced by the congruency between current HC use status and that at the start of the relationship. This is a novel angle to approach the effects of HC's. More specifically, I propose that, because women who use HC's do not exhibit cyclical shifts in the preference for indicators of physical quality, a partnered woman who transitions either on to or off of HC's, may no longer be satisfied with her partner to the same extent. That is, the traits a woman chose in her partner at the start of the relationship may no longer satisfy her preferences when she changes her HC use status. For example, a woman who chooses a partner off of the pill may choose an individual who has outward indicators of physical quality such as a masculine facial structure; however, upon her transition to HC use she may find that her general preference shifts towards more feminine faces, and as a result, is no longer satisfied to the same degree by her partner. Herein, I will refer to this idea as the concept of contraceptive (in)congruency. I predict that such disruption in preferences may leave women with feelings of uncertainty about their relationship which may prompt feelings of jealousy. Indeed, previous research has shown that jealousy is provoked in situations of relationship uncertainty, and that jealousy is positively related to feelings of anxiety about one's attachment to their partner (e.g., Afifi & Reichert, 1996; Dainton & Aylor, 2001; Knobloch, 2005).

There is some recent evidence that contraceptive congruency, the correspondence between current HC use status and that at the initiation of a romantic relationship, may influence relationship dynamics. Roberts and colleagues (2012) showed that HC use versus non-use at the time of meeting one's partner plays an important role in future relationship satisfaction, both emotionally and sexually. They showed that women who met their partners when using the pill reported greater emotional satisfaction within their relationship, but lower levels of sexual satisfaction than women who had met their partner off the pill. This represents an unrecognized consequence of HC use that, until recently, had not been considered. Moreover, this study was the first to show that these subtle shifts have consequences for the quality of actual romantic relationships meaning that HC use could have long-term downstream consequences for relationships. Based on this finding, if contraceptive use changes or becomes incongruent to the start of the relationship, it may be that the dynamics of the relationship, and therefore potentially the expression of jealousy, are altered.

To summarize, I predicted that (1) current HC users will report higher levels of jealousy than women not currently using HC's, and that (2) incongruency between current HC use and contraceptive use at the time of meeting one's partner will produce higher levels of overall jealousy than congruency between these times.

Methods

Measures

Participants completed an online questionnaire which contained basic demographic items and the 15-item scale to assess jealousy (Buunk, 1997). Responses to the jealousy scale items were recorded on a 1-9 point scale, with higher scores indicating higher levels of jealousy (Cronbach's alpha = .86). Scores on the jealousy items were summed to obtain an overall measure on the scale. Participants also indicated how long they had been in their current relationship on a five-point scale (0 to 6 months, 6 to 12 months, 12 to 18 months, 18 to 24 months, and >24 months), if they were currently using HC's and whether at the time they started their

relationship with their partner they were using HC's or not (or if they "could not remember"). Responses to these last questions served as our key independent variables. Participants were also asked to report on general satisfaction within their relationship. This was captured by a single item question which asked "Overall, how satisfied are you in your relationship", answers being recorded on a 0-100 point scale with higher scores indicating greater levels of satisfaction.

Participants

Participants were 129 female undergraduate students from a large European University who received course credit for their participation. Participants completed all survey measures in their native language. All participants indicated that they were presently in a romantic relationship at the time of survey. They were told that we were conducting a study on relationship satisfaction. We excluded eight individuals from the analyses because they indicated that they were not exclusively heterosexual. This exclusion was made due, in part, to the fact that some jealousy scale items specifically asked for participants to imagine one's partner interacting with an opposite sex individual. No participant indicated that they did not remember whether they were using HC's at the time they started their relationship. A final sample of 121 participants was used for analysis, of which current HC use status was congruent with that when they started their relationship for 87 women. Among these 'congruent users' 71 were using HC's and 16 had regular cycles. The remaining 34 participants were 'incongruent users', and the vast majority had switch on to as opposed to off of HC since starting their relationship (N = 30). Participants reported to be born between 1961 and 1995 (N = 111 due to missing cases, M = 1990.59 (~22 years), SD = 3.65) and had dated their current partner on average for approximately one year (5 categories; 1 = 0-6 months, 2 = 6-12 months, 3 = 12-18 months, 4 = 18-24 months, 5 = > 24 months; M = 2.79, SD = 1.34).

Results

We first conducted a univariate ANOVA with jealousy as the dependent variable and current contraceptive use a as a fixed-factor (without considering congruency effects). This revealed a significant effect of contraceptive use ($F = 3.94$, $p = .049$), with women currently using HC's reporting higher levels of jealousy than those not currently using HC's (mean difference ± $SE = 9.11 \pm 4.59$), a finding which is consistent with previous research (e.g., Chapter Two; Geary et al., 2001).

We then conducted a univariate ANOVA with jealousy as the dependent variable and initial contraceptive use at the start of the relationship and current contraceptive use status as fixed factors. The results of this analysis revealed a significant interaction between contraceptive use status when starting the relationship and present contraceptive use status ($F = 3.94$, $p = .050$) (Figure 8). In this instance current HC use ($F = .89$, $p = .35$) as well as HC use at the start of the relationship ($F = .98$, $p = .32$) did not have a significant influence on the model.

Adding age to the model also did not influence the significance of the interaction ($F = 4.04$, $p = .047$) and age did not have a significant influence overall ($F = .001$, $p = .98$). Note that data for age from 11 individuals was missing for this analysis. The same pattern of results was found when relationship satisfaction was added to the model: the interaction remained significant ($F = 4.89$, $p = .029$) but relationship satisfaction was non-significant ($F = 2.18$, $p = .14$). Adding relationship length to the model as fixed factor (mean split) influenced the overall effect of the interaction such that it became marginally significant ($F = 3.48$, $p = .065$); however, relationship length did not have a statistically significant effect on the model ($F = 1.68$, $p = .20$) and again current use ($F = 1.14$, $p = .29$) and use at the start of the relationship ($F = .64$, $p = .42$) were non-significant in this model.

Based on these results we conducted a univariate analysis with jealousy as the dependent variable and present HC congruency with that at the time of initiating the relationship (congruent versus incongruent) as a fixed factor to test our congruency

hypothesis. Results from this analysis indicated that women whose contraceptive use status was incongruent with when they met their partner were significantly more jealous than those women whose status was congruent (mean difference ± *SE* = 7.55 ± 3.79, $F = 3.96$, $p = .049$) (Figure 9). As previously, we then controlled for participant age and relationship satisfaction by separately adding these items to the model as covariates. Neither of these variables had a statistically significant effect on the model (all $F < 1.93$, all $p > .17$) and in all cases the congruency factor remained significant. We also added relationship length to the model as a fixed factor, but it did not have a significant effect on the model ($F = 1.90$, $p = .17$) and the congruency factor remained significant ($F = 4.12$, $p = .045$).

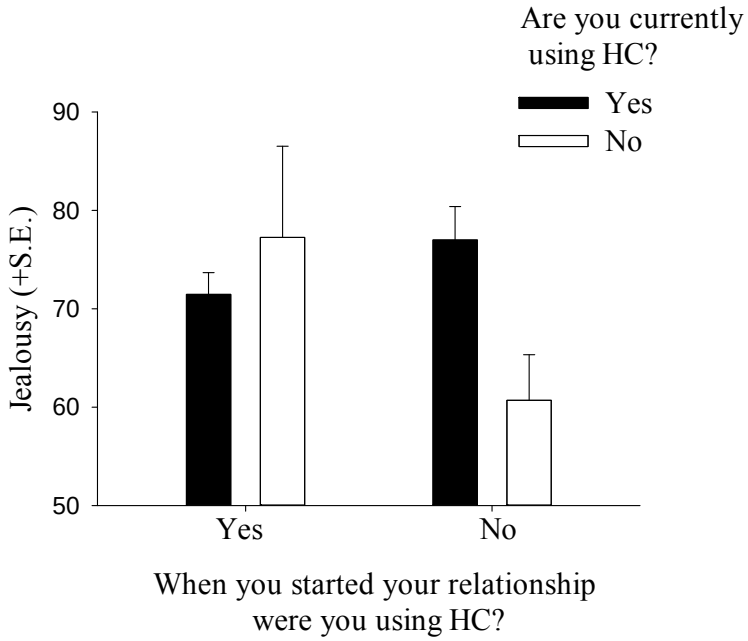


Figure 8. Test for the interaction of current and former HC use on levels of romantic jealousy (+*SE*).[12]

[12] A vigilant reader will notice that the mean scores on these scales are substantially higher than those previously obtained. Note that this is due to the fact that jealousy scores were recorded on a one-to-five-point scale in Chapters Two through Four, while the present data was recorded on a one-to-nine-point scale.

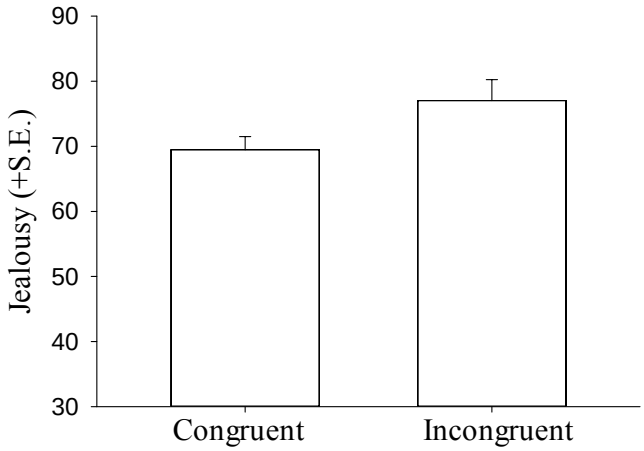


Figure 9. Mean jealousy scores (+*SE*) as a function of contraceptive congruency between current use status and use at the start of the relationship.

Discussion

Our results indicate that the congruency between current HC use and HC use at the start of a relationship has consequences for the expression of romantic jealousy within that partnership. Specifically, we find that, when controlling for a variety of potentially relevant factors, women report higher levels of jealousy if their HC use status is incongruent (as opposed to congruent) from when they initiated their relationship. This finding complements existing literature which suggests that use of HC's, which suppress cyclical variation in hormones, may interfere with adaptive preferences for indicators of physical quality which occur among regularly cycling women (e.g., Puts, 2005; Havlíček et al., 2005; Gangestad et al., 2004). Accordingly, switching use of HC's within an existing relationship may shift female preferences, and this may change the way that women perceive their partners. This suggests that transitioning from non-use to use of HC's can be disruptive for a relationship, but that so long as a woman uses HC's throughout the whole

relationship, while her preferences differ from when regularly cycling, her preferences are stable. Newfound uncertainty in one's partner, or one's shifted view on how their partner satisfies them when switching use status, may explain the feelings of jealousy documented herein (e.g., Afifi & Reichert, 1996; Dainton & Aylor, 2001; Knobloch et al., 2005).

Our data also showed that when not considering effects of use at the start of the relationship, at baseline, jealousy levels were significantly higher among women who currently use HC's than those who have regular cycles. This result is consistent with previous research (Chapter Two; Geary et al., 2001). However, it should be acknowledged that an even better test of this effect would have considered menstrual cycle stage of the regularly cycling women since it is known that jealousy levels increase during the fertile phase (Chapter Two; Geary et al., 2001).

Future research should seek to test an additional possible influence of HC pill effects, namely differences in behaviour based on ever having used HC's versus never having used HC's. It may be that there is a selection bias in the types of women who choose, at any point in their life, to use HC's. Such differences may be driven, for example, by religiosity or personality characteristics. However, in The Netherlands, where the current study was conducted, such a strong selection bias is unlikely. The Dutch have a very open discussion on sexuality within the mass media, with sex education beginning at a young age, and educational campaigns on contraceptive use which target hard to reach groups. Moreover, previous research exists which suggests the HC pills containing higher doses of synthetic estrogen are associated with higher levels of jealousy and mate guarding behaviour (Chapter Three; Welling et al., 2012). Unfortunately, information with respect to HC brand was unavailable in the present sample. This however, presents an interesting further possibility which can be examined in future studies, namely, how one's relative degree of HC congruency effects romantic jealousy. That is, women who met their partner on one form of HC and then subsequently switched to an alternative brand, can be considered to be 'more congruent' than those who changed HC use status

altogether. Future research recruiting larger samples with information on current and past brand type should aim to investigate this possibility.

A limitation to this research is that it did not consider how feelings of jealousy might translate into or prompt actual behavioural change. The extent to which differences in jealousy influence differences in behavioural outcomes between women whose contraceptive use status is congruent versus incongruent to when they met their partner therefore remains to be determined. However, it is worthwhile to note that the systematic study of jealousy may be difficult in that its expression can take many forms, and more importantly, it is often only displayed privately. Indeed, feelings of shame are often reported for expressing jealousy, therefore individuals may attempt to conceal or disguise such feelings (Clanton & Smith, 1977). Based on this, the differences in self-reported upset reported on the jealousy scale we used are therefore likely to reflect observable differences. Moreover, the finding of Welling and colleagues (2012) which showed that women on HC's, particularly those higher in synthetic estrogen dose, display heightened levels of mate guarding suggests that behavioural changes are occurring.

Finally, on average our participants had only been dating their partner for slightly more than a year and relatively new relationships may differ tremendously from longer ones. Expression of jealousy in a new relationship may alienate the partner (Bringle & Buunk, 1985) and jealousy may become more likely after passing through the initial passionate stage of the relationship. Nevertheless, the difference in jealousy levels depending on congruency of HC use was evident even in this sample of relatively young relationships and remained so after controlling for relationship length. This difference is consistent with, and is therefore likely to be a precursor to, differences in relationship satisfaction experienced among older women as a consequence of pill use during initial partner choice (Roberts et al., 2012). Furthermore, future work recruiting larger samples of women, particularly those who transition off of the pill, is necessary to confirm these results since our interaction was driven by women transitioning on to the pill. This might be accomplished by recruiting samples of older women who may no longer be using

HC's, perhaps because their partner has had a vasectomy, but who still have regular cycles. While it is clear that jealousy is higher among women using HC's, we have presented preliminary evidence to suggest congruency matters too. The theoretical concepts presented in this paper might also serve to prompt researchers to examine other social and relationship factors which contraceptive congruency may influence. In summary, our results suggest that changes in HC use over the course of a relationship may have a robust influence. Given the potential important social implications of increased jealousy within romantic relationships, improving our understanding of the mechanism that mediates changes during the transition to or away from using HC's, is of great importance.

Chapter 6

Hormonal contraceptive use lowers female intrasexual competition in pair-bonded women

Cobey, K.D., Klipping, C., Buunk, A.P. (2013). Hormonal contraceptive use lowers female intrasexual competition in pair-bonded women. *Evolution and Human Behavior*, 34, 294-298.

Abstract

The purpose of this study was to test the influence of HC use on levels of female intrasexual competition. Twenty-eight women completed a scale for intrasexual competition on three occasions: when using hormonal contraceptives and when regularly cycling at a fertile and a non-fertile cycle stage. When using HC, pair-bonded, but not single women, reported significantly lower levels of intrasexual competition than when regularly cycling at either fertile or non-fertile cycle stages. This effect remained significant when controlling for age, length of relationship and relationship satisfaction. Neither pair-bonded nor single women reported shifts in intrasexual competition across the menstrual cycle when fertile as compared to non-fertile. This study benefited from a within-subjects design and a more rigorous assessment of fertility status (transvaginal ultrasonography) than which is typical in the field. Results are discussed in consideration of the evolutionary literature on the stability of romantic relationships and fitness advantages associated with intrasexual competition.

Introduction

Over 50 years have elapsed since the introduction of HC's. During this time a great deal of research targeting the study of physical risks associated with their use has been generated (e.g., Kiley & Hammond, 2007). A new but growing body of literature suggests that in addition to physical effects, HC use may also have various psychological effects. In particular, the use of HC's may alter female preferences for indicators of male genetic quality and compatibility (Alvergne & Lummaa, 2010; Roberts et al., 2008). For example, a study by Gangestad and Thornhill (1998) found that pill users do not show preference for the scent of symmetrical men (an indicator believed to be associated with genetic quality), nor changes in symmetry preference across the month when fertile. Moreover, studies investigating attractiveness ratings show that there is no variation in such ratings across the cycle in men rating contraceptive users or in contraceptive users own preferences across the cycle (e.g., Kuukasjärvi et al., 2004; Pipitone & Gallup, 2008; Miller et al., 2007; Penton-Voak et al., 1999). Such alterations may potentially have evolutionary repercussions on relationship formation, long-term relationship satisfaction, and potentially upon actual reproductive outcomes.

In the present research, using a within-subjects design, we tested the influence of HC use on levels of female intrasexual competition. While studies investigating the impact of HC's typically compare between-subjects who are using HC and those who do not, using a within-subjects design is critical because women who use HC may differ on a number of dimensions (e.g., religiosity, economic status, relationship status) from non-users (Manlove et al., 2007; Kusunoki & Upchurch, 2011; Guendelman et al., 2000). Intrasexual competition refers to competition between members of one sex for access to mating opportunities with members of the opposite sex (e.g., Darwin, 1871; Andersson, 1994). It can involve direct physical competition but often, particularly between women, takes the form of more subtle behaviours such as competitor derogation (e.g., Buunk & Fisher, 2009; Fisher, 2004). While relative differences in gamete size and the evolution of

parental care may influence sex differences in the intensity of competition, with men typically competing to a higher extent for partners than women, certain situations are associated with a greater likelihood of female intrasexual competition (Trivers, 1972). For instance, in environments where men differ in their ability to provide resources or differ in physical health, such that there are few 'good men', intrasexual competition may be adaptive. In addition, competition may be elevated in individuals or environments where women need men more for resource provisioning or protection. Work by Burbank (1987) has shown that among women in polygynous societies living as co-wives competition exists over food, money and paternal care. In these instances intrasexual competition can be considered adaptive in that it allows a woman to compete more fiercely to successfully attract a partner and monopolize resources.

Previous research suggests that intrasexual competition relating to attractiveness varies across the menstrual cycle, with higher levels reported when fertile as compared to non-fertile. For example, Fisher (2004) showed that women derogate female, but not male, faces more when fertile as compared to non-fertile. Similarly, work by Durante and colleagues (2008; 2011) has shown that women non-consciously select consumer products which might enhance their attractiveness (e.g., sexy clothing) when fertile as compared to non-fertile. These findings have been explained in light of the idea that, when conception is possible, women have a greater desire to outdo attractive rivals to attract a high quality mate. In line with this idea, research by Vukovic and colleagues (2009) has shown that post-menopausal women are less derogating of attractive (feminine) female faces than pre-menopausal women. Indeed, postmenopausal women have less to gain from derogating same-sex rivals since they can no longer conceive. In light of these findings, herein we compared levels of intrasexual competition when using HC's to both fertile and non-fertile cycle stages. To do this accurately we used transvaginal ultrasonography which measures actual follicular size, to determine fertility. This methodology improves upon the crude, yet typically used (e.g., Fisher, 2004; Miller et al., 2007) 'counting method' which assigns fertility through counting forward or

backwards from the onset of menses to roughly gauge fertility status. Transvaginal ultrasonography also allows for the detection of anovulatory cycles in which LH surges occur but ovulation fails to follow.

It was predicted that women would report lower levels of intrasexual competition when using HC's as compared to when regularly cycling. Low levels of intrasexual competition may be detrimental to female fitness since it may mean that women are less likely to achieve or maintain high quality partners and investment. Our prediction that intrasexual competition will be lower during HC use is primarily based on the idea that HC's suppress the production of natural hormones including testosterone (Bancroft et al., 1991; Alexander et al., 1990; Swinkels et al., 1988). There is a large and diverse literature relating testosterone to competitive behaviour. For example, in female sporting competition testosterone is known to increase in anticipation of competition and is negatively related to losing (Bateup et al., 2002). Women have also been shown to release adrenal steroid hormones such as testosterone to facilitate courtship behaviour with high quality males. Preliminary evidence also suggests that HC use may disrupt this natural inclination to compete to obtain a mate: women using HC's did not experience increases in testosterone when in the presence of an attractive man (Lopez et al., 2009). Research by a number of investigators has also shown that higher dominance scores are associated with higher serum testosterone levels (e.g., Grant & France, 2001; Mazur & Booth, 1998; Mehta et al., 2009; Mehta & Josephs, 2010). Certainly, testosterone has been shown to be positively related to dominance behaviour across a wide range of species (e.g., Anestis, 2006; Beehner et al., 2005; Gould & Ziegler, 2007). Some evidence suggests that dominance rank in non-human primates is related to actual reproductive success, which clearly indicates the adaptive value of competing to achieve high rank (e.g., Dunbar & Dunbar, 1977; Noordwijk & van Schaik, 1999; Pusey et al., 1997).

If dominance is involved in the expression of intrasexual competition, then one would expect women using HC's to have lower levels of intrasexual competition.

There is indeed evidence for a relationship between self-reported dominance (as measured by IPIP http://ipip.ori.org/ipip/) and intrasexual competition (as measured by Buunk & Fisher, 2009) among women (unpublished data bivariate correlation: $r = .30$, $p < .0001$, $N = 330$ women).

In contrast to our idea that testosterone suppression might modify female-female competitive behaviour, other researchers have speculated that increases in estrogen mid-cycle underlie differences in competitive behaviour across the cycle. While this may be valid, it is also plausible that testosterone or a number of different hormones, or interactions of combinations of hormones, underlie these changes. To our knowledge no research has actually empirically shown that individual differences in measured estrogen reliably predict differences in intrasexual competition. Similarly, we know of no study showing that differences in the magnitude of estrogen change prior to ovulation (either between women or between months within an individual) actually relates to intrasexual competition. The concept that estrogen governs shifts across the menstrual cycle is however in line with research which has shown that individual differences in estrogen predict preferences for physical features such as masculinity assumed to be indicative of good genes (e.g., Feinberg et al., 2006; Roney & Simmons, 2008) and similarly that within-women shifts in estrogen predict attraction to cues of men's testosterone (Roney et al., 2011).

If intrasexual competition is governed by testosterone as we assume, we might expect to see higher levels among women when fertile as opposed to non-fertile since testosterone has been shown to fluctuate cyclically increasing from menstruation to mid-cycle in proximity to ovulation (Alexander et al., 1990; Bloch et al., 1988; Morris et al., 1987; Persky et al., 1978; Welling et al., 2007; Judd & Yen, 1973). However, other research suggests that changes in testosterone across the cycle, while significant, can be ignored since daily fluctuations (due to circadian rhythm) and seasonal fluctuations are greater (e.g., Dabbs and de La Rue, 1991). Some research even indicates that testosterone levels are stable across the menstrual

cycle (e.g., Pearlman et al., 1967; Dabbs, 1990; Schultheiss et al., 2003; van Goozen et al., 1997; Leining et al., 2010). If this is true, and if testosterone shifts underlie the effects, we would not necessarily expect a difference in intrasexual competition scores between the fertile and non-fertile phases of the cycle. Furthermore, since we use a scale to measure general intrasexual competition and not competition specific to attractiveness, while overall level differences may matter, it is unlikely that shifts in general intrasexual competition across the menstrual cycle would be evolutionarily adaptive.

Methods

Participants

Participants were recruited from a pre-existing pharmaceutical trial. Details of participant exclusion criteria and recruitment procedures to the trial are consistent with those described in Chapter Two. Participants were 28 women aged between 20 and 31 years (M = 22.90 years, SD = 2.49). Fourteen women reported to be in a relationship and fourteen reported to be single. Participants were paid for their participation in the study.

Measures

Participants completed Buunk and Fisher's (2009) 12-item scale for intrasexual competition three times: when using HC's, when fertile, and when non-fertile. Using a 1-7 point scale, participants reported how applicable each of the scale items was to them (with endpoints labelled 'not at all applicable to me' to 'completely applicable to me'). Examples of scale items include, "I want to be just a little better than other women." and "I tend to look for negative characteristics in women who are very successful". The scale had high reliability across items at each time measure (Cronbach's alphas between .8-.9). Pair-bonded participants were also asked at each survey measure to report how satisfied they were in their relationship. Scores were obtained from a single-item question, on a scale ranging from 0 to 100, with endpoints "not at all" and "completely", respectfully.

Procedure

At the time of recruitment participants had been using a combined oral contraceptive (which was prescribed by their family doctor) for at least three months. Immediately following recruitment participants completed their 'hormonal contraceptive use' survey on an active pill day. Participants then ceased use of their HC and underwent a washout cycle in which no measurements were taken. Following subsequent menses, on day nine of the cycle we began to track participants approximately every 3 days via transvaginal ultrasonography (GE Voluson E8 device, with a 4-8 MHz vaginal transducer) to observe follicular growth and access fertility. Participants were instructed to complete their 'fertile' survey as soon as possible when a dominant follicle, which was greater than or equal to 13 mm in size, had developed and the fertile phase of the cycle had been entered. Based on this criteria participants in our sample completed the fertile survey around day 14 (M = 14.70, SD = 3.42). We continued to observe participants via transvaginal ultrasonography to ensure that ovulation took place. Participants were scheduled to complete their 'non-fertile' survey approximately 6 days after we had observed ovulation but before the onset of anticipated menses (M = 11.29 days after fertile survey, SD = 3.43).

Predictions were tested using hierarchical linear mixed models, with measurements nested for each subject and a random intercept at the participant level (SPSS, 15.0). Parameters were estimated by Restricted Maximum Likelihood and the model had absolute convergence in terms of loglikelihood, parameter and Hessian convergence. In the initial model scores on the scale for intrasexual competition were entered as the dependent variable, with fertility status (pill use, fertile, non-fertile) and relationship status as fixed factors. Subsequently, we analysed the data for single and pair-bonded women individually adding age, length of relationship and relationship satisfaction as covariates. Note that when analysed using repeated measures ANOVA's results were consistent to those reported herein.

Results

The overall effect of fertility status on intrasexual competition obtained from the linear mixed model was non-significant (F = 2.08, p = .14) as was the main effect for relationship status (F = .004, p = .95). However, the interaction between relationship status and fertility status within this model was statistically significant (F = 3.27 p = .046). Given this interaction, we proceeded to re-analyse the data for single and pair-bonded women separately. For pair-bonded women, the overall linear mixed model was significant (F = 5.68, p = .009). Pairwise comparisons indicated that levels of intrasexual competition were significantly lower during HC use than when regularly cycling at fertile as well as non-fertile phases (HC vs. fertile: Mean difference = -5.21, SE = 1.64, p = .004; HC vs. non-fertile: Mean difference = -4.14, SE = 1.64, p = .018). When regularly cycling, there was no significant difference between levels of intrasexual competition at the fertile as compared to the non-fertile stage (Mean difference = 1.07, SE = 1.64, p = .52) (see Figure 10). Participant age (F = 1.31, p = .275), length of relationship (F = .21, p = .65) and relationship satisfaction (F = .58, p = .45) did not have significant effects on the model. For single women, the overall linear mixed model was not significant (F = .485, p = .62). Among single women, there was no significant difference in levels of intrasexual competition when using HC's or when regularly cycling (Mean difference = 1.21, SE = 1.92, p = .53; Mean difference = -.64, SE = 1.92, p = .74), nor was there a significant shift in levels across the menstrual cycle when fertile as compared to non-fertile (Mean difference= -1.86, SE = 1.92, p = .34) (see Figure 11).

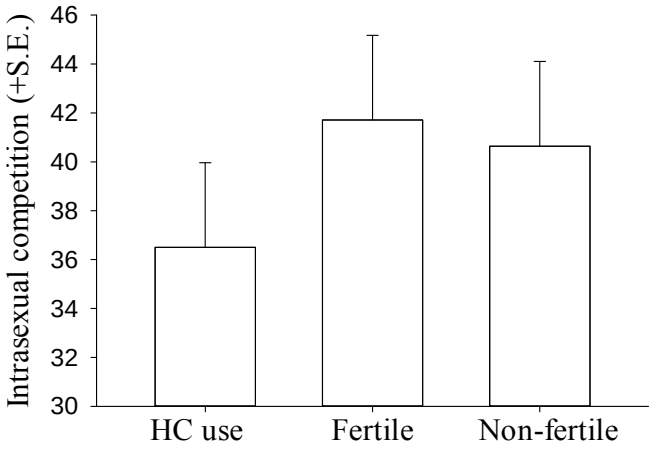


Figure 10. Levels of intrasexual competition (+*SE*) when using HC's as compared to when regularly cycling among partnered women.

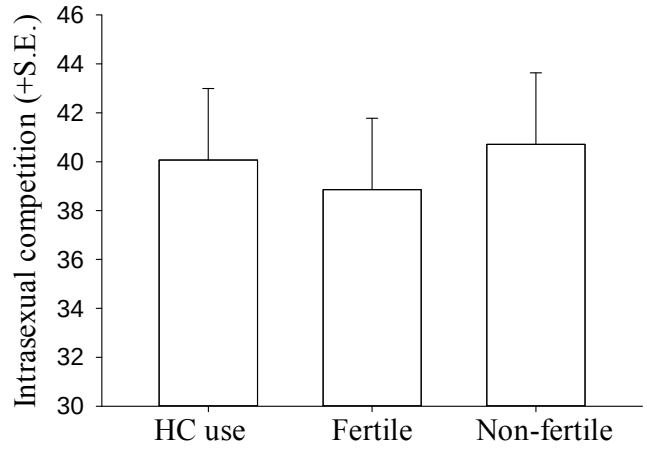


Figure 11. Levels of intrasexual competition (+*SE*) when using HC's and when regularly cycling among single women.

Discussion

We predicted that HC use, which lowers testosterone levels (e.g., Bancroft et al., 1991; Alexander et al., 1990; Swinkels et al., 1988), would be associated with lower levels of intrasexual competition than when regularly cycling. Our results supported this prediction but only among pair-bonded women. This may be a result of the fact that intrasexual competition functions differently in single versus pair-bonded women. Single women, who have not already obtained a mate, may be less influenced by decreases in steroid hormones such as testosterone during HC use because, overall, the cost of not competing for a mate is higher. It is, for example, possible that single women's generalized desire to obtain a mate overrides potential effects of contraceptive use.

Our results also showed that, when regularly cycling, for both single and pair-bonded women, there was no significant difference in levels of intrasexual competition when fertile as compared to non-fertile. Previous research has shown that women more strongly degrade the attractiveness of female faces during phases of high, relative to low, fertility (Fisher, 2004). Likewise, Durante and colleagues (2008; 2011) showed that women unconsciously aim to look more attractive when fertile, placing them in a better position to compete with rivals. If this is taken as behavioural evidence of intrasexual competition, at first glance, our findings require further explanation. Firstly, it should be acknowledged that Fisher (2004) used a between-subjects sample in her study. Failing to track women prospectively across the cycle may mean that results are a product of subtle group differences between women who were fertile versus non-fertile at the time of survey. Furthermore, physical attractiveness is one of a number of dimensions on which women may compete intrasexually. Accordingly, because we used a scale to measure intrasexual competition which encompasses several broad domains in which competition may occur, our results in contrast to those of Fisher (2004) and Durante and colleagues (2008; 2011), are not specific to competition in the arena of physical attractiveness.

Our results do not provide evidence for the concept that mid-cycle shifts in estrogen promote intrasexual competition. Estrogen may be responsible for intrasexual competition as it relates to attractiveness; however, since we do not observe a shift in intrasexual competition mid-cycle when estrogen is high, it is difficult to implicate estrogen levels as the mechanism behind shifts in general competitive behaviour. In line with literature examining the role of testosterone in competition, and the notion that testosterone is suppressed during HC use, we suggest that testosterone is the mechanism behind the lower levels of generalized intrasexual competition observed.

If testosterone influences the expression of intrasexual competition, the absence of cyclical shift in reported levels of intrasexual competition documented herein can be considered consistent with finding that testosterone is stable across the cycle. However, given that other scholars report an increase in testosterone mid-cycle, an alternative explanation may be that shifts in testosterone across the cycle are smaller in magnitude to those which occur upon the transition to HC use. As a result, women's expression of intrasexual competition at a more general level may not be sensitive to these subtle changes.

Using a prospective design, Chapter Two has shown that when women use HC's they report higher levels of jealousy than when they are regularly cycling. Preliminary evidence from Chapter Four also suggests that specific types of contraceptives, namely those containing higher doses of synthetic hormones, are associated with even greater levels of jealousy (see also Welling et al., 2012). Interestingly, in the current study and the prospective study on jealousy in Chapter Two, significant effects were only observed among partnered women. Taken together, this suggests that HC's may have specific and distinct consequences based on the relationship status of the user. Future research which tracks women longitudinally as they leave relationships or enter relationships may thus be valuable in further explaining these findings.

The current research is among the first to document HC induced shifts in female behaviour. If HC use indeed lowers intrasexual competition among pair-bonded women, this would suggest that users who are pair-bonded may suffer negative evolutionarily relevant consequences from their use of HC. For example, lower levels of intrasexual competition among HC users might also result in a greater potential to have one's mate 'plucked' by another woman, given that HC users may be less attentive to cues to competition or threats from external females, or simply less likely to respond to such cues. If HC use reduces a natural propensity for partnered women to compete for mates it may mean that many women in our contemporary population (where HC use is widespread) have a reduced ability to attract new mates or to maintain their existing partner. Acquiring a new mate when in an existing relationship may allow a woman to obtain more resources from a partner. In light of our findings, women using HC's may be at a disadvantage in that they are less likely to seek out and switch to a new partner for whom they might acquire additional benefits. Overall, this could impact female fitness since women who use HC's may settle and start families with partners who they otherwise would not. Furthermore, selection may have favoured a particular level of testosterone in women (so as to ensure women can adequately manage the trade-off between mating effort and parenting effort) and within our contemporary population the novel use of HC's may then be altering the mean population levels of testosterone. This in turn may have evolutionary outcomes at the individual and population level.

Although the current research provides important insights into the potential for HC induced behavioural changes to influence components of mate choice, it is not without limitation. For example, the order of testing was not randomized, introducing the potential for testing effects. Further investigations should also seek to actually measure circulating testosterone levels to assess within-person variation in the degree of testosterone shifts when using HC versus regularly cycling. This research has the potential to demonstrate individual differences in the effects reported. Indeed, it is also possible other hormones, namely estrogen and progesterone, which vary across the cycle and during contraceptive use, may be the

mechanism influencing these behavioural changes and future research which incorporates hormonal assays is required to determine what role, if any, they have in the expression of intrasexual competition. Given the literature relating dominance and testosterone as well as competitive behaviour and testosterone (e.g., Grant & France, 2001; Mazur & Booth, 1998; Mehta et al., 2009; Mehta & Josephs, 2010), we think it is most likely that shifts in testosterone explain our findings. Likewise, estrogen and progesterone fluctuate in pronounced patterns cyclically among women not using HC's and therefore we would have expected to see a cyclical shift in intrasexual competition if these hormones were implicated in general female-female competitive behaviour. In contrast, cyclical shifts in testosterone are less robust and have previously been shown to be lesser than daily fluctuations in testosterone (e.g., Dabbs & de la Rue, 1991). To conclude, we hope that these findings stimulate further investigations which examine the potential for HC use to disrupt aspects of human mating psychology.

Chapter 7

Men perceive their female partners, and themselves, as more attractive around ovulation

Cobey, K.D., Buunk, A.P., Pollet, T.V. Klipping, C., & Roberts, S.C. (revision submitted). Men perceive their female partners, and themselves, as more attractive around ovulation. *Biological Psychology*.

Abstract

The purpose of this study was to test whether men perceive changes in their female partner's attractiveness as a function of her fertility status. We further test how male self-perception varies in relation to partner fertility status. We find that men rate their female partner as more attractive near to ovulation (when fertile) as compared to during the luteal cycle phase or during hormonal contraceptive use. Moreover, our results point to a presently unrecognized negative consequence of hormonal contraceptive use on male self-perception, with men rating themselves lower in attractiveness when their partner is using hormonal contraceptives than when she is regularly cycling. This study benefits from the use of transvaginal ultrasonography to detect fertility during the regular cycle and the use of a within-subjects design (both across the cycle and during hormonal contraceptive use). Results will be discussed in terms of their impact on within-couple social dynamics.

Introduction

Accumulating evidence from laboratory studies shows that women are perceived as more attractive near to ovulation (Haselton & Gildersleeve, 2011). However, research assessing the real world implications of cyclical shifts in female attractiveness is largely unexplored. Notable exceptions are studies showing that lap dancers earned more tip money (Miller et al., 2007) and that men become more proprietary over their partners (Gangestad et al., 2002) when fertile. These effects may occur because men perceive physical changes associated with fertility as more attractive, or alternatively, because women actually behave more attractively. Somewhat surprisingly, however, no study has yet examined the role of cyclical shifts in female attractiveness within romantic couples. Here, we investigate whether changes in men's perceptions of their female partner's occur across her menstrual cycle. In addition, we investigate whether such attractiveness changes are associated with changes in male partner's self-perception, since being partnered with someone rated as closer to one's ideal preference is associated with higher levels of satisfaction, which may subsequently influence self-perception (Campbell et al., 2001). Finally, we test how both these measures may be influenced by use of hormonal contraceptives (HC's), because women who use HC's do not exhibit the aforementioned cyclical shifts in attractiveness or preferences (Alvergne & Lummaa, 2010).

Methods

We used a within-subjects design in which couples were first tested while using HC's, and then, following discontinuation and a washout cycle, near to ovulation and during the luteal phase. Female fertility was assessed using transvaginal ultrasonography, beginning on cycle day nine. Participants completed their non-fertile survey approximately ten days after ovulation occurred. We tested 14 committed heterosexual couples, aged 25.00 years (21-31, *SD* = 2.91) and 23.29 years (20-29, *SD* = 2.61) for male and female partners, respectively. Inclusion

criteria and test procedures are consistent with those of Chapter Two and Chapter Six.

At each survey stage, participants were asked to respond to the following variable: 'Compared to other [women/men] your age, how attractive do you feel you are?' on a 0-100 slider scale with endpoints 'much less attractive than average' and 'much more attractive than average'. Female participants also completed the Menstrual Distress Questionnaire (MDQ; Moss, 1968). In addition, male participants indicated: 'Compared to other women their age, how attractive is your partner?' and 'Overall, how satisfied are you in your relationship' on a 0-100 slider scale, with endpoints being 'much [less/more] attractive than average' and 'not at all satisfied' to 'completely satisfied'. Finally, male participants reported whether they had sex with their partner in the past two days.

Results

Data were analysed using Hierarchical Linear Mixed Modelling with a random intercept using restricted maximum likelihood estimation. We first tested whether men were sensitive to changes in their partner's attractiveness, with male ratings of female attractiveness as the dependent variable and female fertility status (HC, fertile, non-fertile) as a fixed factor. This revealed a significant overall effect of fertility status (F = 3.87, p = .034, Figure 12): males rated their partner as more attractive when she was fertile than both when non-fertile (mean difference = 3.71, SE = 1.57, p = .026) or using HC's (mean difference = 3.86, SE = 1.57, p = .021). This effect remained significant when controlling for male age, relationship length, relationship satisfaction and recent sex (all F < .023, all p > .88); neither did adding female mood (MDQ scores; 1 participant missing; F = .015, p = .90) or female self-ratings of attractiveness (F = .027, p = .87).

Next, we tested whether female cycle phase influenced male partners' self-perception. We found a significant overall effect (F = 3.51, p = .045) and pairwise

comparisons revealed that men rated themselves as significantly more attractive only when their partner was fertile compared to when she was using HC (mean difference = 7.50, *SE* = 2.85, *p* = .014). Finally, we conducted a similar analysis using female self-perceived attractiveness as the dependent variable. This model was not significant (*F* = 1.21, *p* = .32), indicating that women's self-perception remained constant across survey stages.

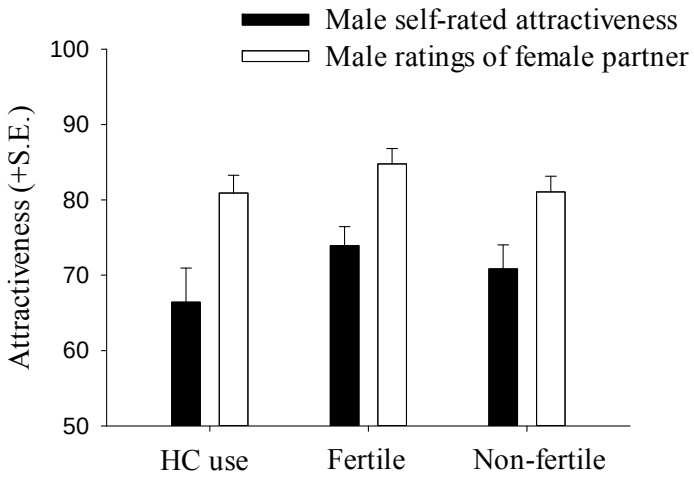


Figure 12. Male partner perception and self-perception as a function of conception risk. Men perceive their partner to be more attractive when she is fertile than when she is either non-fertile or using HC's. Male self-perception is significantly higher when the partner is fertile than when using HC's. Combining fertile and non-fertile measures suggests that men perceive themselves as more attractive when their partner is regularly cycling than when she is using HC's.

Discussion

Our data provide the first evidence that men in relationships detect changes in their partner's attractiveness as a function of cycle phase. Furthermore, cycle phase has consequences on male self-perception. The findings complement the existing body of literature showing that women are rated as more attractive when fertile as compared to non-fertile, and extend findings in this area by documenting a significant decrease in perceptions of female attractiveness during HC use. Although our sample size is modest, our findings are consistent with theoretical predictions and our within-subjects experimental design, which incorporates both key cycle phases and use of HC, is statistically powerful.

One possible mechanism for shifts in men's perception may be differences in the female partner's behaviour. Haselton and Gangestad (2006) found that women regard themselves as more attractive when fertile. However, Hill and Durante (2009) found that women's self-esteem was reduced around ovulation, and in our sample, female self-perception did not differ across measures, suggesting that this may not be responsible for the reported effects in male partners.

We suggest a more likely explanation is a change in perception of women's physical attractiveness (Haselton & Gildersleeve, 2011). For example, women's faces appear more attractive at ovulation compared with the luteal phase (Roberts et al., 2004), perhaps due to cyclical changes in facial texture and shape (Oberzaucher et al., 2012). Similar changes occur in attractiveness of women's body odour (Havlicek et al., 2006; Kuukasjarvi et al., 2004) and voices (Pipitone & Gallup, 2008).

Finally, interestingly, while men's assessment of their partner's attractiveness was equivalent in the two non-fertile measures (HC use, luteal phase), their own self-perception was lowest when their partner used HC's. HC use appears to demolish cyclical changes in other-rated attractiveness but does not induce an attractiveness

difference between users and non-users (Kuukasjarvi et al., 2004). This then raises the intriguing possibility that men's heightened self-perception in their partner's ovulatory phase extends into the luteal phase, in a manner not experienced by partners of HC users. Thus, in addition to our novel evidence for cycle-related shifts in men's perception of their partner's attractiveness, and in their own self-perception, our results hint at a hitherto unrecognized negative consequence of HC on within-couple social dynamics.

Chapter 8

General Discussion

Based in part on:

Cobey, K.D., & Buunk, A.P. (2012). Conducting high quality research on the psychological impact of oral contraceptive use. *Contraception*, 86, 330-331.

Roberts, S.C., Cobey, K.D., Klapilová, K., & Havlíček, J. (in press). Oral contraceptives and female sexual desire: An evolutionary approach offers a fresh perspective. *Archives of Sexual Behaviour*.

This thesis sought to examine psychological behaviour in intimate relationships across the menstrual cycle and during HC use. To date, while an increasing number of studies have examined menstrual cycle effects on intimate behaviour, similar effects have largely been overlooked within the literature on HC use. If unrecognized psychological side effects of HC use exist, staggering numbers of women worldwide are being subjected to negative outcomes due to HC use without their knowledge. Studies which have attempted to study psychological effects resulting from HC use largely focus on changes in general mood or libido (e.g., Oinonen & Mazmanian, 2002; Sanders et al., 2001). I have discussed at length in the General Introduction possible reasons for why psychological side effects of HC's may not have been given the attention they deserve by researchers. Ultimately, it is irrelevant what the cause(s) of this may be: the lack of conclusive research is inadequate by any account for the millions of women who use HC and their medical providers. Moreover, the existing literature examining changes in female social behaviour induced by menstrual cycle shifts and HC use is plagued by weak methodological approaches wherein women are compared between-subjects and reliable measures are not used to confirm the stage of the menstrual cycle.

The present research sought to improve upon these shortcomings by using within-subjects designs and to expand the theoretical focus of literature in this area. Informed from an evolutionary psychology perspective I specifically sought to study subtle interpersonal processes that may be affected by shifts in the menstrual cycle as well as by HC use. This thesis was subdivided into two parts, which I now provide a brief summary of. Following this, I will elaborate on the implications of my findings and discuss theoretical issues that my work on this topic has raised. Subsequently, I will provide a discussion of the hormonal mechanisms that I speculate are involved in cyclical shifts and HC pill effects on female psychology. Finally, I will conclude with a discussion of the practical implications of the research.

Part One: *Hormonal influences on female jealousy*

Chapters Two through Chapter Five of this thesis examined menstrual cycle and HC effects on the expression of female jealousy. Chapter Two describes the results of a within-subjects experiment in which women's self-reported jealousy behaviour was tracked when participants were fertile, non-fertile and using HC's. This study can, in many respects, be considered the foundation of my thesis research. Results indicated that jealousy levels were higher when fertile as compared to non-fertile. Among partnered women, HC use was associated with levels of jealousy equivalent to the levels when fertile. This suggests that HC use, at least among partnered women, alters the expression of romantic jealousy. To my knowledge, this is just the third study in this area which has been published using a within-subjects design tracking women on and off of HC's, and the first study to do so which examined jealousy. It contributes to the field as a methodological paper and sets a standard at which future HC and menstrual cycle phase research should be conducted.

In Chapter Three, I examined shifts in jealousy across the menstrual cycle among women from Willemstad, Curaçao. To date, the vast majority of research documenting cyclical shifts in female preferences and behaviour across the menstrual cycle comes from Western samples of Caucasian students. This, of course, is a general weakness of most psychological research (Henrich et al., 2010). Chapter Three is thus among the first studies in the field to examine cyclical shifts in behaviour among a sample of African Caribbean women. Also unique to this study is that the vast majority of the sample was non-students. In contrast to Chapter Two, for ease of sampling, the results reported in Chapter Three are based on a more crude between-subjects sample. Again, results indicated that women reported significantly higher levels of jealousy when fertile as compared to non-fertile. Results were maintained when controlling for age, relationship status and relationship satisfaction. This finding, in combination with the results of Chapter Two, suggests that shifts in jealousy across the menstrual cycle are robust when examined across cultures and when assessed via different methods. Interestingly

when one considers the results of Chapter Two and Three in combination we see that while shifts in jealousy across the cycle are consistent in both samples, baseline levels of jealousy were significantly higher among women from Curaçao. This is likely to be explained by cultural differences in family structure (i.e., female headed households) uneven sex ratios and higher rates of economic stratification within Curaçao (Abraham-van der Mark, 2003; Ministerie van Binnenlandse Zaken en Koninkrijksrelaties).

Since HC use influenced jealousy among partnered women in Chapter Two, I next designed a study to determine if all HC's increase jealousy to the same extent. The most commonly used form of HC, the combined oral contraceptive pill, consists of synthetic estrogen and progesterone. However, a number of pill formulations which differ in synthetic estrogen and progesterone concentration are available on the market. To examine the possibility that different contraceptives differentially influence jealousy response I recruited a large sample of women who were using a variety of forms of combined HC pills. In Chapter Four, I report the results of this study, where I found that women who used HC's containing higher doses of synthetic estrogen reported higher levels of jealousy than those women who used pills containing relatively lower doses of synthetic estrogen. This result was maintained when controlling for age, relationship status and synthetic progesterone dose. This is the first study to my knowledge which has examined HC effects on female social behaviour more acutely. Results from this study suggest that research using a 'pill user' versus 'non-pill user' comparison simplifies a more complex process. Since publishing this finding the results have been replicated by an American research group with respect to partner mate guarding (Welling et al., 2012). This suggests a degree of robustness in the result which demands further inquiry. It is important to replicate these finding within other domains of behaviour, but also through use of within-subjects designs in which the same woman transitions from one form of combined oral contraceptive to another. Considered in relation to Chapter Two and Chapter Three, these findings seem to implicate estrogen in the expression of jealousy. Work by Geary and colleagues (2001)

showing a positive correlation between estrogen and jealousy reports further substantiates this idea. However, Geary and colleagues (2001) only found that the relationship between estrogen and jealousy was significantly related in cycle week two. This finding complicates the association to some degree, suggesting future research tracking women over multiple months is needed to clarify this relationship.

Chapter Five reported the results of a study that considered how HC use history within a relationship might contribute to present levels of jealousy. I found that relationship jealousy is higher among couples in which the woman's current HC use status is incongruent with that at the initiation of the relationship as compared to couples whose current use was congruent to use at the start of the relationship. This suggests that preferences which are prevalent at the initiation of the relationship are altered by subsequently transitioning to HC use and that this has outcomes on relationship dynamics. This study is novel in that it is among the first to account for HC use at the initiation of the relationship. Future research which tracks couples longitudinally as they transition on to or off of HC's would be an obvious follow-up to the findings reported in this chapter. Further, the finding that HC use at the initiation of the relationship predicts aspects of downstream relationship satisfaction may be relevant to contraceptive prescribers.

Part Two: *Explaining shifts in jealousy: The role of attractiveness and intrasexual competition*

In Chapters Six and Chapter Seven I attempted to disentangle the mechanism behind shifts in jealousy across the cycle and during HC use which I documented in Part One. As outlined in Chapter Two and Chapter Three it is not immediately clear why cyclical shifts in jealousy would be adaptive and therefore enhance fitness. One possibility is that levels of jealousy when fertile are a reflection of higher levels of intrasexual competition at this time. Indeed, increases in competitive behaviour when fertile may help a woman to obtain or retain a high quality mate more easily than she otherwise would.

I examined this possibility in Chapter Six. To do this I tracked levels of intrasexual competition among a group of women who were initially using HC's but subsequently ceased use. Participants reported levels of intrasexual competition when using HC's and when regularly cycling during fertile as well as non-fertile cycle stages. Results revealed that in partnered, but not in single women, levels of intrasexual competition were lower when using hormonal contraception than when regularly cycling. In neither single nor partnered women were shifts in intrasexual competition observed across the menstrual cycle. Based on the absence of cyclical shifts in intrasexual competition, it does not appear that intrasexual competition could be driving the aforementioned increases in jealousy when fertile as reported in Chapter Two and Chapter Three. The finding that intrasexual competition is lower among pill users (who have suppressed testosterone) is however consistent with the idea that testosterone influences competitive behaviour (Archer, 2006). Future research is needed to validate the explanation that testosterone suppression during HC use underlies the observed difference in intrasexual competition.

Chapter Seven examined cyclical shifts in perceptions of attractiveness. It tracked a modest sized group of women and their male partners across the menstrual cycle and during HC use as in Chapter Two and Chapter Six. If changes in self-perception were to occur across the female cycle, this might explain the shifts in jealousy observed in Chapter Two and Chapter Three. A series of laboratory based studies have shown that females are rated as more attractive when fertile as compared to non-fertile, but there is an absence of studies testing the implications of these subtle shifts. The results presented in Chapter Seven indicated that men judge their female partners as significantly more attractive when she is fertile as compared to when she is non-fertile or when she is using HC. Further, male self-perception was shown to be significantly more positive when the female partner was regularly cycling than when using HC. In spite of this, there was no difference in female self-perceived attractiveness across conditions. This study is novel to the literature in that it was the first menstrual cycle study which surveyed men across their female partners

menstrual cycle. Previous research has made use of female self-reports of male behaviour. As with intrasexual competition, the absence of shifts in self-perceived attractiveness across the cycle, suggests that this variable does not explain the patterns we observe in the expression of jealousy. Thus, while it remains plausible that other factors may influence jealousy, we have not found evidence in our studies of what shifts in jealousy, if not adaptive, could be a by-product of.

What's going on?

One possibility is that shifts in jealousy are a by-product of changes in levels of sexual desire. Indeed, it is well known that sexual desire increases near to ovulation when fertile (e.g., Bullivant et al., 2004). This is in line with my finding that jealousy is higher when fertile as compared to non-fertile (Chapter Two; Chapter Three). The pattern of association between sexual desire and HC use is less clear. However, concern about the impact of HC use on women's sexual functioning, particularly lowered sexual desire (or libido) has been expressed for almost as long as HC's have been available. Despite numerous studies over several decades, however, we still do not know the underlying mechanism for any negative effects, nor can we predict which women will suffer from them (Sanders et al., 2001). In order to implicate jealousy as a by-product of sexual desire it is necessary to understand how sexual desire is impacted by HC use.

Research on this topic has consistently produced mixed evidence, of two kinds. First, there is mixed evidence across studies: some report negative associations between desire and HC use, others find no effect, and still others report positive effects (for recent reviews, see Schaffir, 2006; Burows et al., 2012; Davis & Catano, 2004; Pastor et al., 2013). Second, within their respective samples, the aforementioned studies also consistently report considerable individual variation in women's experience: relatively large proportions of women experience either a marked increase or decrease in desire, with others unaffected. For example, in a prospective study, 17% had higher frequency of sexual thoughts and 39% had lower

frequency, following initiation of HC use (Sanders et al., 2001). The picture is further obscured by the fact that direct comparisons across studies are made difficult due to wide variation in methodologies and HC formulations under test. The results contained in Chapter Five of this thesis showing dose dependent HC effects on the expression of jealousy suggest that such comparisons may be problematic. Researchers typically conclude, on the basis of these mixed effects, that the influence of HC use on sexual desire is complex and likely due to multiple psychosocial influences. Indeed, the most recent systematic review concluded that "we cannot define a single indicator reliably and clearly characterising a cause-effect relationship. This is mainly due to the simultaneous and intertwined effects of a variety of complex biological, psychological, social, and multidimensional factors" (Pastor et al., 2013). While this may be an accurate reflection of the current state of play, it is clearly unsatisfactory both to women concerned about possible consequences for their relationships and to healthcare providers who are unclear about what advice to give. Against this background, new perspectives that might help to clarify the issue should be seized upon and scrutinized carefully. Here, I will first describe a prediction drawing from the interface between psychology and evolutionary biology which may clarify the mixed patterns of results with respect to the effect of HC's on sexual desire. Following this, I will discuss how this explanation is consistent with my proposition that jealousy is a by-product of levels of sexual desire, and thus provides an explanation for the findings contained in Chapter Two through to Chapter Five.

I have previously discussed literature demonstrating the potential for HC use to alter women's partner preference (Alvergne & Luumma, 2010). HC use could therefore have important consequences on women's sexual relationships, because it alters both women's attraction to their partner and, potentially, to other men. Recall, for example, that women using HC's show a shift in preference for MHC similar women (Wedekind et al., 1995; Roberts et al., 2008). A study of US women in established relationships, showed that those partnered with men who shared a relatively high number of MHC alleles expressed lower sexual responsivity and

satisfaction with their partner compared with women whose partner was relatively MHC-dissimilar, and particularly so around ovulation (Garver-Apgar et al., 2006). Furthermore, in the same women, within-couple MHC similarity was also associated with higher frequency of women's sexual thoughts about, and actually engaging in sexual activity with, other men. This raises a fundamental consideration for studies of the relationship between HC use and female sexual desire: a critical distinction needs to be made between a woman's general sexual desire and her specific desire for her partner. Previous studies have almost ubiquitously failed to make this distinction. These studies typically employ one of a range of standard questionnaires to measure desire, but examination of these scales shows that they lack sufficient specificity in their respective lists of items. Table 2 shows the higher-order facets of female sexuality, and the target (general or partner-focused) specified in the questionnaire rubric, for six of the most commonly used questionnaires in this area of research. While each of the questionnaires contains items that quantify general sexual desire, not one contains an item specifically about desire for (nor about arousal, lubrication or orgasm during sex with) the woman's main sexual partner. Furthermore, even though several questionnaires contain items relating to partner-focused sexual satisfaction, which is likely correlated with desire, these items are often subsumed within global sexuality scores or in desire subscales which also incorporate general sexual desire (e.g., Wallwiener et al., 2010; Panzer et al., 2006).

Studies demonstrating the influence of HC's on partner choice lead to a further novel, simple and testable idea. This is that congruence between current HC use and previous use (specifically during relationship formation) should more accurately predict a woman's sexual desire for, and satisfaction with, her partner than current HC use in isolation. This concept is in line with the ideas presented in Chapter Five. If a woman's HC use is congruent (i.e., current HC users who were HC users when they met their partner, current non-users who were non-users when they met their partner), her current preference will more closely match the preference that shaped

her partner choice in the first place. The corollary is relatively higher desire for that partner than a woman whose use is incongruent.

The hypothesis generates further testable predictions (Figure 13). One is that women who meet their partner while using HC will tend to experience decreased desire when they subsequently cease use, as their partner preferences realign to their baseline state. A recent study tested this prediction in a survey of >2500 women. As predicted, among current non-users, those who had used HC when they met their partner reported lower attraction to, and lower sexual satisfaction with their partners compared with those who had been non-users (Roberts et al., 2012). A second, but so far untested prediction is that women who were non-users when they met their partner and who subsequently initiate HC use will tend to experience similar negative effects on sexual desire, arousal and satisfaction.

Thus, the congruency hypothesis suggests that decreased desire could be experienced both by ceasing and initiating HC, critically depending on the individual's HC use when the relationship began. This could help to explain the consistently high variation in women's experience that is characteristic of previous studies. In Chapter Five we show that women whose current HC use status is congruent to the start of the relationship express lower levels of jealousy than those whose status is incongruent. This finding might be explained by that fact that these women have lower levels of general sexual desire because they are satisfied by their partner. Thus, jealousy is lower at this time because sexual desire is lower. This complements the idea that women express greater jealousy when near to ovulation since sexual desire is greater at this time. A study examining congruency, jealousy and sexual desire in tandem will clarify the validity of my congruency hypothesis. As it stands, I think that changes in sexual desire are the most probable explanation for shifts in jealousy across the cycle and during HC use.

Table 2 | Facets of female sexual experience in six of the most frequently used questionnaires in Studies testing associations between oral contraception and sexual functioning.

Facet and target*	Questionnaire‡					
	FSFI	**MFSQ**	**SDI**	**SEQ**	**PEQ**	**SPEQ**
General						
Desire	+	+	+	+	+	+
Arousal	+	+	-	-	+	+
Lubrication	+	+	-	+	+	-
Orgasm	+	+	-	-	+	+
Satisfaction§	+	+	-	+	+	+
Pain	+	+	-	-	-	+
Frequency	-	+	-	-	+	+
Autosexual	-	-	+	-	+	-
Partner-focused						
Desire	-	-	-	-	-	-
Arousal	-	-	-	-	-	-
Lubrication	-	-	-	-	-	-
Orgasm	-	-	-	-	-	-
Satisfaction§	+	+	-	-	+	+
Pain	-	-	-	-	+	-
Frequency	-	-	-	-	+	-

*Facets are presented separately for questionnaire items dealing with general sexual functioning and those specifically targeted at sex with a woman's main partner. ‡Questionnaires: FSFI, Female Sexual Function Index; MFSQ, McCoy Female Sexuality Questionnaire; SDI, Sexual Desire Inventory; SEQ, Side Effects Questionnaire; PEQ, Personal Experiences Questionnaire; SPEQ, Short Personal Experiences Questionnaire. §Includes enjoyment.

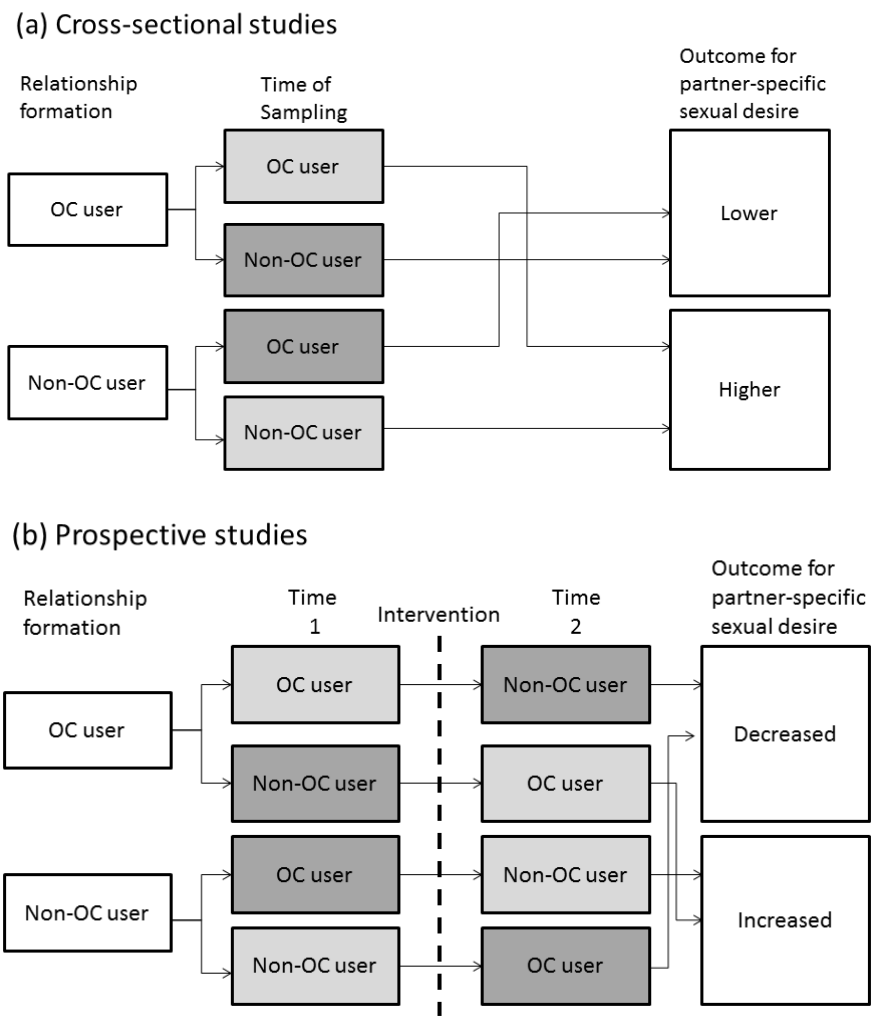


Figure 13. The figure shows how, according to the congruency hypothesis, congruency (light grey shading) or non-congruency (dark grey) in OC use between different critical periods predicts variation in partner-specific desire. (**a**) In cross-sectional studies, OC use during sampling is associated with both higher and lower levels of partner focused desire dependent on previous use during relationship formation. (**b**) In prospective studies, an intervention (i.e. initiating or discontinuing OC use) can induce similar mixed effects.

Theoretical issues

Gangestad and Thornhill's (2008) concept of a *dual sexuality*, which argues that female preferences and behaviours diverge in stages of high and low fertility, formed the basis of my initial motivation to study HC effects. Shifts in preference and behaviour across the menstrual cycle are claimed to enable a woman to pair with a higher quality partner when fertile. This, in turn, is said to be adaptive in that any resulting offspring are of higher quality than they might otherwise have been. However, it must be acknowledged that the evidence for the idea that specific preferences which occur when fertile actually represent underlying 'good genes' is mixed. Folstad and Karter's (1992) *Immunocompetence Hypothesis* argues that physical features which are mediated by sex hormones (e.g., masculinity) are honest cues to the genetic quality of their possessor. For example, it is known that high testosterone is associated with facial masculinity (e.g., Penton-Voak & Chen, 2004) and that high levels of testosterone are harmful to the immune system (e.g., Messingham et al., 2001). Based on this, it is argued that only those men who are healthy enough to tolerate the immunosuppressive consequences of testosterone can afford to develop exaggerated traits like masculine faces. While some studies strongly supports this idea: with men's facial masculinity, for example, having been shown to be related to apparent health (Johnston et al., 2001) as well as medical health records (Rhodes et al., 2003), the findings are admittedly less robust when considered across a range of species (see for example Getty, 2002).

Further, it seems to me that while Gangastand and Thornhill's (2008) *dual sexuality* theory may be valid, there are alternative explanations which may account for the observed shifts across the menstrual cycle. One possibility worthy of discussion is that shifts in preferences associated with hormone changes in the menstrual cycle are actually a by-product of between cycle shifts. For example, while it is well known that within-person hormone levels vary within the cycle; hormones also vary between-cycles. Relatively high levels of hormones from one month to the next may index fertility at a more global level. Research shows that, even in our

contemporary populations where resources are plentiful, menstrual cycles in which estrogen levels are higher are more likely to result in conception (e.g., Baird et al., 1999). Based on this, coupled with the fact that throughout human evolutionary history women may have experienced long phases in which they were non-fertile, a between cycle signal of female conception risk might be adaptive to cue women towards interest in sexual activity with good gene partners in the infrequent months where conception was possible (Roney & Simmons, 2008).

The notion that cyclical shifts in preferences and behaviours may actually be incidentally related to fertility due to between cycle changes is supported by research which finds that individual differences in female estrogen levels predict the degree to which male masculinity is preferred (Roney & Simmons, 2008). If the between-cycle theory is valid, then women may experience changes in preferences within a cycle in line with Gangestad and Thornhill's (2008) *ovulatory shift hypothesis*, as a by-product of estrogen and other hormonal changes that function on a different level. In light of this, menstrual cycle shifts in behaviour (and then subsequently HC pill effects) should be studied over the duration of multiple months of the regular cycle to test the variance explained by the two theories. In some respects the between-cycle theory can be considered analogous to breeding seasons in animals. Admittedly, it would be difficult to disentangle between- and within-cycle explanations.

As an additional point of theoretical issue, I think it is important to note here that ovulation itself is not the mechanism responsible for changes observed across the menstrual cycle. Hormonal shifts surrounding ovulation are the obvious mechanism. Regretfully, I did not have the opportunity to complement the research presented herein with hormonal assays; however, this is an obvious measure to incorporate into future research to complement the existing methods. I will speak later in the discussion at length about the specific hormones likely to be involved in my findings. For now, I will return to why ovulation is not a mechanism for menstrual cycle shifts in behaviour. Discussion of mechanisms with respect to this

topic is often muddied with terms like ‘ovulation phase’ or ‘ovulatory preferences’. I think that use of such terminology is an example which illustrates a greater and more overarching difficulty among specific camps of researchers publishing on this topic, that is, the lack basic foundations in female reproductive biology and more specifically of endocrine changes occurring at reproductive life events such as the menstrual cycle. One way of reaching a consensus with respect to whether or not ovulation can be viewed as a mechanism would be to study cycles where hormonal fluctuation occurs, but ovulation does not follow. In these anovulatory events, I would predict that shifts in behaviour and preferences still occur. This sort of investigation would require the use of transvaginal ultrasonography as in Chapter Two, Chapter Six and Chapter Seven of this thesis.

Methodological limitations and requirements for future research

In spite of several notable strengths in experimental methodological approach (e.g., within-subject designs, transvaginal ultrasonography, male partner data), a number of additional improvements in the design should be encouraged in future research. An overarching limitation of the research contained within this thesis is that it is heavily reliant on self-reports from questionnaire data. While self-reports may serve as a good starting point for investigating changes in behaviour across the menstrual cycle and during HC use, future research should aim to observe and measure actual behaviour. This avoids the possibility that self-report data is subject to social desirability and therefore may not satisfactorily represent behaviour. As it stands, it is unclear how the results documented herein translate into actual behavioural changes in women and how such behaviour might impact actual relationships. With this limitation acknowledged, I would argue that real world behaviours with respect to the empirical topics examined, namely jealousy, intrasexual competition and attractiveness, are most likely to be consistent with the reported results. This is because the topics considered are particularly prone to bias: no one wants to admit to being a jealous and competitive woman or to have an unattractive partner! It is

therefore somewhat even more compelling that we find shifts in self-reported behaviour on these topics.

Furthermore, sample sizes among the studies conducted within-subjects were modest due to the invasive and costly techniques used. Future research which samples larger groups of women may be able to tackle individual differences in effects reported herein. Due to high costs, this is only likely to be achieved through the establishment of industry collaborations with pharmaceutical companies. In particular, larger samples could examine more specific differences in behavioural changes in HC users observed among single versus partnered participants (e.g., Chapter Two and Chapter Six) or the influence of current use and use at the initiation of the relationship (e.g., Chapter Five). Factors not considered in the current research, such as length of time since last relationship among single women, may help to identify additional individual differences in HC pill effects.

It may also be of interest for researchers to more closely examine differences in behaviour among women using different types of HC's. Chapter Four suggests that a study tracking women prospectively as they transition from one form of contraception to another is warranted. Such studies should also seek to examine individual differences that might suggest particular women are better suited to particular pill formulations. Obvious considerations include participant BMI, ethnicity, and age since these are all factors which are known to influence hormone levels (e.g., Mul et al., 2001; Wu et al., 2001; Rowland et al., 2002). Identification of individual differences in the influence of HC's on female psychology may eventually lead to the development of a more specific guideline for prescribing HC's on a case-by-case basis.

Implicating hormones

The results of the studies presented in this thesis cannot conclusively implicate a specific hormone or set of hormones as the mechanism behind the reported changes

during HC use. Indeed, this is a valid criticism of the vast majority of research examining psychological effects of HC use and even more so of the literature of cyclical shifts in behaviour. Based on the results observed herein, I suggest that shifts in estrogen across the cycle, and estrogen suppression during HC use, may moderate changes in emotional reactivity (e.g., jealousy). This is in line with research showing that variation in estrogen levels influences neural correlated emotional responsiveness (Amin et al., 2006). This finding is also in line with previous research and suggests that estrogen is most intimately involved in emotional behavioural outcomes (Fink et al., 1995; Steiner et al., 2003).

Based on this assumption I would argue that estrogen changes are likely to explain the findings related to jealousy documented in Chapters Two trough to Chapter Five. However, a study which assays estrogen throughout the cycle in a large sample remains necessary to validate this interpretation. To accomplish this I would conduct a prospective study in which women are tracked across multiple cycles prior to transitioning to HC use. Daily hormonal assays, from which one could measure the rate of shift in estrogen from the early follicular phase to ovulation, would allow for an acute assessment of estrogen changes and their subsequent outcome on female psychology. Here, I would predict that if estrogen is the mechanism behind cyclical changes in emotional reactivity, women who experience a greater absolute change in estrogen levels during the follicular phase would report greater shifts in behaviour (see Figure 14 and Figure 15). Likewise, if individual baseline levels of estrogen do not correlate with levels of estrogen after commencing HC's, such that estrogen is suppressed to a similar level among all users, I would predict that participants who have higher baseline levels of estrogen would experience greater changes in emotional reactivity during HC use.

The value of tracking participants through multiple cycles is that one could test how differences in the absolute change in estrogen, both within and between cycles, influences emotional reactivity. That is, in cycles where an individual experiences

higher peak levels of estrogen mid-cycle, I would predict greater shifts in emotional reactivity when compared to cycles with relatively lower peak estrogen levels.

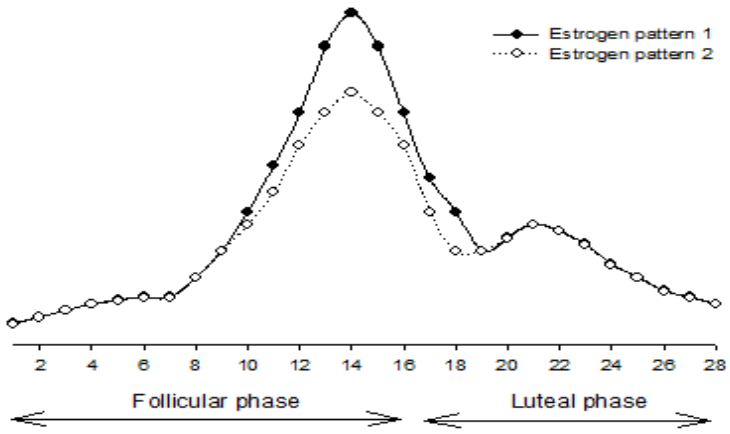


Figure 14. Hypothetical estrogen patterns across the menstrual cycle of two individuals. I would predict that estrogen pattern 2 (empty) would be associated with lesser cyclical shifts in behaviour than estrogen pattern 1 (filled). I predict the same pattern between-cycles: if the lines represented estrogen levels of one woman tracked over two months I would expect cyclical changes to be less pronounced in the month in which estrogen pattern 2 occurred as compared to estrogen pattern 1.

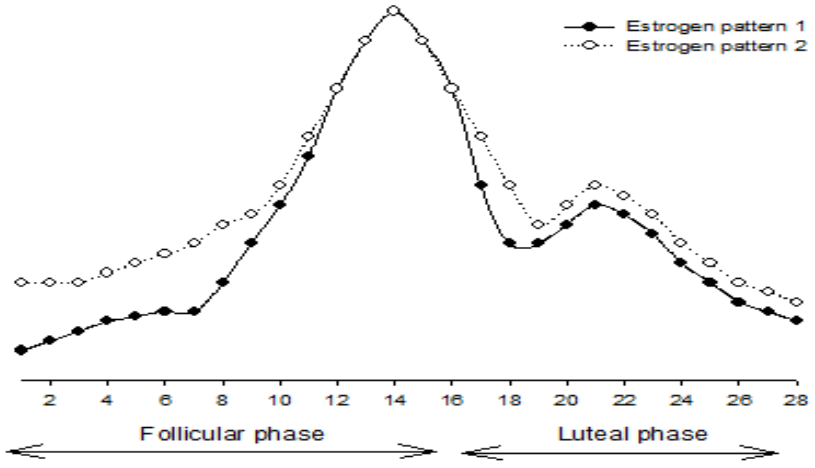


Figure 15. Hypothetical estrogen patterns across the menstrual cycle of two individuals. I would predict that individuals with higher baseline estrogen levels (as in estrogen pattern 2; empty) would be associated with more moderate cyclical shifts in behaviour (than estrogen pattern 1; filled).

In addition to the prediction that estrogen moderates results relating to emotional reactivity or jealousy, I have speculated that testosterone moderates changes in competitive behaviour (Chapter Six). A great deal of research has previously implicated testosterone in competitive behaviour (e.g., Archer, 2006). It is for this reason, in combination with the weak evidence for predictable testosterone shifts across the menstrual cycle (as outlined in Chapter Seven; Pearlman et al., 1967; Dabbs, 1990; Schultheiss et al., 2003), that I think that testosterone suppression during HC use explains our finding that women are less intrasexually competitive when using HC than when regularly cycling. The Challenge Hypothesis argues that testosterone facilitates a trade-off between mating and parenting effort (Archer, 2006). High testosterone is associated with mating effort, while low testosterone is associated with parenting effort (e.g., Pollet et al., 2011; Fleming et al., 2002; Perini et al., 2012; Storey et al., 2011; Gray, 2003; Burham et al., 2003). This concept

isconsistent with the pattern of results observed herein. Research that measures testosterone levels is, of course, needed to verify this explanation. Such research also has the potential to uncover individual differences in intrasexual competition based on testosterone levels. Women who display low levels of intrasexual competition may be less likely to engage in self-enhancement activities and therefore may suffer negative fitness outcomes.

Finally, how do we explain the fact that men report shifts in their perception of their partner's attractiveness, and more significantly, their own attractiveness near to ovulation? While some evidence suggests that men might experience shifts in testosterone in proximity to a fertile women (e.g., Miller & Maner, 2010) this finding was not replicated successfully when considered using a slightly modified design (Roney & Simmons, 2012). I think that it is more likely that men are picking up on changes in their female partner's behaviour and reacting accordingly. Importantly, changes across the menstrual cycle need not be overt for men to perceive and consequently modify their behaviour. These processes may even be to a large extent non-conscious. Of course, male hormones may be involved in this process but at this stage research in this area is only beginning to discover what changes male partners might experience as a result of their partners cycle or HC use. Therefore, at present, it appears premature to single out a particular hormone or set of hormones which explain our male findings.

Finally, it needs to be acknowledged that while estrogen may moderate emotional behaviour and testosterone moderate competitive behaviour as I have argued, it is possible that a third hormone or relative ratios of several hormones combined explain the documented effects. Not until longitudinal within-subject research has been conducted which assays a range of hormones including estrogen, progesterone, testosterone, FSH and LH, can the explanations outlined above be validated. Therefore, at present, these conclusions must be considered as preliminary.

The future of HC's

Overall, the results contained within this thesis point to a number of potentially negative consequences associated with HC use. This finding has the potential to be of direct societal relevance, given that more than 100 million women worldwide use HC's (Trussell, 2007). The findings contained within this thesis do not however speak towards the idea of whether or not a woman should or should not use HC. This decision is a complex choice that is likely to be best resolved at an individual level. However, I believe that adequate knowledge of the risks, whether they are physical or psychological, is essential to make an informed decision to use HC. Put simply, I acknowledge that HC's are associated with a number of positive health benefits (e.g., Huber et al., 2008) and have facilitated a great deal of positive social change (e.g., Goldin & Katz, 2002); however, I would argue that the development of HC is far from complete. Subtle psychological changes have just recently been recognized as a common reason for discontinuing use of HC's (Sanders et al., 2001). Therefore, a major implication of this research is that it calls for additional large scale clinically controlled trials which investigate HC pill effects on female psychology.

As researchers from a variety of disciplines begin to show increasingly convergent evidence for negative psychological consequences of HC use the pressure for pharmaceutical companies to direct funding towards testing these findings will increase. While companies may initially prove reluctant to test their drug for fear of negative findings, the widespread acknowledgement of psychological changes during HC use may one day motivate the development and testing of new HC combinations that limit the experience of these side effects. One example of innovation in this respect can be observed at Pantahrhei BV, a Dutch specialty pharmaceutical company, which recently condicted trials of a new HC that uses a third synthetic hormone (DHEA) to restore levels of androgens in the body in an effort to mitigate mood and sexuality changes among users (Zimmerman et al., in press). I suspect that the eventual acknowledgement of psychological effects of

HC's by large scale pharmaceutical companies working to develop HC's will generate a competitive market in this industry: who will be the first to develop and market a HC which retains contraceptive efficiency, maintains low levels of physical symptomology and reduces psychological disruption? Since HC's are among the most prescribed drugs in the world, the development of such a HC is sure to earn capital.

Conclusion

It may seem that, in many respects, this thesis generates more questions than it provides answers. Nevertheless, in light of the findings within this thesis we can conclude a number of things. A great deal of this thesis targeted the investigation of the hormonal influences of jealousy. While I am confident that cycle shifts in jealousy occur (Chapter Two; Chapter Three; Geary et al., 2001) and that HC use influences the expression of jealousy (Chapter Two; Chapter Four; Chapter Five) I was unable to specify how these shifts may be adaptive. It appears that such shifts are not guided by intrasexual competition (Chapter Six) or changes in self-perceptions of attractiveness (Chapter Seven), though these variables proved interesting when considering HC effects. Given that estrogen peaks mid-cycle when fertile it is an obvious etiological candidate. I therefore argue that estrogen is likely to be the mechanism behind the observed patterns of jealousy but that cyclical shifts in jealousy are not adaptive. Jealousy may be a by-product of shifts in sexual desire but this remains to be tested in greater detail.

Considering the strong evidence I have provided which shows that HC use influences intimate behaviour, there is a real and timely need for large scale and clinically controlled trials to address these consequences more broadly. This thesis prompts three immediate opportunities for investigation: (1) large scale controlled trials of HC's influence on interpersonal behaviour; (2) studies of how different types of HC's differentially influence interpersonal behaviours; and (3) studies of

how the congruency between current use and use at the initiation of a romantic relationship influences interpersonal behaviour. While HC's may have triumphed socially, the results of this thesis stress that it is premature to view HC's as a total scientific triumph.

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Dutch Summary

Introductie

De hormonale anticonceptiepil (HA) is het meest onderzochte medicijn ter wereld. Als gevolg hiervan is er reeds een grote hoeveelheid literatuur ter beschikking over de werking van de HA. Tot op de dag van vandaag richtte het onderzoek zich echter voornamelijk op de lichamelijke risicofactoren verbonden met het gebruik van de HA of op de sociale invloed die de introductie van een betrouwbare en reguleerbare anticonceptie op de rol van vrouwen in de maatschappij heeft gehad. Het is uiteraard positief dat deze belangrijke en relevante onderwerpen veel aandacht hebben gekregen. Echter, is er nog relatief weinig bekend over de psychologische bijwerkingen van de HA. Dit proefschrift richtte zich op de effecten van HA op jaloezie en competitie met andere vrouwen. Dit onderwerp wordt in het proefschrift benaderd vanuit een *evolutionair psychologisch* (EP) perspectief met de nadruk op biologische invloeden. EP benadert menselijk gedrag vanuit een 'adaptief' perspectief. Volgens dit perspectief worden fysiologische systemen gevormd middels natuurlijke selectie. EP probeert te doorgronden hoe bepaalde eigenschappen een organisme kunnen helpen om te overleven en/of zich voort te planten. De EP benadering biedt relevante theoretische inzichten betreffende de gedragsveranderingen die men kan verwachten als gevolg van het gebruik van HA.

Mijn initiële benadering voor het onderzoeken van de psychologische effecten van HA kwam voort uit literatuur die psychologische veranderingen beschreef in vrouwen tijdens de menstruatiecyclus. Vrouwen die geen gebruik maken van de HA vertonen duidelijke veranderingen in hun partnervoorkeuren en gedrag bij de overgang van de vruchtbare naar de niet-vruchtbare periode in hun cyclus. Deze psychologische veranderingen tijdens de vruchtbare periode worden gezien als evolutionair voordelig omdat ze ervoor zorgen dat vrouwen zich voortplanten met partners van hogere kwaliteit en op die manier betere genen doorgeven aan hun nakomelingen. Echter, de hormonen die fluctueren tijdens de vruchtbare periode, het vermoedelijke mechanisme achter de psychologische veranderingen, worden onderdrukt bij het gebruik van HA. Dat zou kunnen leiden tot minder adaptief gedrag bij HA gebruikers. Vanuit deze benadering beargumenteer ik in dit

proefschrift dat het gebruik van HA de voorkeuren en het gedrag van vrouwen verandert in vergelijking met vrouwen met een natuurlijke menstruatiecyclus. Tevens lever ik bewijs dat de verstoring van de natuurlijke vruchtbaarheidscyclus psychologische gevolgen kan hebben voor de dynamiek binnen intieme relaties.

Samenvatting van de empirische resultaten

Dit proefschrift is opgedeeld in twee delen, welke ik hieronder kort zal beschrijven.

Deel 1: *Hormonale effecten op jaloezie in vrouwen*

In Hoofdstukken 2 tot en met 5 werden de effecten van de HA op het de beleving van jaloezie in vrouwen onderzocht. Jaloezie kan voor vrouwen als evolutionair voordelig worden gezien, aangezien ze op deze manier kan voorkomen dat haar partner haar verlaat of in relaties met andere vrouwen investeert. Hoofdstuk Twee beschrijft de resultaten van een binnen proefpersonen experiment waarin zelfgeraporteerd jaloers gedrag van vrouwen werd vastgesteld tijdens de vruchtbare en niet-vruchtbare periode van de cyclus, alsmede wanneer zij HA gebruikten. De resultaten toonden aan dat de mate van jaloezie hoger was tijdens de vruchtbare periode dan in de niet-vruchtbare periode. Voor vrouwen met een partner was de mate van jaloezie wanneer zij HA gebruikten vergelijkbaar met de mate van jaloezie tijdens de vruchtbare periode. Dit suggereert dat het gebruik van de HA de beleving van jaloezie binnen een relatie verandert, in ieder geval voor vrouwen met een partner. Naar mijn weten is dit pas het derde gepubliceerde onderzoek waarin gebruik wordt gemaakt van een binnen proefpersonen design waarin vrouwen afwisselend wel of niet de pil slikten, en het eerste onderzoek dat specifiek jaloezie onderzocht. Ook methodologisch draagt het artikel bij aan het onderzoeksveld, door middel van het binnen proefpersonen benadering alsmede door het gebruik van transvaginale echografie, waarmee het een standaard zet voor toekomstig onderzoek naar HA en de menstruatie cyclus.

In Hoofdstuk 3 werden de veranderingen in jaloezie gedurende de menstruatie cyclus onderzocht bij vrouwen uit Willemstad, Curaçao. Het overgrote deel van

onderzoek naar veranderingen in vrouwelijke voorkeuren en gedrag gedurende de cyclus betreft onderzoeken met westerse, blanke studenten; een tekortkoming die in het algemeen geldt voor psychologisch onderzoek. In tegenstelling tot Hoofdstuk 2, is in Hoofdstuk 3 gebruik gemaakt van een tussen proefpersonen experiment om de steekproef te kunnen vergroten. In overeenstemming met de resultaten van Hoofdstuk 2, toonden de resultaten aan dat vrouwen een significant hogere mate van jaloezie rapporteerden tijdens de vruchtbare periode, in vergelijking met de niet-vruchtbare periode van hun menstruatie cyclus. Deze resultaten bleven behouden wanneer er gecorrigeerd werd voor leeftijd, relatiestatus en tevredenheid met de relatie. De resultaten van dit onderzoek, in combinatie met de resultaten in Hoofdstuk 2, suggereren dat veranderingen in jaloezie gedurende de menstruatie cyclus robuust zijn, aangezien ze aangetoond worden in verschillende culturen en met behulp van verschillende onderzoeksmethoden. Wanneer men de resultaten van Hoofdstuk 2 en 3 samen neemt, is het interessant om op te merken dat, hoewel veranderingen in jaloezie gedurende de menstruatie cyclus vergelijkbaar waren in beide onderzoeken, de mate van jaloezie bij vrouwen uit Curaçao significant hoger was.

Op basis van het effect van de pil in vrouwen met een partner dat gevonden werd in Hoofdstuk 2, ontwikkelde ik een vervolgonderzoek om vast te stellen of verschillende HA's jaloezie in dezelfde mate verhogen. De meest gebruikte vorm van HA, de gecombineerde orale anticonceptiepil, bestaat uit synthetische oestrogenen en progesteron. Er zijn echter verscheidene soorten HA pillen beschikbaar voor vrouwen, die verschillen in de concentratie oestrogenen en progesteron. Om te onderzoeken of deze anticonceptie pillen variëren in hun effect op jaloezie, maakte ik gebruik van een groot aantal vrouwen die verschillende vormen van de gecombineerde HA pil gebruikten. In Hoofdstuk 4 rapporteer ik de resultaten van dit onderzoek. Vrouwen die een pil gebruikten met een hogere dosis oestrogenen rapporteerden een hogere mate van jaloezie dan vrouwen die een pil gebruikten met een lagere dosis oestrogenen. Dit resultaat bleef gelijk wanneer er gecorrigeerd werd voor leeftijd, relatiestatus, en de hoogte van de dosis syntethische

progesteron. Dit is naar mijn weten het eerste onderzoek dat de effecten van de anticonceptie pil op het sociale gedrag van vrouwen in meer detail heeft onderzocht. De resultaten van dit onderzoek suggereren dat onderzoek waarin slechts een vergelijking wordt gemaakt tussen 'pil gebruiker' en 'geen pil gebruiker' een dergelijk complex effect van de pil te kort doet. Sinds de publicatie van het onderzoek uit Hoofdstuk 4 zijn de resultaten gerepliceerd door een Amerikaanse onderzoeksgroep met betrekking tot controlegedrag door een partner. Dit suggereert dat de resultaten redelijk robuust zijn.

Hoofdstuk 5 beschrijft de resultaten van een onderzoek waarin gekeken werd of een geschiedenis van het gebruik van hormonale anticonceptie de huidige mate van jaloezie beïnvloedt. De resultaten toonden aan dat jaloezie binnen de relatie hoger is bij koppels waarbij het huidige hormonale contraceptie gebruik verschilt met het gebruik tijdens het begin van de relatie. Anders gezegd, koppels waarbij HA gebruik overeenkomt met het gebruik in het begin van de relatie rapporteerden een lagere mate van jaloezie. Dit suggereert dat voorkeuren die de overhand hebben aan het begin van de relatie veranderd zijn wanneer er begonnen of gestopt wordt met het gebruik van HA tijdens de relatie en dat deze wijziging in pilgebruik invloed heeft op de dynamiek binnen de relatie. Dat het gebruik van HA aan het begin van de relatie aspecten van tevredenheid met die relatie op een later tijdstip voorspelt, kan relevant zijn voor artsen die anticonceptiva voorschrijven alsmede voor degenen die advies geven over het gebruik van anticonceptie.

Deel 2: *Verklaringen voor veranderingen in jaloezie: De rol van aantrekkelijkheid en intraseksuele* competitie

In Hoofdstukken 6 en 7 heb ik geprobeerd het mechanisme achter de veranderingen in jaloezie gedurende de menstruatie cyclus en gedurende het gebruik van de anticonceptie pil te ontrafelen. Het is niet direct duidelijk waarom in de vruchtbare periode veranderingen in de mate van jaloezie evolutionair voordelig zouden zijn. Een mogelijkheid is dat een hogere mate van jaloezie tijdens de vruchtbare periode een uiting kan zijn van een hogere mate van intraseksuele competitie tijdens deze

periode. Een verhoogde mate van competitie tijdens de vruchtbare periode zou wellicht een vrouw kunnen helpen om gemakkelijker een partner van hoge kwaliteit te krijgen of te behouden dan anders mogelijk zou zijn.

Ik onderzocht deze mogelijkheid in Hoofdstuk 6, door de mate van intraseksuele competitie te onderzoeken in een groep vrouwen die in eerste instantie de pil gebruikten maar vervolgens stopten met het gebruik. Het betrof opnieuw een binnen proefpersonen ontwerp. De proefpersonen rapporteerden de mate van intraseksuele competitie die zij ervoeren terwijl zij de pil gebruikten en gedurende een regelmatige menstruatie cyclus, zowel tijdens de vruchtbare en niet vruchtbare periode van deze cyclus. De resultaten toonden aan dat bij vrouwen met een partner, maar niet bij vrouwen zonder partner, de mate van intraseksuele competitie lager was wanneer zij de HA gebruikten dan tijdens een natuurlijke menstruatie cyclus. Zowel voor vrouwen zonder partner als voor vrouwen met een partner werden er geen veranderingen in intraseksuele competitie geobserveerd gedurende de verschillende periodes van de menstruatie cyclus. Dit lijkt het erop te wijzen dat de eerdergenoemde toename in jaloezie tijdens de vruchtbare periode niet verklaard kunnen worden door een toename van intraseksuele competitie. De bevinding dat intraseksuele competitie lager is in pilgebruikers (bij wie testosteron onderdrukt wordt) is echter in overeenstemming met het idee dat testosteron competitief gedrag beïnvloedt. Gezien de afwezigheid van wisselingen in intraseksuele competitie tijdens de menstruatie cyclus en het gegeven dat het gehalte van testosteron niet substantieel verandert tijdens de menstruatie cyclus, terwijl de niveaus van oestrogenen en progesteron juist wel fluctueren, kan testosteron mogelijkerwijs het lagere niveau van intraseksuele competitie bij pilgebruikers verklaren.

In Hoodstuk 7 volgde ik een kleine groep vrouwen en hun mannelijke partner gedurende de menstruatie cyclus en gedurende het gebruik van de pil, vergelijkbaar met Hoofdstukken 2 en 6. Een reeks onderzoeken in verschillende psychologie-laboratoria hebben aangetoond dat vrouwen als meer aantrekkelijk worden beoordeeld tijdens hun vruchtbare periode in vergelijking met de niet-vruchtbare periode. Mijn onderzoek liet zien dat mannen hun vrouwelijke partners als

significant aantrekkelijker beoordelen wanneer zij vruchtbaar is dan wanneer zij niet vruchtbaar is of HA gebruikt. Tevens vonden de mannen zichzelf significant aantrekkelijker wanneer de vrouwelijke partner een natuurlijke menstruatie cyclus had dan wanneer zij HA gebruikte. Ondanks deze patronen rapporteerden vrouwen zelf geen verschillen in de perceptie van hun eigen aantrekkelijkheid over de verschillende condities. Er lijken desalniettemin onbewuste veranderingen op te treden in de waarneming van mannen, die mogelijk bijdragen aan de veranderingen in de mate van jaloezie in vrouwen.

Conclusie

Het onderzoek beschreven in dit proefschrift wijst op niet eerder vastgestelde negatieve bijwerkingen van HA gebruik. Een groot gedeelte van dit onderzoek betrof de mechanismen verantwoordelijk voor veranderingen in jaloezie. Hoewel ik overtuigd ben van het bestaan cyclische veranderingen in jaloezie (Hoofdstuk Twee, Hoofdstuk Drie) en dat jaloezie beïnvloed wordt door HA gebruik, is het niet direct duidelijk wat de adaptieve functie van deze veranderingen in jaloezie zijn. Ze lijken niet voort te komen uit veranderingen in intraseksuele competitie (Hoofdstuk Zes) of veranderingen in percepties van eigen aantrekkelijkheid (Hoofdstuk Zeven), alhoewel deze variabelen wel interessant zijn in het licht van HA pil effecten. Aangezien het gehalte van oestrogeen piekt gedurende het midden van de cyclus en de hoogste mate van jaloezie ook in deze periode wordt gevonden, betoog ik dat oestrogeen waarschijnlijk het mechanisme is achter de geobserveerde patronen in jaloezie. Zowel het binnen proefpersonen design als de stringente criteria gebruikt om vruchtbaarheid te bepalen, zoals gebruikt in het onderzoek van dit proefschrift, vergroten de betrouwbaarheid van de gevonden resultaten en valideren eerdere bevindingen.

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