Title
Do Hormonal Contraceptives Alter Mate Choice and Relationship Functioning in Humans?

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Publication Date
2014

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA

Los Angeles

Do Hormonal Contraceptives Alter Mate Choice and Relationship Functioning in Humans?

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Psychology

by

Christina Marie Larson

2014

ABSTRACT OF THE DISSERTATION

Do Hormonal Contraceptives Alter Mate Choice and Relationship Functioning in Humans?

By

Christina Marie Larson

Doctor of Philosophy in Psychology

University of California, Los Angeles, 2014

Professor Martie G. Haselton, Chair

Most women in the United States use hormonal contraceptives at some point in their lives, yet little is known about their psychological side-effects. A number of scholars have recently argued that hormonal contraceptives might impair women's ability to choose desirable mates and cause problems in their relationship functioning. My dissertation evaluated these claims through a comprehensive review of the literature and two empirical studies. In my review of more than 30 studies examining associations between hormonal contraceptive use and variables related to mate choice and relationship functioning, I found modest support for hypotheses about the effects of hormonal contraceptive use. The most robust finding was that, unsurprisingly, hormonal contraceptive users did not experience cycle shifts in mate preferences and attractiveness that had been identified in previous research (e.g. Gildersleeve, Haselton, & Fales, 2014). I note a general weakness in the literature – none of the studies comparing hormonal contraceptive users to non-users employed experimental methods, precluding causal

conclusions about the effects of hormonal contraceptives. I also report two empirical studies. In the first, I tested one particular hypothesis regarding negative effects of hormonal contraceptive use. Partners who are similar to one another in their Major Histocompatibility Complex (MHC) genes are thought to be relatively less genetically compatible than partners who are dissimilar in their MHC genes. Researchers have hypothesized that hormonal contraceptives disrupt MHC preferences. I examined whether hormonal contraceptive users are indeed more MHC-similar to their partners than non-users. Both members of 274 couples were genotyped at the MHC region; the female partner reported her hormonal contraceptive use at the time the relationship began. Contrary to predictions, I found that women who used hormonal contraceptives when they met their partner were *more* MHC dissimilar to their partners than non-users, although this difference was not statistically significant. Additional analyses involving many potential confounds that might be masking a true relationship did not produce the predicted effect. The results of this study are inconsistent with the hypothesis that hormonal contraceptives will cause women to choose MHC similar, and thus genetically incompatible, romantic partners. In the second study, I addressed the hypothesis that cycle shifts previously documented among naturally cycling women (reviewed in Larson, Pillsworth, & Haselton, 2012) would be absent among hormonal contraceptive users. To test this hypothesis, I recruited a sample of 56 women to complete nightly surveys assessing their current attractions toward their romantic partner and toward men other than their partner (for a total of 1,366 observations). Consistent with the hypothesis, I found that cycle shifts in attraction to *other men* observed among non-users were absent among hormonal contraceptive users. The results of this study therefore demonstrated a potential relationship-*protective* effect of hormonal contraceptive use. Overall, the results of my dissertation indicate that although hormonal contraceptive users and non-users do differ in some

important ways, the differences are not as large, global, or negative as previous researchers have implied.

The dissertation of Christina Marie Larson is approved.

Daniel M.T. Fessler
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University of California, Los Angeles
2014

To my parents:

Thank you for your endless love, support, and encouragement

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ACKNOWLEDGMENTS

I am grateful for all the invaluable help my research assistants provided in collecting data for this dissertation, and the valuable feedback members of the Haselton lab and the members of my committee provided at various stages of the research. This dissertation was funded in part by support from a NSF/UCLA Interdisciplinary Research Science Traineeship, a UCLA Pauley Fellowship, a UCLA Graduate Research Mentorship, and research grants from the International Society for Human Ethology Owen Aldis Research Award, the Kinsey Institute Student Research Grant Award, and a UCLA Academic Senate Grant awarded to M. G. Haselton. Chapter II is a version of a manuscript that will be submitted for publication, co-authored with M. G. Haselton. Chapter III is a version of a manuscript that will be submitted for publication, co-authored with M. G. Haselton, E. Pillsworth, K.A. Gildersleeve, S.W. Gangestad, S. Saphire-Bernstein, G. Gonzaga, H. Strekarian, & C. Garver-Apgar. Chapter IV is a version of a version of a manuscript that will be submitted for publication, co-authored with M. G. Haselton.

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Larson, C. M., Haselton, M. G., Gildersleeve, K. A., & Pillsworth, E. G. (2013). Changes in women's feelings about their romantic relationships across the ovulatory cycle. *Hormones and Behavior, 63,* 128-135.

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SELECTED CONFERENCE PRESENTATIONS

Larson, C.M., Haselton, M.G. *Do Hormonal Contraceptives Alter Women's Mate Choice and Relationship Functioning? Hypothesized Mechanisms of Action.* Paper presented at the Human Behavior and Evolution Society Conference, Miami, Florida, July 13- 17, 2013.

Larson, C.M., Johnson, K., & Haselton, M.G. *An Analysis of Women's Body Language Across the Ovulation Cycle.* Paper presented at the International Society for Human Ethology Conference, Vienna, Austria, August 13- 17, 2012.

Larson, C.M., Haselton, M., & Pillsworth, E. *Changes across the Ovulation Cycle in Women's Extra-pair Attraction are Moderated by Third-Party Ratings of Partner Attractiveness.* Poster presented at the Human Behavior and Evolution Society Conference, Albuquerque, New Mexico, June 13-17, 2012.

Larson, C.M., Haselton, M.G., Gildersleeve, K.A., & Pillsworth, E.G. *Changes in Women's Feelings about their Romantic Relationship Across the Ovulation Cycle.* Paper presented at the Human Behavior and Evolution Society Conference, Montpellier, France, June 29-July 3, 2011.

Larson, C.M., Gildersleeve, K.A., & Haselton, M. *Male Physical Strength is Associated with Favorable Attitudes toward Casual Sex and Sexual Success.* Poster presented at the Society for Personality and Social Psychology Conference, Las Vegas, Nevada, January 28-30, 2010.

Chapter I:

Introduction

In 2010, the journal *Trends in Ecology and Evolution* published a review titled "Does the contraceptive pill alter mate choice in humans?" (Alvergne & Lummaa, 2010). In the piece, the authors reviewed less than a dozen studies documenting differences between hormonal contraceptive users and non-users in mate preferences and women's attractiveness. Although the authors acknowledged some of the limitations of past research, they nonetheless predicted that a) using hormonal contraceptives would cause women to make maladaptive mate choices, which could someday lessen their children's health and survival, b) changing hormonal contraceptive use while in a relationship would lead to relationship conflict and dissolution, and c) using hormonal contraceptive would hinder women's ability to compete for and retain romantic partners by reducing their physical attractiveness. This article received widespread attention from both the academic community and the general public. For example, NBC.com covered the article, concluding that hormonal contraceptives "may also have changed 'the laws of attraction' between the sexes" (Carroll, 2010, para. 1).

This article is indicative of a growing body of literature in which researchers advance hypotheses about the widespread and negative effects of hormonal contraceptive use based on research documenting differences between hormonal contraceptive users and non-users (Boero, 1996; Cobey & Buunk, 2012; Cobey, Klipping, & Buunk, 2013; Cobey, Roberts & Buunk, 2013; Havlicek & Roberts, 2009; Little et al., 2002; Puts & Pope, 2013; Roberts, Cobey, Klapilova, & Havlicek, 2013; Roberts, Gosling, Carter, & Petrie, 2008; Roberts, Miner, & Shackelford, 2010; Roberts, Klapilova, Little, Burriss, Jones, DeBruine, Petrie, & Havlicek, 2012; Smith et al., 2009; Voilrath & Milinski, 1995; Wedekind, Seebeck, Bettens, & Paepke, 1995; Welling, 2013). It is also indicative of the interest in this topic beyond the academic community. Many of studies examining differences between hormonal contraceptive users and non-users have received

coverage in the popular press, often with provocative claims such as "How the Pill could make you let go of Mr. Right" (Macrae, 2013) and "Women on birth control date bedroom 'duds'" (Jaslow, 2011). An extreme example of the phenomenon is the popular Psychology Today post, "How the Pill Could Ruin Your Life" (Ryans, 2010).

Against this backdrop, however, is a body of evidence that is weak and inconsistent and limited in ways that preclude it from providing strong support for these claims. Although many researchers have investigated associations between hormonal contraceptive use and relationship relevant variables and many scholars have written about the potential effects hormonal contraceptives might have, there is not a complete synthesis of the evidence, one of the key assumptions about the negative effects of hormonal contraceptives – that they will cause women to choose genetically incompatible partners – is untested, and many studies fail to account for shifts in reproductive hormones across the cycle, which theory and past research suggests are crucial for fully understanding associations between hormonal contraceptives use and women's relationship dynamics. I address these issues in my dissertation.

In Chapter II I provide a comprehensive and critical review of the literature, evaluating the strength of the evidence, addressing limitations in study design, and discussing which claims the evidence supports. In Chapter III I provide the first direct test of the hypothesis that hormonal contraceptive use will cause women to choose romantic partners who are less genetically compatible than the partners they would otherwise choose. In Chapter IV I investigate cycle shifts in women's attractions among naturally cycling women as compared with hormonal contraceptive users. I close with a summary of findings and general conclusions.

Chapter II:

Do Hormonal Contraceptives Alter Women's Mate Choice and Relationship Functioning?

A Review

Abstract

More than fifty years ago, the introduction of the first hormonal contraceptive revolutionized women's lives, and hormonal contraceptives have provided women with a safe, effective, and reversible form of birth control ever since. Scholars have recently begun to raise alarm by arguing that hormonal contraceptives might cause previously unconsidered side-effects through impairing women's ability to choose appropriate romantic partners and altering romantic relationship dynamics. Although these claims have received widespread attention, this paper is the first to comprehensively review all the relevant research in order to establish which claims are supported by the evidence. Through a review of more than 30 studies, we conclude that although the evidence supports some predictions (e.g. that hormonal contraceptive users will not experience cycle shifts in mate preferences and attractiveness), it does not support others (e.g. that hormonal contraceptive users will have weaker preferences for masculinity than non-users). In many cases, the current evidence does not compel any strong conclusions. Although many of the studies do not assess whether hormonal contraceptive users and non-users differ along potentially confounding dimensions, the evidence available suggests that there are important differences between the two groups of women that are often not considered. Finally, because none of the studies in the literature employed the experimental methods necessary to demonstrate causality, the evidence does not and cannot support arguments about the effects of hormonal contraceptives on women's mate choices and relationship functioning.

Do Hormonal Contraceptives Alter Women's Mate Choice and Relationship Functioning?

A Review

In 1960, G.D. Searle & Company released Enovid, the first hormonal contraceptive available to women. This first hormonal contraceptive, and the many variations that followed it, prevent ovulation and thus pregnancy by suppressing women's reproductive hormones. "The pill" was the first form of contraception that was simultaneously convenient, reversible, highly effective, and did not require male partner compliance[1]. Hailed by *The Economist* as the invention that defined the 20th century (1999), "the pill" and other hormonal contraceptives have revolutionized women's lives. For example, women's newfound control over their fertility increased their ability to delay childbirth and marriage, limit the number of children they had, pursue higher education, attain professional careers, and spend time in the labor market (Bailey, 2006; Edlund & Machado, 2009; Goldin & Katz, 2002). Women's ability to control their fertility with hormonal contraceptives is credited with narrowing the divide between men and women in power and salary (Bailey, Hershbein, & Miller, 2012; Chiappori & Oreffice, 2008), and with lowering rates of unplanned pregnancies and abortions (Ananant & Hungerman, 2011).

Prescriptions for hormonal contraceptive pills peaked at approximately 68 million in 1972 (Gerstman, Gross, Kennedy, Bennet, Tomitas, & Stadel, 1991), and the pill has been the leading form of contraception in the United States ever since (Mosher, Martinez, Chandra, Abma, & Willson, 2004). Today, hormonal contraceptives remain popular. In the US, 21.5% of women aged 15 to 44 are currently using some form of hormonal contraception (of women using

[1] Previously available methods included condoms, diaphragms, the withdrawal method, and the rhythm method (Asbell, 1995). The current percentage of women experiencing an unplanned pregnancy within 12 months of using hormonal oral contraceptives (the "failure rate") is 8.7%; by contrast, the current failure rate of these other methods range from 16% to 25.4% (Speroff & Fritz, 2011; Kost, Singh, Vaughan, Trussell, & Bankole, 2008). In the pre-pill era various pessaries and douches were also commonly used to prevent pregnancy, but the majority of these techniques had little contraceptive benefits and some had dangerous side-effects, including infection, infertility, and death (Asbell, 1995).

a reversible form of contraception, 55.3% of them are using a hormonal contraceptive), and 82% of reproductive-aged women in the Unites States have used the hormonal contraceptive pill at some point in their lives (Mosher & Jones, 2010). Hormonal contraceptives are particularly popular among younger women and women who are not married or cohabiting (e.g. 51.7% of contraceptive users in the US who have never been married and are not cohabiting with a romantic partner are using the hormonal pill or hormonal injections; see Table 7). Worldwide, hormonal contraceptive use is prevalent in developed regions, but is less common in undeveloped regions (United Nations, 2011).

Against this backdrop, recent reports that hormonal contraceptives might impair women's mate choice and hinder their relationship functioning have raised alarm. Might the hormonal contraceptive revolution come with serious psychological costs? In this paper, we provide the first comprehensive review of the pertinent literature, helping to address this question in the most complete way to date.

The Current Contribution

A growing body of research suggests that reproductive hormones have important influences on psychological systems related to mating (Ellison & Gray (Eds.), 2009; Gildersleeve, Haselton, & Fales, 2014; Roney, Simmons, & Gray, 2011; Roney and Simmons, 2008, 2013). Hormonal contraceptives alter women's endogenous reproductive hormones through the introduction of exogenous synthetic reproductive hormones. Therefore, hormonal contraceptives might affect women's psychological systems related to mating.

This idea has recently received widespread attention, especially in the field of evolutionary psychology. Numerous papers have advanced the hypothesis that hormonal contraceptives might alter women's mate preferences, disrupt mate choice, and otherwise impair

women's romantic relationships (Alvergne & Lummaa, 2010; Boero, 1996; Cobey & Buunk, 2012; Cobey, Roberts & Buunk, 2013; Havlicek & Roberts, 2009; Little, Jones, Penton-Voak, Burt, & Perrett, 2002; Puts & Pope, 2013; Roberts, Cobey, Klapilova, & Havlicek, 2013; Roberts, Gosling, Carter, & Petrie, 2008; Roberts, Little, Burriss, Cobey, Klapilová, Havlíček, Jones, DeBruine, & Petrie, 2014; Roberts, Miner, & Shackelford, 2010; Roberts, Klapilova, Little, Burriss, Jones, DeBruine, Petrie, & Havlicek, 2012; Smith et al., 2009; Voilrath & Milinski, 1995; Wedekind, Seebeck, Bettens, & Paepke, 1995). Several of these papers were position pieces focused almost entirely on raising concerns about the potentially negative consequences of hormonal contraceptive use (Alvergne & Lummaa, 2010; Boero, 1996; Cobey & Buunk, 2012; Roberts et al., 2013; Voilrath & Milinski, 1995; Welling, 2013). In addition, to date, over 30 studies have examined the relationship between hormonal contraceptive use, mate preferences, mate choice, and relationship functioning (see Table 1).

What the literature lacks, however, is a complete synthesis of the evidence. The papers noted above have cited only a portion of the evidence and have not grappled with limitations in study design – which, in all reviewed studies, is correlational – findings that fail to support hypotheses about detrimental effects of hormonal contraceptive use, or considered the magnitude or practical significance of statistically significant results. We address this gap in the current paper by providing a comprehensive and critical review, including effect sizes, sample sizes, and information about study design. Before reviewing the evidence, we will summarize the background evidence on associations between hormones and romantic and social behavior which led to some of the concerns about effects of hormonal contraceptive use and lay out what specific concerns are being raised. We close with a summary of what can be concluded from the evidence and make suggestions for future research.

Background

Ovulatory Shifts in Women's Mate Preferences

Throughout human evolutionary history, sexual intercourse could result in conception only if it occurred on one of the few high-fertility days of the cycle immediately leading up to and including the day of ovulation. It follows that many of women's sexual decisions had the greatest impact on fitness on these crucial few days of the cycle. As a result, women might possess mating adaptations sensitive to hormone levels, and hence fertility, across the cycle.

The ovulatory shift hypothesis posits one such adaptation. According to this hypothesis, women's sexual attraction to men possessing characteristics historically associated with high genetic quality is enhanced on high- relative to low-fertility days of the cycle (Gangestad & Thornhill, 1998; Gangestad, Thornhill& Garver-Apgar, 2005; Gildersleeve, Haselton, & Fales, 2014). The ovulatory shift hypothesis predicts that women's preferences will shift primarily when they evaluate men's attractiveness as an immediate sex partner – a context in which a preference shift could lead to immediate sexual behavior resulting in conception. The ovulatory shift hypothesis predicts no such shifts when women evaluate men's attractiveness as a long-term partner – a context in which a preference shift presumably would often not lead to immediate sexual behavior resulting in conception. The ovulatory shift hypothesis furthermore predicts that women's preferences will shift for characteristics historically associated with high genetic quality, but not other potentially desirable characteristics of men, such as characteristics historically associated with being a good long-term partner (e.g., a good provider or co-parent).

One characteristic hypothesized to historically have been associated with high genetic quality is symmetry (the extent to which the two sides of the body are symmetrical). This is because symmetry is thought to reflect an organism's ability to successfully execute a genetic

blueprint for a symmetrical body when confronted with environmental insults during development (see Van Dongen & Gangestad, 2011). Likewise, masculinity is hypothesized to historically have been associated with high genetic quality because masculinity could indicate the ability of an organism to bear the costs of developing metabolically costly (or otherwise costly) masculine traits (reviewed in Gildersleeve et al., 2014).

Consistent with the ovulatory shift hypothesis, a recent meta-analysis of 96 effects in 50 studies revealed robust increases on high- relative to low-fertility days of the cycle in women's preferences for characteristics hypothesized to have historically been associated with high genetic quality, including symmetry, facial, body, and vocal masculinity, behavioral dominance, and facial cues of testosterone (Gildersleeve et al., 2014). Cycle shifts were present when women evaluated men's "short-term" attractiveness and absent when women evaluated men's "long-term" attractiveness (and in-between, but still statistically significant, when women evaluated men's attractiveness in an unspecified mating context). Cycle shifts were also absent when women evaluated characteristics hypothesized to have historically been associated with high long-term partner quality, such as kindness and possession of material resources.

A related body of evidence indicates that on high fertility days of the cycle women might prefer cues of genetically compatibility. Genes in the Major Histocompatibility Complex (MHC) code for cell surface markers used to detect pathogens that have invaded a host's body. MHC alleles are expressed co-dominantly (both paternally- and maternally-inherited alleles are expressed). Therefore, individuals who inherit different alleles from each parent have more complex cell surface markers than do individuals whose parents share MHC alleles, improving their body's ability to recognize and respond to a wide array of pathogens (Penn, Damjanovich, & Potts, 2002). In two studies, women tested during a high-fertility phase of the cycle preferred

the scent of men with whom they shared fewer MHC alleles (a preference for dissimilarity) (Wedekind et al., 1995; Wedekind & Furi, 1997; but see Roberts et al., 2008; Thornhill, Gangestad, Miller, Scheyd, McCollough, & Franklin, 2003). In an additional study of couples, the extent to which women's partners were MHC similar to them was associated with reduced sexually responsivity to those partners, increased sexual attraction to men other than their partners, and an increased likelihood of having engaged in sex with men other than their partners during their relationship (Garver-Apgar, Gangestad, Thornhill, Miller, & Olp, 2006).

Shifts in Women's Attractiveness across the Cycle

Ancestrally, if there were any outward indications of a woman's fertility within the cycle, even if subtle, men probably evolved to detect them and find them attractive. Ancestral men who experienced such attractions would have concentrated more mating effort, on average, within the narrow window of fertility within a woman's cycle, increasing the chances that such efforts resulted in reproduction. Indeed, it appears that there are changes across the cycle in women's body scents, voices, social behavior, and possibly physical appearance that others can detect (Haselton & Gildersleeve, 2011). Preliminary results from a new meta-analysis of over 90 effects in more than 4 dozen studies offer support for the notion that there are robust cycle shifts in women's attractiveness (Gildersleeve & Haselton, *in progress*). Aggregating across possible ovulation cues (e.g., ratings of scent, vocal attractiveness, facial attractiveness, etc.) the meta-analysis documented increases in women's attractiveness (as rated by third parties) at high relative to low fertility, such that women's attractiveness was about three-tenths of a standard deviation higher at high relative to low fertility. In addition, although analyses of specific ovulation cues included fewer studies and were much lower in power, the meta-analysis

documented robust shifts in women's scent attractiveness, such that women's scent attractiveness was again about three tenths of a standard deviation higher at high relative to low fertility.

Hormonal Mechanisms Underlying Cycle Shifts

These cycle shifts are likely to be mediated by the shifts in the reproductive hormones that cause fertility levels to vary. Researchers are not yet certain which of these hormones or which combinations of hormones underlie cycle shifts (or whether different cycle shifts have different hormonal underpinnings). However, some evidence suggests that estradiol is a likely candidate for the mechanism underlying shifts in women's mate preferences (Thornhill and Gangestad, 2008). For example, studies that have assayed women's estradiol levels throughout the cycle have found that estradiol is positively associated with preferences for facial cues of men's testosterone (Roney et al., 2011; Roney and Simmons, 2008). Estradiol is also positively associated with how attractive women are to men (Durante & Li, 2009; Puts, Bailey, Cárdenas, Burriss, Welling, Wheatley, Dawood, 2013), particularly when estradiol is high relative to progesterone levels, which reflects the hormonal state during peak fertility (Puts et al., 2013). In addition, progesterone, which is lower during fertile than non-fertile phases of the cycle, is negatively associated with women's attractiveness (Puts et al., 2013). These results suggest that fluctuating levels of estradiol and progesterone underlie cycle shifts in women's mate preferences and attractiveness.

Hormonal contraceptives alter women's cycling reproductive hormones in a number of ways, suggesting that they might influence women's mate preferences and the other related phenomena noted above in several different ways. All hormonal contraceptives contain a synthetic progestogen (such as drospirenone, desogestrel, and medroxyprogesterone acetate), and most also contain a synthetic estrogen (ethiniyl estradiol). These exogenous hormones eliminate

ovulation and suppress women's endogenous reproductive hormones (Fleischman, Navarrete, & Fessler, 2010; Frye, 2006). Therefore, hormonal contraceptives could have effects because they (a) eliminate ovulation thereby potentially eliminating any psychological effects ovulation itself might have, (b) suppress women's endogenous hormones thereby potentially dampening psychological effects positively associated with these hormones, and (c) add exogenous synthetic versions of progesterone and estradiol, which, if they bind to receptors involved in psychological shifts, could potentially enhance psychological effects positively associated with progesterone and estradiol. Whichever of these is the case (or whether all three mechanisms play a role) it is clear that hormonal contraceptives alter the hormonal milieu of women's bodies and the way their reproductive systems function. Given the links between hormones, reproductive function, and mating-related outcomes, it is plausible that hormonal contraceptives will influence psychological processes related to women's mate choices and relationship functioning.

Concern about Effects of Hormonal Contraceptives

Given the reviewed evidence of cycle shifts in mate preferences for characteristics historically associated with high genetic quality and the fact that hormonal contraceptives eliminate ovulation and corresponding hormone shifts, numerous scholars have hypothesized that hormonal contraceptives will also eliminate cycle shifts in women's mate preferences. Some have hypothesized that either by eliminating these cycle shifts or by suppressing the endogenous hormones hypothesized to cause them, hormonal contraceptives will eliminate or diminish women's overall preferences for these characteristics and reduce the likelihood that women who use hormonal contraceptives (HC users) will choose partners who have these characteristics, relative to women who do not use hormonal contraceptives (non-users) (e.g. Alvergne & Lummaa, 2010; Little, Burriss, Petrie, Jones, & Roberts, 2013; Roberts et al., 2014; Welling,

2013). Similarly, many researchers have hypothesized that hormonal contraceptive use diminishes women's preferences for MHC dissimilarity, leading HC users to choose romantic partners who are less MHC similar, and therefore less genetically compatible relative to the partners of non-users (Alvergne & Lummaa, 2010; Roberts et al., 2008; Roberts et al, 2012; Voilrath & Milinski, 1995; Wedekind, et al., 1995).

Another straightforward prediction is that by eliminating cycle shifts in reproductive hormones, hormonal contraceptives will also eliminate cycle shifts in women's attractiveness. Some researchers have hypothesized that either by eliminating cycle shifts in attractiveness or by suppressing estradiol, hormonal contraceptives will decrease women's overall physical attractiveness (Alvergne & Lummaa, 2010; Puts & Pope, 2013; Roberts et al., 2014; Welling, 2013). Furthermore, some researchers hypothesized that by diminishing women's attractiveness, hormonal contraceptives might make it more difficult for women to compete for romantic partners, maintain a relationship with their romantic partner, or to maintain their partner's sexual interest in them (Alvergne & Lummaa, 2010; Puts & Pope, 2013; Roberts et al., 2014; Welling, 2013). In addition, based on the hypothesis that hormonal contraceptive use diminishes women's competitiveness towards other women, hormonal contraceptive users might have further difficulties obtaining and maintaining a relationship with preferred romantic partners (Cobey, Klipping, & Buunk, 2013).

Many have hypothesized that by altering women's mate choices, hormonal contraceptives will also negatively affect relationship dynamics, leading to relationship conflict and dissolution, particularly if women's use of hormonal contraceptives changes, assuming this will also cause her preferences to change (Alvergne & Lummaa, 2010; Boero, 1996; Cobey, Roberts, & Buunk, 2013; Havlicek & Roberts, 2009; Roberts et al., 2008; Roberts et al., 2013;

Roberts et al. 2012; Roberts et al., 2014; Voilrath & Milinski, 1995; Welling, Puts, Roberts, Little, & Burriss, 2012; Welling, 2013). The hypothesis that if a woman's current hormonal contraceptive use does not match her use when she chose her partner, her partner will no longer match her preferences which will harm her relationship has recently been formalized as the congruency hypothesis (Cobey , Roberts, & Buunk, 2013; Roberts et al., 2013; Roberts et al., 2014). Others have argued that through impairing mate choice, hormonal contraceptives might destabilize relationships through altering women's jealousy and mate guarding levels (Cobey, Roberts, & Buunk, 2013; Welling et al., 2012). Extending even further, some scholars have hypothesized that through impairing women's ability to choose a genetically compatible partner or a partner with high genetic quality, hormonal contraceptives might later cause women to have a difficult time becoming pregnant and might cause women to give birth to children with impaired immune systems (Alvergne & Lummaa, 2010; Little et al., 2013; Wedekind et al., 1995; Welling, 2013).

We now turn to the evidence, covering all the research questions the extant literature can address. For some concerns regarding the potential influence of hormonal contraceptives, there is research that speaks directly to the claims. Other claims remain untested, particularly those regarding downstream consequences of hormonal contraceptive use. When possible, we speculate on the likelihood that these concerns will be founded, given the conclusions we can draw regarding associations between hormonal contraceptive use and women's mate choices and relationship functioning.

Evidence for Effects of Hormonal Contraceptive Use on Women's Mate Choice and Relationship Functioning

Review Inclusion Criteria

We review the evidence from all studies that assessed women's use of hormonal contraceptives and conducted separate analyses for HC users and non-users. Studies must have assessed current HC use or HC use during a specified point in time pertinent to relationship functioning, such as when a romantic relationship began. We do not review studies in which either HC users or non-users were excluded from analyses. We limited the review to studies assessing outcomes directly pertaining to women's mate choice and relationship functioning, such as women's mate preferences, women's attractiveness, and romantic jealousy. Because there are already several reviews of research on HC use and sexual desire and behavior (Bancroft & Sartorius, 1990; Davis & Castano, 2006; Pastor, Holla, & Chmel, 2013; Schaffir, 2006), we do not review research on these outcomes.

We organize the review in terms of the questions extant research can address. Table 1 presents an overview of all studies meeting the inclusion criteria above. Table 2 presents results from the subset of studies that examined cycle shifts among HC users and non-users. Table 3 presents results from the three studies assessing preferences for MHC dissimilarity. Table 4 presents results from the two studies employing a combination cross-sectional longitudinal design. Table 5 presents analyses directly comparing HC users to non-users (collapsing across cycle phase) along masculinity preferences, mate choice, women's attractiveness, and other variables related to relationship functioning. Although not presented in a separate table, we also review the three studies that speak to the congruency hypothesis. Table 6 presents analyses from all the reviewed studies that directly compared HC users to non-users (collapsing across cycle

phase) along demographic variables and other potential confound variables. Relatedly, Table 7 presents prevalence of HC use as a function of different demographic characteristics from the 2008 National Survey of Family Growth (NSFG; Mosher & Jones, 2010). The NSFG surveyed a large nationally-representative group of reproductive-aged women, providing information on women outside of the population typically sampled in the reviewed studies (i.e. college students). These data help to elucidate differences between HC users and non-users in the broader population. When possible, we present both effect sizes and significance tests in the tables described below.

Study Characteristics

Table 1 presents an overview of all studies meeting the inclusion criteria, along with key characteristics of the studies, such as phenomenon under investigation, study design, and number of participants. As shown in this table, many studies have examined HC use in conjunction with variables associated with women's mate choice and relationship functioning. The majority of the studies (17 out of 32) examined women's mate preferences, but only three examined women's actual mate choices (one of these studies was focused on testing the congruency hypothesis and therefore only reported associations between HC use at relationship initiation and the outcome variables when controlling for current HC use, Roberts et al., 2014). Five studies examined women's attractiveness to men. The remaining studies examined a variety of outcomes broadly related to relationship functioning, such as romantic jealousy, extra-pair sexual behavior, and intrasexual competition.

As noted in the introduction, no study employed a true experimental design (randomly assigning women to use vs. not use hormonal contraceptives). The majority of the studies employed a cross-sectional design in which women who used hormonal contraceptives were

compared with women who did not. Two studies (Little et al., 2013 Study 1; Roberts et al., 2008) employed a combination of cross-sectional and longitudinal designs in which two groups of women were assessed at two time points: one group of women who remained non-users throughout the study were compared to another group of women who began using hormonal contraceptives between their first and second session. Only three studies employed a completely longitudinal design in which women's responses at three time points – once as HC users, and twice as a non-users (at high and low fertility) – were compared (Cobey, Buunk, Roberts, Klipping, Appels, Zimmerman, Coelingh, Benninke, & Pollet, 2012; Cobey, Klipping, & Buunk, 2013; Cobey, Buunk, Pollet, Klipping, & Roberts, 2013). Two studies (Jones, Little, Boothroyd, DeBruine, Feinberg, Smith, Cornwell, et al., 2005; Roberts et al., 2012) had very large samples (*n*'s > 1,000 for each group), but the majority of the studies had relatively small sample sizes. Few studies assessed or accounted for the type of hormonal contraceptive women used, but more than half of the studies did account for women's position within the cycle. Many studies did not examine whether HC users and non-users differed along potential confounding variables and the majority of the studies did not control for potential confounding variables.

In sum, one can draw several conclusions simply by noting the features of the studies in this literature. First, the literature cannot support causal conclusions about the effects of hormonal contraceptives. Therefore using causal language (e.g. words like influence, affect, alter, change) to describe findings in this literature is inaccurate and misleading. Second, because the majority of the studies were cross-sectional and few collected information on or controlled for potential confounding variables, it is possible that systematic differences between women who chose to use hormonal contraceptives and those who did not could have an influence on any associations between hormonal contraceptive use and the outcomes observed. Third, most

studies did not account for the wide range of hormonal contraceptive formulations currently available (Hather, Trussel, Cates, Stewart, & Kowal, 2007). Hormonal contraceptives can differ greatly from one another, for example, in the dose of hormones they contain, the form of progestin they use, the hormone receptors they activate, and the extent to which they suppress ovarian activity (Frye, 2006; Hather et al., 2007; Sitruk-Ware, 2004). Therefore, failing to account for this variation might result heterogeneous samples of HC users whose hormonal profiles differ from one another. This might make it difficult to detect subtle hormonally driven effects, introducing unaccounted for noise into the literature.

Do Hormonal Contraceptives Eliminate Cycle Shifts in Mate Preferences, Attractiveness, and Relationship Functioning?

Table 2 presents results from the subset of studies assessing cycle shifts among HC users and non-users, and analyses comparing users and non-users at high versus low fertility[2]. As this table shows, none of the studies assessing mate preferences across the cycle found statistically significant cycle shifts among HC users. In contrast, all of the studies assessing mate preferences across the cycle found statistically significant cycle shifts among non-users in contexts where they were predicted by the ovulatory shift hypothesis. Only one of the analyses assessing women's attractiveness found a marginally significant cycle shift among HC users (Schwarz & Hassebrauck, 2008), whereas five of the seven analyses found significant or marginally significant cycle shifts among non-users (Cobey, Buunk, et al., 2013; Kuukasjarvi, Eriksson, Koskela, Mappes, Nissinen, & Rantala, 2004; Miller, Tybur, & Jordan, 2007; Pipitone & Gallup, 2008; Schwarz & Hassebrauck, 2008). Of the studies examining cycle shifts in other variables

[2] HC users do not have true ovulatory cycles or experience high-fertility phases. Therefore, studies in this area assign HC users a fertility equivalent based on what their fertility would be if they were naturally cycling given their proximity to menstruation within the cycle. Therefore, statements about "high fertility" phases among HC users refer to the equivalent day of the cycle, and do not imply that HC users have phases of high fertility or experience changes in fertility across the cycle.

related to relationship functioning, one found that non-users showed a statistically significant shift in levels of intrasexual competition whereas HC users did not (Piccoli, Foroni, & Carnaghi, 2013). The remaining three studies used a longitudinal design in which women's responses were assessed at both the high- and low-fertility phase of the cycle when women were not using hormonal contraceptives, but only once when women were using hormonal contraceptives (Cobey, Buunk, et al., 2013; Cobey et al., 2012; Cobey, Klipping, & Buunk, 2013). Therefore, these studies could assess cycle shifts while women were non-users but not while they were HC users. In sum, the evidence to date is consistent with the hypothesis that hormonal contraceptives eliminate cycle shifts in women's mate preferences and attractiveness. Although there is not yet enough evidence to conclude whether cycle shifts in other variables related to relationship functioning observed among non-users are absent among HC users, the consistent evidence that HC users do not experience cycle shifts in preferences and attractiveness suggest that this conclusion is very likely to be supported in future research.

Are Differences between HC Users and Non-Users Present Only At Mid-cycle?

As shown in Table 2, non-users experience specific theory-consistent cycle shifts whereas HC users do not, consistent with the hypothesis that hormonal contraceptives cause psychological effects through eliminating ovulation and its associated psychological shifts. This hypothesis leads to two predictions regarding differences between HC users and non-users. The first is that between-group differences will be contingent on cycle phase, such that HC users will differ from non-users more at high relative to low fertility. For example, because mid-cycle boosts in preferences for masculinity in a short-term mate are present among non-users but absent among HC users, this hypothesis suggests that HC users will have weaker preferences for masculinity than non-users at mid-cycle, but not at other cycle phases. The second prediction is

that these cycle-contingent between-group differences will only be seen for outcomes that shift across the cycle. For example, HC users are predicted to have weaker preferences for masculinity than non-users at mid-cycle when assessing men as short-term partners, but not when assessing men as long-term partners.

Table 2 presents mixed support for these predictions. Among analyses in which HC users and non-users are predicted to significantly differ at high but not low fertility (i.e. women's attractiveness and women's preferences for characteristics historically associated with high genetic quality in a short-term or unspecified context), five found these predicted results (Cobey, Buunk, et al., 2013; Gangestad & Thornhill, 1998; Grammer, 1993; Miller et al., 2007; Pipitone & Gallup, 2008), but five found no statistically significant between-group differences at either high or low fertility (Cobey, Buunk, et al., 2013, Kuukasjarvi et al., 2004; Little, Jones, & Burriss, 2007; Lukaszewski & Roney, 2009; Penton-Voak & Perrett, 2000).

Among analyses in which HC users and non-users are not predicted to differ significantly at either high or low fertility (i.e. preferences for characteristics historically associated with high genetic quality in a long-term context, preferences for characteristics historically associated with high long-term partner quality), two found this predicted result (Little et al., 2007; Lukaszewski & Roney, 2009), but one found that HC users statistically significantly differed from non-users at high but not low fertility (Lukaszewski & Roney, 2009). Among analyses in which this hypothesis does not make strong predictions about between-group differences at high versus low fertility (i.e. other variables related to relationship functioning), one found that HC users statistically significantly differed from non-users at high but not low fertility (Cobey, Buunk, et al., 2013), one found that the between-group difference was significant at low but not high fertility (Cobey et al., 2012), one found significant between-group differences at both high and

low fertility (Cobey, Klipping, & Buunk, 2013), and one found no significant between-group differences (Cobey, Klipping, & Buunk, 2013).

In sum, there is mixed evidence consistent with the hypothesis that by eliminating cycle shifts, hormonal contraceptives will cause HC users to differ from non-users at high but not low fertility only in specific contexts. However, several factors suggest caution in interpreting these results. First, many of the studies in Table 2 did not include statistics comparing the two groups of women separately at the two cycle phases. Second, the comparisons between HC users and non-users at high and low fertility involved a between-participant design for most of the studies reviewed, whereas comparisons between high and low fertility among HC users and non-users involved a within-participant design in several studies. Therefore, for many studies the between-group analyses were underpowered relative to analyses on cycle shifts. Given the robust findings that cycle shifts present among non-users are absent among HC users, it seems probable that between-group differences will be contingent on cycle phase, but more research is needed in this area to empirically establish that this is the case.

Do Hormonal Contraceptive Users have Weaker Preferences for MHC Dissimilarity than Non-users?

Table 3 presents results from the three studies assessing scent preferences for MHC dissimilarity among HC users and non-users. In the first two studies, non-users statistically significantly or marginally significantly preferred the scent of MHC dissimilar (vs. similar) individuals (Wedekind et al., 1995; Wedekind & Furi, 1997). In contrast, HC users did not prefer the scent of MHC dissimilar individuals and in one study marginally significantly preferred the scent of MHC *similar* individuals, leading to statistically significantly stronger preferences for dissimilarity among non-users than HC users (Wedekind et al., 1995). In the third study (Roberts

et al., 2008 Session 2), the researchers first ran analyses on the entire sample of scent donors and raters, and then ran analyses on a "core" sample of participants[3]. In contrast to the previous studies, among both the entire sample (presented in Table 3) and the core sample (presented in Table 4), neither HC users nor non-users had statistically significant MHC-based scent preferences, and preferences for dissimilarity were not significantly stronger among non-users than HC users. In sum, there are not enough studies in this area and the results are not consistent enough to draw firm conclusions regarding associations between hormonal contraceptive use and MHC-based scent preferences. This lack of a strong conclusion does, however, suggest that claims that there is strong evidence that hormonal contraceptive use is associated with diminished preferences for MHC dissimilarity do not accurately represent the data. Therefore, concerns that hormonal contraceptive use will cause HC users to choose MHC similar partners are not founded based on the available evidence.

Does Initiation of Hormonal Contraceptive Use Decrease Preferences for MHC Dissimilarity?

The study by Roberts and colleagues (2008) is particularly noteworthy because it was the first to employ a cross-sectional longitudinal design in which researchers followed women over time and compared their preferences before they began using hormonal contraceptives to their preferences after they began using hormonal contraceptives. In this study, women completed two sessions, spaced approximately three months apart. At the first session all participants were non-users, but approximately half of the women planned to soon begin using hormonal contraceptives. At the second session, these women were now HC users whereas the other participants remained non-users. Both Session 1 and Session 2 were scheduled to take place

[3] The core sample excluded raters and donors who were born outside of the UK or were of a non-UK ethnic origin, and donors whose samples smelled of tobacco smoke or fragranced products.

during a high-fertility phase of the menstrual cycle (or on equivalent days of the cycle at Session 2 for HC users). Table 4 presents the results of this study.

Roberts and colleagues (2008) found a statistically significant interaction between Session and initiation of HC use among the core sample of participants, such that preferences for MHC dissimilarity decreased between Session 1 and Session 2 among women who became HC users and increased between Session 1 and Session 2 among women who remained non-users[4]. This significant interaction between Session and HC use is consistent with the hypothesis that initiation of hormonal contraceptive use decreases preferences for MHC dissimilarity, and is often interpreted as providing evidence for this hypothesis (e.g. Alvergne & Lummaa, 2010; Roberts et al., 2013). However, a closer examination reveals that the pattern of results behind the statistically significant interaction differs from what would be expected if the hypothesis were true.

If initiating hormonal contraceptive use decreases women's preferences for MHC dissimilarity, at Session 1 preferences for dissimilarity should not significantly differ between women who subsequently became HC users and women who remained non-users, preferences for dissimilarity should significantly decrease between Session 1 and Session 2 among women who became HC users at Session 2, but should not change among women who remained non-users, and at Session 2 preferences for dissimilarity should be significantly weaker among the women who became HC users than among the women who remained non-users. Furthermore, strong evidence for this hypothesis would entail finding this pattern of results for all relevant

[4] The interaction was statistically significant when ratings of desirability, pleasantness and intensity were combined (p=.03). The interaction remained significant when controlling for women's relationship status and self-rated attractiveness. However, the interaction was not statistically significant in analyses on the entire sample rather than the core sample. Table 4 presents results for the core sample. Table 3 presents results for the full sample at Session 2 only.

outcome variables (both desirability and pleasantness) and among both the core and the full sample of participants.

Consistent with some of these predictions, for ratings of desirability among the core sample, the researchers found that preferences for MHC dissimilarity did significantly decrease between Session 1 and Session 2 among women who became HC users at Session 2, but not among women who remained non-users. However, contrary to the predictions, at Session 1 women who later became HC users had statistically significantly stronger preferences for MHC dissimilarity than did later non-users, whereas the two groups of women did not statistically significantly differ in their preferences for MHC dissimilarity at Session 2. This unexpected difference between the two groups of women at Session 1 (at which time all women were non-users) appears to be driving the marginally significant interaction in desirability ratings between HC use and Session, and the significant decrease in dissimilarity preferences between Session 1 and 2 among women who become HC users. In addition, this pattern of results is not robust, and the interaction between HC use and Session is not significant for ratings of pleasantness among the core sample, or for ratings of either pleasantness or desirability among the full sample of participants. In sum, the evidence does not compel strong conclusions that initiation of HC use is associated with decreased preference for MHC dissimilarity.

Do Hormonal Contraceptive Users have Weaker Preferences for Masculinity than Non-users?

Table 5 presents results from the nine studies (14 analyses) assessing preferences for masculinity among HC users and non-users (collapsing across the cycle). As shown in Table 5, many studies have investigated whether HC users have weaker preferences for masculinity than non-users, but the results of these studies are mixed. Only three analyses produced the predicted

result of statistically significantly weaker preferences for masculinity among HC users relative to non-users (Grammer, 1993; Little et al., 2013; Lukaszewski & Roney, 2009)[5] and one of these studies only assessed women at high fertility, and as such cannot speak to whether preferences differ between the two groups of women when collapsing across the cycle (Little et al., 2013). Two analyses found evidence in the opposite direction, with statistically significantly stronger preferences for masculinity among HC users relative to non-users (Little et al., 2007; Lukasszewski & Roney, 2009). Of the remaining analyses finding no statistically significant differences between the two groups of women, four found that HC users had weaker preferences for masculinity and five found that HC users had stronger preferences for masculinity, relative to non-users.

When comparing masculinity preferences among HC users and non-users, context might be an important variable to consider. Because much of the concern regarding hormonal contraceptive use has focused on the potential consequences for women's choice of long-term relationship partners (e.g. Alvergne & Lummaa, 2010; Little et al., 2013; Roberts, et al., 2013), women's long-term preferences might be of particular interest because they are likely to be better predictors of long-term partner choice than are short-term preferences. Alternatively, given the evidence that hormonal contraceptives eliminate cycle shifts in preferences for masculinity in short-term contexts but not long-term contexts (Gildersleeve, et al., 2014), masculinity preferences might only be weaker among HC users than non-users in a short-term or unspecified context.

Among the studies assessing women's preferences in a long-term mating context, only one analysis found that HC users had statistically significantly weaker preferences for

[5] Preferences for facial masculinity were statistically significantly higher among non-users than users in a fourth study when controlling for participant age, relationship status, and preferences for vocal masculinity ($p = .01$; Feinberg et al., 2008).

masculinity than non-users (Lukaszewski & Roney, 2009). In the three remaining analyses, HC users had non-significantly stronger preferences than non-users (Little et al., 2002; Little et al., 2007; Smith et al., 2009). Among the studies assessing women's preferences in a short-term mating context, two analyses found that HC users had statistically stronger preferences for masculinity than non-users (Little et al., 2007; Lukaszewski & Roney, 2009). Among the two non-significant analyses, HC users had stronger preferences than non-users in one (Smith et al., 2009) and weaker preferences in the other (Little et al., 2002). Among the studies that did not specify a context, or averaged across short- and long-term ratings, two analyses found that HC users had statistically significantly weaker preferences for masculinity than non-users (Grammer, 1993; Little et al., 2013). In the four non-significant analyses, three found that HC users had weaker preferences than non-users (Feinberg, DeBruine, Jones, & Little, 2008; Vukovik, Feinberg, Jones, DeBruine, Welling, Little, & Smith, 2008), and one found that they had stronger preferences (Penton-Voak & Perrett, 2000).

In sum, there is not consistent or compelling evidence that HC users have weaker preferences for masculinity than non-users. Although some studies found weaker masculinity preferences among HC users relative to non-users, others found stronger preferences among HC users, and the majority of the studies did not find statistically significant differences between HC users and non-users. However, given these mixed results we should not yet draw the conclusion that HC users *do not* have weaker preferences for masculinity than non-users. For example, there might be moderating variables which were not considered in previous studies masking true differences between HC users and non-users. However, the results can tell us that conclusions that hormonal contraceptive users have weaker preferences for masculinity than do non-users are not supported by the evidence when all the relevant studies are considered.

Does Initiation of Hormonal Contraceptive Use Decrease Preferences for Masculinity?

The results of the one cross-sectional longitudinal study assessing changes in masculinity preferences as a function of initiating HC use are presented in Table 4. Little and colleagues (2013) employed the same methodology as Roberts and colleagues (2008), testing women once when all women were non-users and a second time when approximately half of the woman had become HC users.[6] Both Session 1 and Session 2 were scheduled to take place during a high-fertility phase of the menstrual cycle (or on equivalent days of the cycle at Session 2 for HC users). Like Roberts and colleagues, Little et al found a statistically significant interaction between session and HC use, and in this study the pattern of results leading to this significant interaction was consistent with the hypothesis that hormonal contraceptive use is associated with decreased preferences for masculinity.

Specifically, the researchers found that preferences for masculinity in male faces decreased significantly between Session 1 and 2 among women who became HC users, but did not significantly change between Session 1 and 2 among women who remained non-users[7]. At Session 1, preferences for masculinity did not significantly differ between women who later became HC users and women who remained non-users, but at Session 2, preferences for masculinity were significantly weaker among HC users than among non-users. Although these results are consistent with the hypothesis that initiation of hormonal contraceptives *caused* women's preferences for masculinity to decrease, because hormonal contraceptive use was not randomly assigned, the study cannot provide support for this causal hypothesis.

[6] Although in their paper, Little and colleagues (2013) refer to the study as an experiment, the women who became HC users as the "experimental" group, and the women who remained non-users as the "control" group, the study did not use a true experimental design in which women were randomly assigned to begin or refrain from hormonal contraceptive use (women self-selected into the "experimental" or "control" conditions).

[7] In addition, the researchers found that preferences for masculinity in female faces did not similarly change between Sessions 1 and 2 among women who became HC users, suggesting that the results were specific to women's mate preferences.

An important caveat to this study is that all sessions occurred during the high-fertility phase of the menstrual cycle (or the equivalent distance from menstruation among HC users). Given the robust evidence that women's preferences for masculinity are heightened at high relative to low fertility if they are non-users but not if they are HC users, this study provides further evidence consistent with the hypothesis that that mid-cycle boosts in masculinity preferences will be absent among HC users. But because women were not tested outside of the high-fertility window, this study cannot provide information on whether HC users have lower preferences for masculinity than non-users across the entire cycle. It is possible that the weakened preferences for masculinity between Session 1 and Session 2 observed among HC users simply reflected the difference in preferences between high and low fertility, not a decline specifically induced by hormonal contraceptive use. For example, it is entirely possible that if the women who remained non-users had been tested at a low-fertility phase of the cycle during the second session they might have shown the same decline in preferences for masculinity as the HC users did, leading to no significant difference in masculinity preferences between HC users and non-users at Session 2.

In sum, the one cross-sectional longitudinal study assessing masculinity preferences found evidence consistent with the hypothesis that hormonal contraceptive use is associated with decreased preferences for masculinity across the cycle. However, because women's preferences were assessed only at high fertility, the evidence from this study is also consistent with the hypothesis that HC users lack mid-cycle boosts in preferences for masculinity and that HC users and non-users will differ only at high fertility. Other research consistently supports the hypothesis that cycle shifts in preferences are present among non-users and absent among HC users, but it does not consistently support the hypothesis that HC users have weaker preferences

for masculinity than non-users (when collapsing across the cycle). Therefore, interpreting the results of this study as evidence of a lack of mid-cycle boosts in masculinity preferences among HC users is more consistent with the body of literature than interpreting the results as evidence that HC users have weaker preferences for masculinity than non-users overall. In order to truly disentangle between these two possibilities, future research will need to assess preferences at both high- and low-fertility phases of the cycle. Until then, this study should not be interpreted as providing strong support for one hypothesis over the other.

Do Hormonal Contraceptive Users Have Stronger Preferences for Apparent Health in Faces than Non-users?

One study examined whether preferences for apparent health in faces differed as a function of hormonal contraceptive use (Jones et al., 2005). In this study, HC users and non-users were asked to choose the face they preferred out of pairs of faces that had been digitally manipulated toward composite faces of people previously rated as looking healthy, or faces of people previously rated as looking unhealthy. Hormonal contraceptive users were statistically significantly more likely than non-users to prefer the healthy faces, and this effect remained significant when controlling for participants' age, relationship status, and UK residency. However, the size of the effect was very small (d = 0.1). In previous studies in this paper, the authors found that preferences for health were positively associated with progesterone levels, and interpreted the stronger preferences among hormonal contraceptive users as evidence that the high levels of progestins in hormonal contraceptives influenced women's preferences. Therefore, although the evidence is consistent with the hypothesis that HC users have stronger preferences for health than non-users, the difference in preferences between HC users and non-users is small and more research is needed before we can answer the question with confidence.

Are Hormonal Contraceptive Users Less Attractive than Non-users?

Table 5 presents results from the four studies (five analyses) assessing variables related to women's attractiveness among HC users and non-users (collapsing across cycle phase). One study found that HC users were statistically significantly less attractive than non-users (as assessed by tip earnings from working as a lap dancer; Miller et al., 2007) with a very large effect size. The remaining four analyses found that ratings of attractiveness were lower among HC users than non-users, though these differences were not statistically significant (Cobey, Buunk, et al., 2013; Kuukasjärvi et al., 2004; Pipitone & Gallup, 2008). As shown in in Table 2, the differences in attractiveness between HC users and non-users were all larger at high than low fertility, suggesting that the results collapsing across cycle phase might be driven primarily by between-group differences at high fertility.

In sum, these studies provide consistent but preliminary support for the hypothesis that hormonal contraceptive users are less attractive than non-users, as all the studies found differences in the same direction, but the differences were largely not statistically significant. Although there are several studies assessing women's attractiveness, attractiveness was measured in different ways (women's self-ratings, male partner ratings, tip earnings) and across different modalities (body, odor, voice) in all of the studies. Therefore, more research, particularly direct replications, would strengthen these findings. Analyses comparing HC users to non-users separately at high and low fertility reveal that the between-group differences are greater at high than low fertility, suggesting that mid-cycle boosts in attractiveness among non-users might be contributing to the higher overall levels of attractiveness among non-users relative to HC users. Therefore, it is important that research assessing attractiveness among HC users as compared to non-users continues to account for cycle phase.

Do Hormonal Contraceptive Users Differ from Non-users on other Variables Related to Relationship Functioning?

As shown in Table 5, a number of additional studies have examined hormonal contraceptive use in relation to variables that might be related to relationship functioning[8]. Three studies investigated romantic jealousy, two investigated intrasexual competition, and there was one study each investigating mate guarding, male partner attractiveness, and extra-pair behavior.

Romantic jealousy. Of the romantic jealousy studies, one found that among women in relationships, HC users endorsed items about their tendency to feel romantic jealousy at statistically significantly higher levels than did non-users (Cobey Roberts, & Buunk, 2013)[9] and a second found that HC users reported that they would feel negative emotions (hurt, anger, and jealousy) in response to imagined sexual and emotional infidelity more than non-users did (Geary, DeSoto, Hoard, Sheldon, & Cooper, 2001)[10]. The third jealousy study employed a within-participants longitudinal design in which women were assessed both while using and while not using hormonal contraceptives (Cobey et al., 2012). In this study, women's endorsement of items about their tendency to feel romantic jealousy did not statistically significantly differ between sessions in which they were HC users and sessions in which they were non-users, when averaging across responses at high and low fertility. In sum, although the between-participant studies suggested that HC users have higher levels of jealousy than do non-users, the within-participant study did not find this effect when collapsing across the cycle.

[8] While sexual desire and activity are variables related to relationship functioning, associations between these variables and hormonal contraceptive use have been reviewed extensively elsewhere (e.g. Bancroft & Sartorius, 1990; Davis & Castano, 2006; Pastor, Holla, & Chmel, 2013; Schaffir, 2006).

[9] However, this effect was non-significant when controlling for hormonal contraceptive use at relationship initiation, see section on hormonal contraceptive use congruency.

[10] When looking at the emotions separately, HC users reported significantly stronger feelings than non-users for both an emotional and a sexual infidelity. However, when controlling for sexual activity within the past week and relationship with most recent sexual partner, only two of these six effects remained significant.

Therefore, more studies are needed before we can draw firm conclusions regarding the relationship between hormonal contraceptive use and romantic jealousy.

Intrasexual competition. One of the studies assessing intrasexual competition and hormonal contraceptive use employed a between-participant design (Piccoli et al., 2013) and the other employed a within-participants longitudinal design using the methods outlined above (Cobey, Klipping, & Buunk, 2013). The study employing a between-participant design did not find statistically significant differences in intrasexual competition between HC users and non-users (the study did not differentiate between women by relationship status). The study employing a within-participant design also did not find statistically significant differences in intrasexual competition between HC users and non-users when collapsing across women's relationship status. However, among women in a relationship, intrasexual competition was statistically significantly lower among HC users than non-users, but among single women, intrasexual competition did not statistically significantly differ between HC users and non-users. In sum, there is not yet strong evidence that HC users are less intrasexually competitive than non-users. It is possible that this between group difference is present among women in relationships, but only one study addressed this possibility, and the sample size was very small (n = 14), suggesting it is too soon to draw generalizations about this phenomenon until more research has been done.

Mate guarding. One study assessed levels of mate guarding among romantic couples in which the female partner was either a HC user or a non-user (Welling et al., 2013). The study found that both women and their partners reported that women engaged in statistically significantly higher levels of mate-guarding if she was a HC user versus a non-user. Male partners also reported that their own levels of mate guarding behavior were statistically

significantly higher if their partner was a HC user versus a non-user, though women's reports of their partner's mate guarding did not statistically significantly differ between HC users and non-users. This study offers preliminary evidence that levels of mate guarding and HC use are associated, though more research is needed before this conclusion can be made with confidence.

Male partner ratings of own attractiveness. One study assessed men's ratings of their own attractiveness as a function of their partner's use of hormonal contraceptives (Cobey, Buunk, et al., 2013). This study also used the longitudinal within-participant methods described above and found that men rated themselves as statistically significantly less attractive when their partner was using hormonal contraceptives than when she was not. This study offers preliminary evidence that men's self-rated attractiveness differs as a function of their partner's hormonal contraceptive use, but because the sample size of this study was very small (n = 14), more research is needed, and again we should be cautious in generalizing beyond this small sample.

Extra-pair behavior. One study examined extra-pair behaviors as a function of current hormonal contraceptive in a sample of women participating in the Czech National Survey of Sexual Behavior who had been in a romantic relationship for at least one year (Klapilova, Cobey, Wells, Roberts, Weiss, & Havlicek, 2014). Because the majority of the women in the sample had not engaged in extra-pair sexual activity within the past year, the authors conducted two sets of analyses. First, they conducted analyses predicting the likelihood that women had engaged in extra-pair activity with at least one partner in the past year. Second, among the subset of women reporting at least one extra-pair partner, they conducted analyses predicting the number of extra-pair partners women had had in the past year. They controlled for variables that might be confounded with hormonal contraceptive use and extra-pair behavior (e.g. relationship length, parity) in all analyses. Although the likelihood of having engaged in at least one extra-pair affair

in the past year was not associated with hormonal contraceptive use, among women who had engaged in extra-pair activity, HC users had significantly fewer extra-pair partners in the past year relative to non-users. However, in most analyses, the control variables were much stronger predictors of extra-pair activity than was hormonal contraceptive use, suggesting that HC use might play a role on women's sexual behaviors in certain contexts, but its role might be minor in comparison to other factors known to influence women's sexual activity.

In sum, although there have been a number of studies examining variables related to relationship functioning among HC users and non-users, most of the studies focused on different variables, making overall conclusions about this group of studies difficult. Some evidence suggested that jealousy was higher among HC users than non-users, though not every study found this result, and the effect might depend on moderating variables, such as hormonal contraceptive use congruency. There is not evidence that levels intrasexual competition differ as a function of hormonal contraceptive use among single women, though one study among a very small sample of women found evidence that intrasexual competition was lower when women used hormonal contraceptives than when they did not. Preliminary results suggested that mate guarding behavior was higher among women who were hormonal contraceptive users than non-users, and that among women who engaged in extra-pair behavior in the past year, the number of partners they engaged in this behavior with was lower among HC users than non-users. Preliminary evidence also suggests that male romantic partners might engage in more mate-guarding and feel that they are less attractive if their partner is using hormonal contraceptives than if she is not. However, all of these results have only been documented in one study each and several studies had a very small sample of participants, so more research is needed in this area to determine which results are robust.

Future research on these topics could clarify these results by examining how the variables are related to each other. For example, a study of women in relationships examining their romantic jealousy, intrasexual competition, and mate guarding at the same time could help explain how higher levels of jealousy and mate guarding relate to lower levels of intrasexual competition among HC users as compared with non-users (if the results of past research replicate). Additionally, variables that have had moderating effects in past research in this area (e.g. current relationship status, hormonal contraceptive use at relationship initiation) as well as variables that have had moderating effects in past research on other outcomes related to relationship functioning (e.g. male partner sexual attractiveness, see Larson, Haselton, Gildersleeve, & Pillsworth, 2013; Larson, Pillsworth, & Haselton, 2012) should be included in future research. Finally, research in this area could provide more information on whether hormonal contraceptive use alters relationship functioning by including previously unstudied variables crucial to fully understanding relationship functioning, such as relationship satisfaction and relationship commitment.

Do the Mate Choices of Hormonal Contraceptive Users and Non-users Differ?

Only three studies have investigated whether women's actual mate choices varied as a function of their hormonal contraceptive use, as shown in Table 5. The first study assessed whether women's satisfaction with various aspects of their relationship and relationship longevity differed depending on their use of hormonal contraceptives at relationship initiation (Roberts et al., 2012). The second assessed these same sexual and non-sexual satisfaction items, but offered only an indirect investigation of the effects of hormonal contraceptive use on mate choice because it was focused on hormonal contraceptive congruency, and as such did not report results on the influence of hormonal contraceptive use at relationship initiation independent of

the influence of current use (Roberts et al., 2014). The third study assessed whether male partner facial masculinity differed depending on women's use of hormonal contraceptives at relationship initiation (Little et al., 2013, Study 2).

In the first study, Roberts and colleagues (2012) recruited an online sample of women who had at least one child. Women reported whether they were using hormonal contraceptives when they met the father of the first child, and whether they were still romantically involved with this man. If they were still involved in their relationship, they rated their current satisfaction with sexual and non-sexual aspects of their relationship, rated their partner's attractiveness, and reported on their sexual behaviors with their partner (see Table 5). If they were not still involved in their relationship, they reported on their satisfaction and behaviors when they were involved in the relationship.

Among women who were still involved in a relationship with their partner, women who were non-users at relationship initiation were statistically significantly more satisfied than HC users on four out of six measures of sexual satisfaction, and one out of two measures of partner attractiveness. However, the two groups of women did not differ on the two behavioral measures relating to sexual satisfaction (frequency of rejecting partner's sexual advances and frequency of having sex to be compliant). For the non-sexual satisfaction measures, women who were HC users at relationship initiation were statistically significantly more satisfied than non-users on two of the five items but marginally significantly less satisfied than non-users on one item. Follow-up analyses revealed that sexual satisfaction (averaged across individual items) was statistically significantly higher among non-users than users when controlling for relationship length, women's sociosexuality, and ratings of non-sexual satisfaction (averaged across individual items), and when limiting the sample to women who were not currently pregnant or

using hormonal contraceptives. Similarly, non-sexual satisfaction was statistically significantly higher among HC users than non-users when controlling for these items.[11] In addition, Roberts and colleagues (2012) found that women who were HC users at relationship initiation were statistically significantly more likely than non-users to still be involved in their relationship. However, among relationships that did end, HC users were statistically significantly more likely than non-users to have been the partner who initiated the break-up. These results held when controlling for women's sociosexuality and age.

Although many of the analyses from this study yielded statistically significant results, the sizes of these effects were very small (on average, when the two groups of women differed significantly, they differed by about one-tenth of a standard deviation). In addition, all the rating items except partner attractiveness assessed women's *satisfaction* with their partner's qualities, but not the extent to which their partner possessed these qualities. Therefore, these results speak to whether hormonal contraceptive use at relationship initiation was associated with women's satisfaction with, for example, how sexually adventurous their partner was, but not whether hormonal contraceptive use at relationship initiation was associated with actually choosing less sexually adventurous partners. Although women who were HC users at relationship initiation differed from non-users in how likely it was that their relationship ended and who initiated the end, it is not clear whether these differences reflect that hormonal contraceptives caused women to choose different partners than they would otherwise, or that women who use hormonal contraceptives differ from women who do not along a number of demographic characteristics,

[11] Among who were no longer in a relationship with the father of their first child, hormonal contraceptive use at relationship initiation was not a statistically significant predictor of non-sexual satisfaction items, compliant sex, or rejecting partner's sexual advances. However, HC users at relationship initiation reporting being statistically significantly less satisfied with the sexual aspects of the relationship (controlling for satisfaction with non-sexual aspects of the relationship), and rated their partner as less attractive, relative to non-users.

such as socioeconomic status and education (see Table 7), and that these characteristics tend to have protective effects on relationships (e.g. Karney & Bradbury, 1995).

In a new study, Roberts and colleagues (2014) recruited heterosexual couples and asked both members of the couple to rate their satisfaction with sexual and non-sexual aspects of their relationship using the same items as Roberts et al. (2012). They asked women about their current hormonal contraceptive use and their use at relationship initiation. Results of their analyses focusing on the influence of hormonal contraceptive congruency are presented in the next section. The focus of their study was on the role of hormonal contraceptive congruency, but the authors did report the relationship between HC use at relationship initiation and women's and men's sexual and non-sexual satisfaction in analyses also controlling for current HC use, the interaction between HC current use and HC use at relationship initiation, sexual or non-sexual satisfaction, relationship length, SES, age, and parity. In these analyses, HC use at relationship initiation did not significantly predict men's sexual or non-sexual satisfaction, and in contrast to their previous results, in this study, HC use at relationship initiation did not significantly predict women's sexual or non-sexual satisfaction. Differences between the results of this study and the results of the earlier study conducted by this research group could be due to several factors. First, the 2014 study controlled for a number of variables not included in the earlier study, particularly the interaction between current and past use of hormonal contraceptives. Second, as shown in Table 5, the size of the effects documented by Roberts and colleagues (2012) were all very small by conventional standards. Because the more recent study had substantially fewer participants than the first study (N = 365 vs N = 2519), the study might simply have not had enough power to detect the small between group differences found in the original study. Alternatively, the difference in results between these two studies could reflect that the influence of hormonal

contraceptive use at relationship initiation on women's sexual and non-sexual satisfaction is not a robust effect. More research will be needed to address these possibilities.

The second study to assess whether women's partners varied as a function of women's hormonal contraceptive use at relationship initiation addressed this question more directly. Little and colleagues (2013, Study 2) recruited participants and age-matched the male partners of women who were HC users at relationship initiation to the male partners of women who were non-users. They photographed the men's faces and examined whether the partners of women who used hormonal contraceptives at relationship initiation were less facially masculine than the partners of women who did not use hormonal contraceptives at relationship initiation. They assessed men's facial masculinity first by asking raters to choose the most masculine face of the age-matched pairs of men, second by asking a second set of raters to choose the most masculine face out of pairs of images digitally manipulated to represent the aggregate face of the partners of HC users or the partners of non-users, and third by measuring men's faces along sexually dimorphic traits and assessing which group of men possessed these traits to a greater extent. Across all three measures, the researchers found that the partners of HC users at relationship initiation were statistically significantly less masculine than the partners of non-users at relationship initiation, with medium to large effect sizes.

It is important to consider the evidence on associations between hormonal contraceptive use and mate preferences when evaluating studies on hormonal contraceptive use and mate choices. All three studies rest on the hypothesis that differences between HC users and non-users in mate preferences led to the observed differences in their romantic partners (or, by extension, women's satisfaction with aspects of their relationship). Roberts and colleagues (2012) hypothesized that women who were HC users at relationship initiation were less sexually

satisfied because they were more MHC similar to their partners (relative to non-users), and higher degrees of MHC sharing is associated with lower levels of sexual satisfaction (Garver-Apgar et al., 2006). This hypothesis rests on the assumption that HC users chose more MHC similar partners than non-users because they had weaker preferences for MHC dissimilarity than non-users. However, as reviewed above, there is not strong evidence that HC use is associated with weaker preferences for MHC dissimilarity, and no evidence that HC users choose more similar partners than do non-users. Similarly, Little and colleagues (2013) rest their findings on the hypothesis that weaker preferences among HC users relative to non-users caused them to choose less masculine partners. But again, the research on mate preferences does not support this hypothesis as there is not strong evidence that HC use is associated with weaker preferences for masculinity. Focusing on the past research that most directly speaks to the findings that HC users have partners with less masculine faces than non-users—research on preferences for facial masculinity—only one out of seven studies found statistically significantly weaker preferences for masculinity among HC users than among non-users (Little et al., 2013, Study 1). Given the many constraints on mate choice, it is surprising that the results of the mate choice studies are so much stronger than the results of the studies on mate preferences.

In sum, much more evidence is needed before we can conclude that hormonal contraceptive users choose different partners than non-users. One study found differences in women's satisfaction with various aspects of their relationship depending on their use of hormonal contraceptives at relationship initiation, but the differences between these two groups of women were very small. A second study again investigating women's sexual and non-sexual satisfaction as a function of their contraceptive use at relationship initiation did not find significant effects of hormonal contraceptive use when controlling for other factors, such as

hormonal contraceptive use congruency. The third study found large differences in how facially masculine women's partners were depending on their use of hormonal contraceptives at relationship initiation, offering preliminary evidence that hormonal contraceptive use at relationship initiation might be associated with choosing a less masculine partner. Therefore, it is too soon to draw conclusions regarding whether the types of partners HC users and non-users choose differ. Additionally, findings on differences between HC users and non-users in mate choice need to be reconciled with findings that the preferences of HC users and non-users largely do not differ. Finally, because these studies were not experimental they cannot speak to whether hormonal contraceptive use caused women to choose different partners rather than the possibility that some other factor influenced both women's decision to use hormonal contraceptives and the types of men they chose.

Does Congruency between Current Hormonal Contraceptive Use and Hormonal Contraceptive Use at Relationship Initiation Influence Relationship Functioning?

Two recent studies provided tests of the congruency hypothesis, and a third study provided a partial test of this hypothesis. Cobey, Roberts, & Buunk (2013) studied the congruency hypothesis by examining if women's tendency to feel romantic jealousy differed depending on whether their current hormonal contraceptive use and their use at relationship initiation matched. They found that although current HC users reported statistically significantly higher levels of jealousy than did non-users (see Table 5) this effect was moderated by hormonal contraceptive use congruency. Specifically, women whose hormonal contraceptive use was incongruent (i.e. their current hormonal contraceptive use did not match their use at relationship initiation) reported statistically significantly higher levels of jealousy relative to women whose hormonal contraceptive was congruent ($p = .05$, $d = .18$). In addition, when controlling for

congruency, the main effect of current hormonal contraceptive use on jealousy was no longer statistically significant. The authors interpreted these results as evidence that when women's hormonal contraceptive use is incongruent, their partners no longer match the types of men they prefer which causes them to feel insecure and uncertain about their relationship leading to increased feelings of jealousy. As shown in Figure 1 of Cobey et al. (2013), levels of jealousy were higher when women became congruent through both starting and stopping hormonal contraceptive use, relative to remaining a stable HC user or non-user[12].

The second study to test the congruency hypothesis examined whether women's sexual and non-sexual satisfaction and their partner's sexual and non-sexual satisfaction differed depending on whether women's current hormonal contraceptive use and their use at relationship initiation matched (Roberts et al., 2014). Consistent with the congruency hypothesis, they found that hormonal contraceptive congruency significantly predicted women's sexual satisfaction, such that women whose HC use was congruent were significantly more sexually satisfied than women whose HC user was incongruent. This effect remained significant when controlling for potential confound variables, such as relationship length and parity. However, they found no evidence that congruency was a significant predictor of women's non-sexual satisfaction or of men's sexual or non-sexual satisfaction. Although congruency was a significant predictor of women's sexual satisfaction, the partial eta squared associated with this predictor (a measure of effect size for analyses of variance) was tiny (partial $\eta^2 < .02$). This means that less than 2% of the variance in women's sexual satisfaction was predicted by hormonal contraceptive use congruency. By way of comparison, women's non-sexual satisfaction with their relationship predicted 21% of the variance in their sexual satisfaction. So although in this study congruency

[12] Note, however, the sample size for some of these groups was small (women who ceased using hormonal contraceptives: $n = 4$, women who began using hormonal contraceptives: $n = 30$, women who remained HC users: $n = 71$, women who remained non-users: $n = 16$).

was a significant predictor of sexual satisfaction, it did not appear to have a meaningful effect on women's sexual satisfaction.

A third study provided a partial test of this hypothesis by examining differences in women's sexual and non-sexual satisfaction between current non-users who were HC users when their relationship began (and were thus incongruent) to current non-users were also non-users when their relationship began (and thus were congruent). In their study of hormonal contraceptive use and mate choice, Roberts and colleagues (2012) ran follow-up analyses limiting the sample to current non-users and found that sexual satisfaction was again higher among women who were non-users at relationship initiation (and thus were congruent) than among women who were HC users at relationship initiation (and thus were incongruent). In their letter to the editor outlining the congruency hypothesis, Roberts and colleagues (2013) interpreted these results as providing evidence for the hypothesis that hormonal contraceptives cause women to choose different partners than they would otherwise, and when ceasing hormonal contraceptive use their partners no longer match their changed preferences, which reduces their sexual satisfaction. However, the data from Roberts et al. (2012) also provides evidence that contradicts the congruency hypothesis. In their follow-up analyses of only current non-users, women who were HC users at relationship initiation (and thus incongruent) were significantly more satisfied with non-sexual aspects of their relationship relative to women who were non-users at relationship initiation (and thus congruent). It is unclear why, if congruency is an important factor, it would produce results in the opposite direction for these two different types of relationship satisfaction. In addition, as noted in their letter to the editor (Roberts et al., 2013), there were too few women who were current HC users in the sample to test whether non-congruency through initiating hormonal contraceptive use also diminished sexual satisfaction.

Therefore, this study cannot differentiate between effects of congruency and effects of hormonal contraceptive use at relationship initiation.

Like the results for the mate choice studies, results from studies testing the congruency hypothesis need to be evaluated in the light of research on mate preferences. At the crux of the congruency hypothesis are the assumptions that hormonal contraceptives alter women's preferences, that these altered preferences cause women to choose a different partner than they would otherwise, and that when women change their use of contraceptives their preferences also change. However, there is not yet strong evidence in support of any of these predictions. Furthermore, focusing on hormonal contraceptive congruency or non-congruency shifts attention away from important relationship dynamics that likely influence women's choice to start or stop hormonal contraceptive use (e.g. beginning a sexual relationship, desiring a pregnancy) and might also influence relationship functioning. For example, if a woman suspects that her partner is engaging in extra-pair sexual activity, she may be motivated to switch from using hormonal contraception (which does not offer protection against STIs) to a non-hormonal form of contraception that does protect against STIs, such as condoms. In this scenario, the woman's jealousy is very likely heightened, and her hormonal contraceptive status would now be incongruent, but the non-congruency did not cause the heightened jealousy.

Although three studies found some evidence in support of the congruency hypothesis, the third study also found evidence that contradicted the hypothesis and was unable to separate the effects of congruency from the effects of hormonal contraceptive use at relationship initiation. In addition, although HC congruency was a significant predictor of women's sexual satisfaction in one study, it explained almost none of the variance in women's sexual satisfaction. For the congruency hypothesis to be true, certain predictions about the effects of hormonal

contraceptives on women's mate preferences and women's mate choices also need to be true, but so far there is not strong evidence in support of any of these predictions. In sum, although there is some evidence consistent with the congruency hypothesis, there is not yet evidence that hormonal contraceptive congruency plays an important role in relationship dynamics. In order for the congruency hypothesis to receive strong support, additional research that provides a full test of the congruency hypothesis (looking at women starting and stopping hormonal contraceptive use) is needed, as is additional research providing support for the predictions regarding the influence of hormonal contraceptives on women's preferences on which the congruency hypothesis rests.

Do Hormonal Contraceptive Users and Non-users Differ along Potentially Confounding Variables?

As shown in Table 6, among the reviewed studies that assessed whether HC users and non-users differed along potentially confounding variables, many found statistically significant differences between the two groups of women. As shown in Table 7, in the broader population of women in the United States, the likelihood that women choose a hormonal rather than a non-hormonal form of contraception differs along a number of demographic dimensions, such as age, educational achievement, and parity.

Relationship status. As shown in Table 6, five out of six studies found that HC users were statistically significantly more likely than non-users to be currently involved in a romantic relationship (Jones et al., 2005; Little et al., 2002; Piccoli et al., 2013; Smith et al., 2009; Schwarz & Hassebruak, 2008). However, the only study to compare relationship quality between HC users and non-users currently involved in a relationship did not find statistically significant differences in relationship satisfaction or commitment between the two groups of women

(Welling et al., 2012). In a broad national study of Czech women who had been in their current relationship for at least one year, the length of the current relationship was statistically significantly shorter among HC users than among non-users (Klapilova et al., 2014).

As shown in Table 7, among a broad sample of women in the United States currently using some form of contraception, women were more likely to be using a hormonal (vs. a non-hormonal) form if they were not currently married or living with a romantic partner, but less likely to be using a hormonal (vs. non-hormonal) form if they were married or living with a partner (Mosher & Jones, 2010). Note that the study only classified whether women were married or living with a partner, but not whether they were involved in a romantic relationship per se, and women not using any form of contraception – many of whom were likely to be single – were excluded from Table 7. Therefore, the data from the NSFG cannot address whether women using hormonal contraceptives are more likely than non-users to be currently involved in a romantic relationship. What it can address is when women use contraception which form they choose. The likelihood that women choose a hormonal form of contraception declines with marriage and cohabitation, but marriage and cohabitation are often confounded with other variables associated with hormonal contraceptive use, such as age and parity. Research suggests that as age and parity increase hormonal contraceptive use decreases, often in favor of irreversible forms of contraception (e.g. surgical sterilization; Mosher & Jones, 2010).

In sum, in the few studies that assessed relationship status, being in a romantic relationship was consistently significantly confounded with hormonal contraceptive use. Although some studies accounted for this by controlling for relationship status (e.g. Feinberg et al., 2008; Jones et al., 2005) and others accounted for it by limiting the sample to women in a

relationship (e.g. Cobey, Roberts, & Buunk, 2013, Welling et al., 2012), most studies did not assess or account for this potentially important confound.

Sexual activity. Perhaps surprisingly, relatively few studies asked women about their sexual activity. None asked women whether they were currently involved in a sexual relationship. One study asked women whether they had engaged in sexual activity in the past week and found that HC users were statistically significantly more likely to have done so than non-users (Geary et al., 2001). Perhaps consistent with the notion that HC users are more likely to be involved in a romantic relationship relative to non-users, HC users were more likely to report that their most recent sexual partner was a serious dating partner (versus an acquaintance or someone they just met) relative to non-users (Geary et al., 2001), and HC users were more likely to be interested in long-term (vs. short-term) relationships, relative to non-users (Smith et al., 2009). Two analyses found no statistically significant differences between HC users and non-users in number of lifetime sexual partners (Klapilova et al., 2014; Pipitone & Gallup, 2008), and a third found no difference in number of lifetime one-night stands (Klapilova et al., 2014). However, a fourth analysis found that HC users had statistically significantly more lifetime sexual partners than non-users when controlling for age (Little et al., 2002). Among women currently in a relationship, sociosexuality did not significantly differ between HC users and non-users, nor did male partner sociosexuality (Welling et al., 2012).

In sum, although there is preliminary evidence that hormonal contraceptive users might differ from non-users in current and past sexual activity, too few studies have addressed this possibility to draw firm conclusions. Given these preliminary results, and the fact that the primary function of hormonal contraceptive use is to prevent pregnancy, it seems likely that the majority of the hormonal contraceptive users in these studies were sexually active. However,

because none of the studies asked whether women not using hormonal contraception were instead using an alternative form of birth control, the percentage of non-users who were sexually active is unknown. Therefore, it seems extremely important for future research to examine whether current sexual activity is a confounding variable.

Demographic variables. As shown in Table 6, HC users and non-users do not seem to differ much along the demographic variables assessed in the reviewed studies. However, as Table 7 shows, the likelihood that women use hormonal contraceptives versus another form contraception varies along a number of different demographic variables, such as ethnicity, poverty level, and education. Although the studies reviewed largely do not collect information on these variables, many involved samples that were likely fairly homogenous along these dimensions, suggesting the variables might not have a confounding effect. For example, of the six studies comparing age between HC users and non-users in largely college populations (Little et al., 2013 Study 1; Jones et al., 2005; Piccoli et al., 2013; Pipitone & Gallup, 2008; Vukovik et al., 2008; Welling et al. 2012) only one found a marginally significant difference in age (Little et al., 2013). However, in the one study comparing age between HC users and non-users in a broad national sample of Czech women, HC users were statistically significantly younger than non-users (Klapolova et al., 2014).

Overall, the analyses documented in Tables 6 and 7 suggest that there are important differences between hormonal contraceptive users and non-users that have largely been overlooked—of the 32 papers reviewed, only 12 reported whether HC users and non-users differed along any potential confounding variables. Although some studies did include control variables or limit their sample to reduce these confounds (see Table 1), the majority did not. In sum, the evidence suggests that HC users differ from non-users on several different confounding

variables and that these confounds are often not accounted for in the reviewed studies. Because most studies did not assess whether HC users and non-users differed along a number of dimensions, there is still a great deal we do not know about the similarities and differences between these two groups of women, and the role these similarities and differences play on women's mate choices and relationship functioning.

Conclusion

Discussion of Results and Implications of the Review

Research exploring potential effects of hormonal contraceptive use on women's mate choices and relationship functioning has been increasingly popular in recent years – there are now more than 30 empirical studies in the area and nearly a dozen commentaries on the potential effects of HC use on relationship relevant variables. Speculations about the negative effects hormonal contraceptives might have on women's ability to choose appropriate romantic partners, their ability to attract desirable partners, and their ability to maintain relationships abound. However, a systematic and thorough review of the empirical studies informing these speculations suggests that many claims are not supported by the literature. In most cases, the hypothesis in question is a causal one: that hormonal contraceptives have negative effects on mate choice and relationship functioning. However, as we reviewed, none of the studies have used the experimental methods necessary to make causal claims. In addition, the evidence speaking to many of these speculations is weak either because the association with HC use in question has rarely been documented, evidence of the association is inconsistent, or the evidence is consistent but the size of the documented effect is small.

The one area in which the evidence supporting the claims is strong is research on shifts across the ovulatory cycle. Although the body of evidence cannot support causal conclusions, the

evidence is overwhelmingly consistent with the hypothesis that hormonal contraceptives eliminate cycle shifts in variables related to mate choice and relationship functioning. Research comparing changes across the cycle among non-users as compared with HC users consistently documented that cycle shifts in women's mate preferences and physical attractiveness present among non-users were absent among HC users. The fact that cycle shifts among naturally cycling women are mediated by changes in reproductive hormones across the cycle (Puts et al., 2013; Roney et al., 2011; Roney and Simmons, 2008) and hormonal contraceptives suppress these hormone shifts (Fleishman et al., 2010; Frye, 2006) provides further evidence consistent with the causal hypothesis and offers a straightforward mechanism of action by which hormonal contraceptives are likely to have effects. In addition, there are no plausible alternative explanations explaining these cycle contingent between-group differences. Therefore, all the available evidence suggests that conclusions that HC use eliminating cycle shifts are likely to be true. However, there is not yet evidence in support of claims regarding the downstream consequences of eliminating cycle shifts.

In contrast, in all other areas, the evidence was not strongly consistent with causal conclusions regarding the negative effects of hormonal contraceptive use. In most cases, support for the causal conclusions would entail consistently documenting significant differences between HC users and non-users in the outcome variable. However, this pattern of results was not found for most outcomes. In addition, to confidently draw causal conclusions, alternative explanations should not easily account for the data. However, for some between-group differences (e.g. in mate choices), it seems possible that factors that influence whether women chose to use hormonal contraceptives contributed to the differences between HC users and non-users observed. The conclusion that most of the evidence reviewed entails is that there is not strong

evidence in favor of the causal conclusions being made. This does not mean that hormonal contraceptive use does not influence the outcomes under investigation, but rather that more data investigating the relationship is needed.

On face of it, conclusions from a review that the evidence does not support strong conclusions might seem un-noteworthy and uninformative. However, because many papers and news articles have concluded that there is strong evidence that hormonal contraceptives have effects on women's mate choices and relationship functioning, these results are actually quite important. Because many papers have advanced conclusions regarding the effects of hormonal contraceptives, this review and its results are important and noteworthy since they speak to the veracity of claims already being made. Put another way, the headings of the paper addressed research questions: e.g. do hormonal contraceptive users have weaker preferences for MHC dissimilarity than non-users? Do hormonal contraceptive users have weaker preferences for masculinity than non-users? Do the mate choices of hormonal contraceptive users and non-users differ? For most of these questions the response was that there was not enough evidence to answer the question with confidence. The question we might have asked instead is: Does the literature support the conclusion that hormonal contraceptive users have weaker preferences for MHC dissimilarity than non-users, or that hormonal contraceptive users have weaker preferences for masculinity than non-users, or that the mate choices of hormonal contraceptive users and non-users differ? For these questions, we can confidently say that the answer is no.

The reason addressing discrepancies between claims being made and what the research supports is particularly important in this area of research is that studies in this area have garnered interest outside the academic community, and research in this area has a very real possibility of influencing women's important contraceptive decisions. It seems entirely plausible that some

women might turn to the literature for information or take news reports of research into consideration when making decisions about which form of contraception to use. Therefore it is important that the information women receive is complete and accurate. Hormonal contraceptives are among the most effective forms of reversible contraception. Therefore, reports that dissuade women from using a hormonal form of contraception (when she would have otherwise chosen that form) might then increasing her risk of experiencing an unplanned pregnancy. Indeed, in one study, among women who stopped using the hormonal contraceptive pill but remained at risk for unplanned pregnancy, 80% switched to a less reliable form of contraception or to no contraception at all (Rosenberg & Waugh, 1998). In addition, claims that hormonal contraceptive use at relationship initiation might impair women's ability to choose appropriate partners might needlessly cause women in relationships who were HC users at relationship initiation to worry about whether they chose the correct partner.

Weaknesses in the Literature and Suggestions for Future Research

Although there are many strong studies in this area, there is room for improvement. It is unlikely that most researchers will be able to conduct studies overcoming the primary limitation to this literature – that hormonal contraceptive use is not a randomly assigned – due to practical and ethical considerations. However, researchers can do a better job of accounting for this obstacle by clearly addressing the fact that the literature cannot support causal conclusions when interpreting and disseminating their results. Although papers in this area almost always include a comment explicitly acknowledging that the research cannot support causal conclusions, in many cases, the authors nonetheless use causal language to describe their correlational results, or the correlational results from previous research. In addition, authors sometimes refer to HC users and non-users using language usually reserved for studies involving random assignment to

condition (i.e. as ‘experimental’ and ‘control’ groups). Such language is inaccurate and misleading (albeit unintentionally). Therefore, researchers should endeavor to be mindful of the language they use to describe their results, and to ensure that the published literature accurately reflects the data, editors and reviewers should not allow authors to use causal language for non-experimental research in this area.

Other weaknesses in the literature are easier to fix. As reviewed in Tables 6 and 7, the available evidence suggests that women who choose to use hormonal contraceptives differ from women who do not along a number of dimensions, but many studies do not address and control for these variables. Identifying and controlling for factors that systematically differ between HC users and non-users might reduce noise in the data, thereby helping elucidate differences of interest between the two groups of women. Because relatively few studies reported how HC users and non-users differ along potential control variables, and the range of differences reported is limited, there is still a good deal that we do not know regarding differences between HC users and non-users. Moving forward, research that collects information on as many potential control variables as possible will not only benefit itself by allowing for confounds to be controlled for, research that reports how the two groups of women compare along the dimensions will benefit the literature as a whole by adding to our understanding of how HC users and non-users differ. This can help inform future research regarding which variables are crucial to control for or whether researchers might be able to reduce unwanted differences between HC users and non-users by tailoring eligibility criteria (e.g. only women in relationships).

The consistent evidence that cycle phase is important in comparing HC users to non-users suggests that future research in the area will benefit from assessing and accounting for fertility. Different forms and brands of hormonal contraceptives differ from each other along a number of

dimensions including the dose of hormones they contain, the form of progestin they use, the hormone receptors the progestin component binds to, and the timing of the dose of hormones administered (Frye, 2006; Hather et al., 2007; Sitruk-Ware, 2004). These differences might result in differences in the psychological effects of hormonal contraceptives. Failing to account for this variation might result heterogeneous samples of HC users whose hormonal profiles differ from one another, making it difficult to detect differences between HC users and non-users. This suggests that researchers might benefit from assessing and accounting for the type of hormonal contraceptive participants use.

Conclusions

The question of whether hormonal contraceptives influences women's mate choices and relationship functioning has received much attention, and for good reason. Hormonal contraceptive use is widespread, and we still know little about its psychological effects. In addition, understanding the effects of exogenous reproductive hormones might offer insights into the role of endogenous reproductive hormones on psychological systems related to mating. Given the mounting evidence that endogenous reproductive hormones influence women's social and romantic behaviors, and the fact that hormonal contraceptives alter the hormonal milieu of women's bodies, there are strong reasons to believe that hormonal contraceptives will have an influence on women's mate choices and relationship functioning (although it is unclear just how strong of an influence they will have). It is therefore important that researchers continue to endeavor to understand these effects.

However, a major obstacle in conducting research in this area is the impracticality of using the experimental methods necessary to draw causal conclusions. Therefore, researchers need to be mindful of the limitations in what conclusions can be drawn. This is especially

important because conclusions from research in this area are often disseminated broadly outside of the academic community and might impact women's contraceptive decisions cause women to worry about the implications of their past contraceptive decisions. Therefore, it is our responsibility as researchers to be extremely careful, measured, and accurate in the conclusions about this research we disseminate to the community, and that the limitations to this research are clearly stated. As reviewed, this has not always been the case in the past, but it is our hope that this will be the case in the future.

Table 1

Overview of Studies Examining Variables Related to Mate Choice and Relationship Functioning among Hormonal Contraceptive Users as Compared with Non-users

Citation	Outcome investigated	Correlational study design?	NHC *n*	HC *n*	HC type assessed	Cycle position assessed	Potential confounds assessed	Study reviewed in
Masculinity preferences								
Feinberg et al. (2008)	Preference for facial and vocal masculinity	Yes (Cross-sectional)	307	112	No	No	Yes, controlled for in T5	T5
Grammer (1993)	Preference for scent of putative male pheromone	Yes (Cross-sectional)	184	105	No	Yes, see T2	No	T2, T5
Little et al. (2002)	Preference for facial masculinity	Yes (Cross-sectional)	107	51	No	No	Yes, see T6	T5, T6
Little et al. (2013) Study 1	Preferences for facial masculinity	Yes (Cross-sectional and longitudinal)	37	18	No	Yes, all women tested between FCD 10 and 14	Yes, controlled for in T4, see T6	T4, T5, T6
Little et al. (2007)	Preferences for body masculinity	Yes (Cross-sectional)	92	61	No	Yes, see T2	Yes, controlled for in T2	T2, T5
Lukaszewski & Roney (2009)	Preferences for masculine personality traits	Yes (Cross-sectional)	92	102	No	Yes, see T2	No	T2, T5
Penton-Voak et al. (1999)	Preference for facial masculinity	Yes (Cross-sectional)	43	22	No	Yes, see T2	No	T2, T5
Penton-Voak & Perrett (2000)	Preference for facial masculinity	Yes (Cross-sectional)	139	39	No	Yes, see T2	No	T2, T5
Puts (2006)	Preferences for vocal masculinity	Yes (Cross-sectional)	142	64	No	Yes, see T2	No	T2, T5
Smith et al. (2009)	Preference for facial masculinity	Yes (Cross-sectional)	66	81	Yes, not included in analyses	No	Yes, see T6	T5, T6
Vukovik et al. (2008)	Preference for vocal masculinity	Yes (Cross-sectional)	58	65	Yes, not included in analyses	No	Yes, see T6	T5, T6

Table 1 (*continued*)

Citation	Outcome investigated	Correlational study design?	NHC *n*	HC *n*	HC type assessed	Cycle position assessed	Potential confounds assessed	Study reviewed in
MHC preferences								
Wedekind et al. (1995)	Preference for scent of MHC dissimilarity	Yes (Cross-sectional)	31	18	No	Yes, attempted to schedule all women on FCD 7-14 (mean day = 12)	No	T3
Wedekind & Furi (1997)	Preference for scent of MHC dissimilarity	Yes (Cross-sectional)	32	26	No	Yes, attempted to schedule all women on FCD 7-14 (mean day = 12)	No	T3
Roberts et al. (2008)	Preference for scent of MHC dissimilarity	Yes (Cross-sectional and longitudinal)	60	37	Yes, sample limited to women using a monophasic combined oral contraceptive	Yes, all women tested between FCD 10 and 14	Yes, controlled for in T4 and analyses in T4 limited to "core sample" (HC N=33, NHC N=52); see T5	T3, T4, T6
Other mate preferences								
Gangestad & Thornhill (1998)	Preference for scent of symmetry	Yes (Cross-sectional)	28	17	No	Yes, see T2	No	T2
Jones et al. (2005)	Preference for facial cues of apparent health	Yes (Cross-sectional)	1325	1570	No	No	Yes, controlled for in T5, see T6	T5, T6
Thornhill & Gangestad (1999)	Preference for scent of symmetry and facial attractiveness	Yes (Cross-sectional)	48	16	Yes, analyzed data separately for women using oral contraceptives vs. Depo-Provera	Yes, see T2	No	T2

Table 1 (*continued*)

Citation	Outcome investigated	Correlational study design?	NHC *n*	HC *n*	HC type assessed	Cycle position assessed	Potential confounds assessed	Study reviewed in
			Mate choice					
Little et al. (2013) Study 2	Facial masculinity of romantic partners	Yes (Cross-sectional)	85	85	No	No	No, but male partners of NHC and HC users age matched	T5
Roberts et al. (2012)	Satisfaction with relationship, relationship longevity	Yes (Cross-sectional)	1514	1005	Yes, sample limited to women using a combined oral contraceptive	No	Yes, controlled for in T5 and sample limited to parous women	T5
Roberts et al. (2014)	Satisfaction with relationship	Yes (Cross-sectional)	227	138	Yes, some analyses limited to women using a combined oral contraceptive	No	Yes, controlled for in T5	T5
			Women's attractiveness					
Cobey, Buunk, et al. (2013)	Women's self- and partner-rated attractiveness	Yes (Longitudinal)	14		Yes, sample limited to women using a combined oral contraceptive	Yes, see T2	N/A	T2, T5
Kuukasjärvi et al. (2004)	Women’s body odor attractiveness	Yes (Cross-sectional)	39	42	No	Yes, see T2	No	T2, T5
Miller et al. (2007)	Lap dancer tip earnings	Yes (Cross-sectional)	11	7	Yes, sample limited to women using a combined oral contraceptive	Yes, see T2	No	T2, T5
Pipitone & Gallup (2008)	Women’s vocal attractiveness	Yes (Cross-sectional)	17	21	No	Yes, see T2	Yes, see T6	T2, T5, T6
Schwarz & Hassebrauck (2008)	Women's self-rated attractiveness	Yes (Cross-sectional)	40	19	No	Yes, see T2	Yes, see T6	T2, T5, T6

Table 1 (*continued*)

Citation	Outcome investigated	Correlational study design?	NHC *n*	HC *n*	HC type assessed	Cycle position assessed	Potential confounds assessed	Study reviewed in
Other variables related to relationship functioning								
Cobey et al. (2012)	Romantic jealousy	Yes (Longitudinal)	29		Yes, sample limited to women using a combined oral contraceptive	Yes, see T2	N/A	T2, T5
Cobey, Roberts, & Buunk (2013)	Romantic jealousy	Yes (Cross-sectional)	20	101	No	No	Yes, controlled for in T5	T5
Cobey, Klipping, & Buunk (2013)	Intrasexual competition	Yes (Longitudinal)	28		Yes, sample limited to women using a combined oral contraceptive	Yes, see T2	N/A	
Geary et al. (2001)	Romantic jealousy	Yes (Cross-sectional)	77	61	No	No	Yes, controlled for in T5, see T6. Sample limited to women who had had sex at least once	T5, T6
Klapilova et al. (2014)	Extra-pair sexual behavior	Yes (Cross-sectional)	493	662	Yes, sample limited to women using an oral contraceptive	No	Yes, controlled for in T5, see T6	T5, T6
Piccoli et al. (2013)	Intrasexual competition	Yes (Cross-sectional)	38	21	No	Yes, see T2	Yes, see T6	T2, T6
Welling et al. (2012)	Mate guarding behavior	Yes (Cross-sectional)	35	69	Yes, assessed progestogen and estrogen dose	No	Yes, controlled for in T5, see T6	T5, T6

Table 1 (*continued*)

Note: HC denotes HC users and NHC denotes non-users.

Table 1. Overview of studies examining variables related to mate choice and relationship functioning among hormonal contraceptive users as compared with non-users. The correlational column denotes if the study did not randomly assign women to use hormonal contraceptives (i.e. correlational design, versus experimental design). In parentheses is whether HC vs. NHC was among different groups of women/a between subjects design (cross-sectional), or whether it was among the same group of women/a within subjects design (longitudinal). In some cases, researchers assessed women at two time points, during which time some women began using HCs and some did not (cross-sectional and longitudinal). The HC type assessed column denotes whether the study assessed either the form of hormonal contraceptive women used (e.g. oral contraceptive, depo-provera, etc.), the brand they used, or the type or dose of hormones used, and whether these variables were included in the analyses, or used to constrain the sample. The cycle position assessed column denotes whether the study assessed where women were in their cycle, and whether this variable is included in the analyses (if yes, details and results are presented in Table 2, or used to constrain the sample). FCD refers to forward cycle day (number of days after menstrual onset). The potential confounds assessed column denotes whether the study assessed potential confounding variables, whether they controlled for the variables, whether they reported if HC users and non-users differed along that variable (if so, results are presented in Table 6), or whether they used the variable to constrain the sample. The study reviewed in column denotes which tables contain details on the study.

Table 2

Cycle Shifts among Hormonal Contraceptive Users as Compared with Non-users

Outcome Measures		Cycle shift present for NHC?	Cycle shift present for HC?	NHC greater at high fertility?	NHC greater at low fertility?	Citation
Mate Preferences						
Cues of high genetic quality	Relationship Context					
Body masculinity	Short-term	**Yes** [1]	No	Yes (p = .92, d = 0.02)	No (p = .15, d = -0.3)	Little et al. (2007)
Facial masculinity	Short-term	**Yes**	No	Not reported	Not reported	Penton-Voak et al. (1999)
Scent cues of body symmetry	Unspecified	**Yes**	No	**Yes (p = .09)**	No (*ns*)	Gangestad & Thornhill (1998)
Scent of purported male pheromone	Unspecified	**Yes**	No	**Yes (p < .001, d = 0.77)**	No (p = .86, d = -0.03)	Grammer (1993)
Dominant personality traits	Unspecified [2]	**Yes**	No	Yes (p = .44, d = 0.31)	Yes (p = .62, d = 0.12)	Lukaszewski & Roney (2009)
Facial masculinity	Unspecified	**Yes**	No	No (p = .68, d = -0.13)	No (p = .79, d = -0.06)	Penton-Voak & Perrett (2000)
Vocal masculinity	Unspecified	**Yes**	No	Not reported	Not reported	Puts (2006)
Scent cues of body symmetry	Unspecified	**Yes**	No	Not reported	Not reported	Thornhill & Gangestad (1999)
Scent cues of facial attractiveness	Unspecified	**Yes**	No	Not reported	Not reported	Thornhill & Gangestad (1999)
Body masculinity	Long-term	No	No	No (p = .7, d = -0.1)	No (p = .9, d = -0.03)	Little et al. (2007)
Facial masculinity	Long-term	No	No	Not reported	Not reported	Penton-Voak et al. (1999)
Cues of high long-term partner quality						
Kind personality traits	Unspecified [2]	No	No	Yes (p = .16, d = 0.56)	Yes (p = .32, d = 0.24)	Lukaszewski & Roney (2009)
Trustworthy personality traits	Unspecified [2]	No	No	**Yes (p = .04, d = 0.83)**	Yes (p = .55, d = 0.14)	Lukaszewski & Roney (2009)
Female attractiveness						
Women's ratings of own attractiveness		No	N/A	Yes (p = .73, d = 0.09)	Yes (p = .37, d = 0.25)	Cobey, Buunk, et al. (2013)
Men's ratings of partner attractiveness		**Yes**	N/A	**Yes (p = .02, d = .66)**	Yes (p = .93, d = 0.02)	Cobey, Buunk, et al. (2013)
Body odor attractiveness		**Yes (p = .09)**	No	Yes (p = .22, d = 0.68)	No (p = .98, d = -0.01)	Kuukasjärvi et al. (2004)
Tip earnings as lap dancers		**Yes**	No	**Yes (p < .001, d = 2.11)**	Yes (p = .13, d = 0.72)	Miller et al. (2007)
Vocal attractiveness		**Yes**	No	**Yes (p < .01, d = 0.89)**	No (p = .56, d = -0.19)	Pipitone & Gallup (2008)

Table 2 (*continued*)

Outcome Measures	Cycle shift present for NHC?	Cycle shift present for HC?	NHC greater at high fertility?	NHC greater at low fertility?	Citation
Female attractiveness					
Self-rated attractiveness	No	**Yes (p = .08)**	Not reported	Not reported	Schwarz & Hassebrauck (2008)
Dressing provocatively	**Yes**	No	Not reported	Not reported	Schwarz & Hassebrauck (2008)
Other					
Romantic jealousy	**Yes**	N/A	Yes (p = .61, d = 0.09)	**No (p = .04, d = -0.39)**	Cobey et al. (2012)
Intrasexual competition	No	N/A	Single women: No [3] (p = .53, d = -0.17) **Mated women: Yes (p < .01, d = 0.85)**	Single women: Yes (p = .74, d = 0.09) **Mated women: Yes (p = .02, d = 0.67)**	Cobey, Klipping, & Buunk (2013)
Men's ratings of own attractiveness	**Yes**	N/A	**Yes (p = .01, d = 0.7)**	Yes (p = .14, d = 0.42)	Cobey, Buunk, et al. (2013)
Intrasexual competition	**Yes**	No	Not reported	Not reported	Piccoli et al. (2013)

Note: HC denotes HC users and NHC denotes non-users. N/A denotes that the study did not test HC users at more than one cycle phase. Results that are significant (p < .05) or marginally significant (p < .1) are bolded. Unless otherwise specified, analyses do not include any control variables.

1. Results controlling for partnership status, age, and self-rated attractiveness.
2. Analyses collapsing across short-term and long-term ratings.
3. Analyses collapsing across relationship status not reported. Single women: n = 14, Mated women: n = 14.

Table 2. Studies assessing cycle shifts among HC users and non-users, and analyses comparing users and non-users at high versus low fertility. NHC results column denotes whether cycle shifts are significant among non-users and HC results column denotes whether cycle shifts are significant among HC users. In all cases of significant or marginally significant cycle shifts, the outcome variable is higher at high than low fertility. NHC greater at high-fertility column and NHC greater at low fertility column denotes whether the outcome variable was higher among non-users at high or low fertility than among HC users on the equivalent cycle days.

Table 3

Studies Examining MHC Preferences among Hormonal Contraceptive Users as Compared with Non-users

Outcome measures	NHC Preferences	HC Preferences	Preferences for dissimilarity stronger for NHC?	Citation
Scent desirability ratings	Dissimilarity (p = .55, d = 0.11)	Dissimilarity (p = .56, d = 0.13)	No (p = .92, d = -0.02)	Roberts et al. (2008) Session 2 [1]
Scent pleasantness ratings	Dissimilarity (p = .89, d = 0.02)	Dissimilarity (p = .38, d = 0.14)	No (p = .56, d = -0.12)	
Average of scent pleasantness and sexiness ratings	**Dissimilarity (p < .01, d = 0.51)**	**Similarity (p = .07, d = -0.44)**	**Yes (p < .01, d = 0.96)**	Wedekind et al. (1995)
Scent pleasantness ratings	**Dissimilarity (p = .07, r = -.12)** [2]	Similarity (p = .29, r = .08)	Not reported	Wedekind & Furi. (1997) [3]

Note: HC denotes HC users and NHC denotes non-users. Results that are significant (p < .05) or marginally significant (p < .1) are bolded. Unless otherwise specified, analyses do not include any control variables. Analyses from Roberts et al. (2008) and Wedekind et al. (1995) use raters (vs. donors) as units of analysis, analyses from Wedekind & Furi (1997) use donors (vs. raters) as units of analysis.

1. Results are from the full sample of participants at Session 2. Results from the core sample of participants at Session 1 and 2 are presented in Table 4.
2. r indicates correlation between pleasantness ratings and number of shared alleles.
3. p values are from directed tests as recommended by Rice and Gaines (1994).

Table 3. Studies assessing preferences for MHC dissimilarity (vs. similarity) among HC users as compared with non-users. NHC preferences and HC preferences columns denote whether analyses examining MHC preferences revealed a preference for dissimilarity or similarity. The preferences for dissimilarity stronger for NHC column denotes whether non-users had stronger preferences for dissimilarity than HC users.

Table 4

Studies Employing a Cross-Sectional Longitudinal Design

Outcome measures	Sample	Session 1 (all women NHC)	Session 2 (some women NHC some HC)	Change between Session 1 and Session 2	Citation
Facial masculinity preferences	Women who were NHC at Session 2	**Masculinity (p = .01, d = 0.44)**	**Masculinity (p = .04, d = 0.34)**	Decrease in masculnity preference (p = .75, d = 0.11)	Little et al. (2013)
	Women who were HC at Session 2	Masculinity (p = .11, d = 0.4)	**Femininity (p = .08, d = -0.44)**	**Decrease in masculnity preference (p = .002, d = 1.74)**	
Between-group differences		Masculinity preferences stronger for NHC than HC (p = .95, d = 0.03)	**Masculinity preferences stronger for NHC than HC (p = .01, d = 0.8)** [1]	**Interaction between session and HCuse significant (p = .01)** [2]	
MHC-based scent desirability ratings	Women who were NHC at Session 2	Similarity (p = .25, d = -0.17)	Dissimilarity (p = .95, d < 0.01)	Increase in dissimilarity preference (p = .16 d = -0.2)	Roberts et al. (2008) [3]
	Women who were HC at Session 2	**Dissimilarity (p = .09, d = 0.31)**	Similarity (p = .5, d = -0.12)	**Decrease in dissimilarity preference (p = .02, d = 0.46)**	
Between-group differences		**Dissimilarity preference weaker for NHC than HC (p = .04, d = -0.48)**	Dissimilarity preference stronger for NHC than HC (p = .65, d = 0.1)	**Interaction between session and HC use marginally significant (p = .06)** [4]	
MHC-based scent pleasantnness ratings	Women who were NHC at Session 2	Similarity (p = .68, d = -0.06)	None (p = 1.0, d = 0)	Increase in dissimilarity preference (p = .62, d = -0.07)	
	Women who were HC at Session 2	Dissimilarity (p = .29, d = 0.19)	Dissimilarity (p = .38, d = 0.16)	Decrease in dissimilarity preference (p = .55, d = 0.11)	
Between-group differences		Dissimilarity preference weaker for NHC than HC (p = .26, d = -0.26)	Dissimilarity preference weaker for NHC than HC (p = .46, d = -0.17)	Interaction between session and HC use non-significant (p = .64)	

Note : HC denotes HC users and NHC denotes non-users. Results that are significant (p < .05) or marginally significant (p < .1) are bolded. Unless otherwise specified, analyses do not include any control variables. All analyses use women (vs. male stimuli) as units of analysis. For both studies, women were tested during a high-fertility phase of the ovulatory cycle (or on equivalent days of the cycle among HC users).

1. These results also reported in Table 5.
2. Results unchanged when controlling for women's age.
3. Results are from the core sample of participants. Analyses from Session 1 and change between Session 1 and 2 for the full sample not available. Results at Session 2 for the full sample are presented in Table 3.
4. Results unchanged when controlling for women's relationship status and self-rated attractiveness.

Table 4 . Studies assessing changes in women's preferences after becoming HC users as compared with women who remained non-users. The sample column denotes whether women were HC users or non-users at Session 2. Session 1 column denotes women's preferences at Session 1 (at which time all women were non-users), and compares the preferences of the later HC users to the preferences of the later non-users. Session 2 column denotes women's preferences at Session 2 (at which time some women were HC users and some non-users), and compares the preferences of HC users to non-users. The change between Session 1 and Session 2 column denotes change in preferences between Session 1 and Session 2 for each group of women, and compares the changes in preferences between the two groups of women.

Table 5

Studies Examining Mate Preferences, Mate Choices, Women's Attractiveness, and Other Variables Related to Relationship Functioning among Hormonal Contraceptive Users as Compared with Non-users, Collapsing Across Cycle Phase

Outcome Measures		NHC greater?	Significance and effect size	Citation
Masculinity preferences				
Outcome Measures	Context			
Facial masculinity	Short-term	Yes	(p = .35, d = 0.19)	Little et al. (2002)
Body masculinity	Short-term	**No**	(***p* = .03, *d* = -0.35**)	Little et al. (2007)
Dominant personality traits	Short-term	**No**	(***p* = .04, *d* = -0.42**)	Lukaszewski & Roney (2009)
Facial masculinity	Short-term	No	(p = .62, d = -0.08)	Smith et al. (2009)
Facial masculinity	Unspecified	Yes	(p = .27, d = 0.12)[1]	Feinberg et al. (2008)
Vocal masculinity	Unspecified	Yes	(p = .39, d = 0.10)[2]	
Scent of purported male pheromone	Unspecified	**Yes**	**(p < .05, d = 0.23)**	Grammer (1993)
Facial masculinity	Unspecified [3]	**Yes**	(***p* = .01, *d* = 0.8**)[4]	Little et al. (2013) Study 1
Facial masculinity	Unspecified	No	(p = .76, d = -0.06)	Penton-Voak & Perrett (2000)
Vocal masculinity	Unspecified	Yes	(p = .48, d = 0.13)	Vukovik et al. (2008)
Facial masculinity	Long-term	No	(p = .24, d = -0.35)	Little et al. (2002)
Body masculinity	Long-term	No	(p = .64, d = -0.08)	Little et al. (2007)
Dominant personality traits	Long-term	**Yes**	(***p* = .04, *d* = 0.42**)	Lukaszewski & Roney (2009)
Facial masculinity	Long-term	No	(p = .41, d = -0.14)	Smith et al. (2009)
Other mate preferences				
Apparent health in faces		**No**	**(p < .001, d = -0.1)**[5]	Jones et al. (2005)

Table 5 (*continued*)

Outcome Measures		NHC greater?	Significance and effect size	Citation
Mate choice				
Outcome Measures	Category			
Third-party ratings of partner masculinity faces as units of analysis	Partner Facial Masculinity	**Yes**	(***p* = .04, *d* = 0.47**)	Little et al. (2013) Study 2
Third-party ratings of partner masculinity raters as units of analysis		**Yes**	(***p* < .001, *d* = 2.65**)	
Third party ratings of composite face masculinity raters as units of analysis		**Yes**	**(*p* = .001, *d* = 0.76)**	
Partner facial morphology masculinity faces as units of analysis		**Yes**	(***p* = .05, *d* = 0.44**)	
Satisfaction with sexual arousal with partner	Sexual Satisfaction	**Yes**	**(*p* = .02, *d* = 0.08)**	Roberts et al. (2012)[6]
Satisfaction with partner's sexual adventurousness		**Yes**	**(*p* = .01, *d* = 0.1)**	
Satisfaction with sexual responsiveness to partner		**Yes**	**(*p* = .005, *d* = 0.1)**	
Satisfaction with sexual attraction to partner		**Yes**	**(*p* = .001, *d* = 0.14)**	
Satisfaction with orgasms with partner		Yes	(*p* = .32, *d* = 0.02)	
Ratings of partner's facial attractiveness	Partner Attractiveness	Yes	(*p* = .68, *d* = 0.03)	
Ratings of partner's body attractiveness		**Yes**	**(*p* = .01, *d* = 0.12)**	
Satisfaction with partner's financial provisioning	Non-sexual satisfaction	**No**	**(*p* = .01, *d* = -0.14)**	
Satisfaction with partner's faithfulness/loyalty		No	(*p* = .64, *d* = -0.03)	
Satisfaction with partner's intelligence		**No**	**(*p* = .05, *d* = -0.12)**	
Satisfaction with partner's ambition		Yes	(*p* = .42, *d* = 0.01)	
Satisfaction with partner's support		**Yes**	**(*p* = .06, *d* = 0.06)**	
Frequency of rejecting partner's sexual advances	Sexual Behaviors	Yes	(*p* = .59, *d* = 0.01)	
Frequency of having sex with partner compliantly		Yes	(*p* = .36, *d* = 0.08)	

Table 5 (*continued*)

Outcome Measures		NHC greater?	Significance and effect size	Citation
Mate choice				
Likelihood relationship is ongoing	Relationship Outcomes	**No**	**(p < .001, r = -0.1)**	Roberts et al. (2012)6
If relationship ended, likelihood female initiated the ending		**No**	**(p = .001, r = -0.12)**	
Women's sexual satisfaction	Sexual satisfaction	No	(p = .52, partial η^2 = .002)[7]	Roberts et al. (2014)
Men's sexual satisfaction		No	(p = .42, partial η^2 = .002)[7]	
Women's non-sexual satisfaction	Non-sexual satisfaction	Yes	(p = .1, partial η^2 = .01)[8]	
Men's non-sexual satisfaction		Yes	(p = .78, partial η^2 < .001)[8]	
Women's attractiveness				
Outcome Measure				
Women's ratings of own attractiveness		Yes	(p = .53, d = 0.17)	Cobey, Buunk, et al. (2013)
Men's ratings of partner attractiveness		Yes	(p = .22, d = 0.34)	Cobey, Buunk, et al. (2013)
Body odor attractiveness		Yes	(p = .75, d = 0.08)	Kuukasjärvi et al. (2004)
Tip earnings as lap dancers		**Yes**	**(p = .02, d = 1.2)**	Miller et al. (2007)
Vocal attractiveness		Yes	(p = 0.41, d = 0.19)	Pipitone & Gallup (2008)
Other variables related to relationship functioning				
Outcome Measure	Category			
Negative emotions felt in response to imagined emotional infidelity	Jealousy	**No**	**(p = .01, d = -0.5)**	Geary et al. (2001)[9]
Negative emotions felt in response to imagined sexual infidelity		**No**	**(p < .01, d = -0.52)**	
Jealousy in response to imagined scenarios	Jealousy	No	(p = .42, d = -0.15)	Cobey et al. (2012)[10]
Jealousy in response to imagined scenarios about a current partner	Jealousy	**No**	**(p = .05, d = -0.18)**	Cobey, Roberts & Buunk (2013)[11]

Table 5 (*continued*)

Outcome Measures		NHC greater?	Significance and effect size	Citation
Other variables related to relationship functioning				
Outcome Measure	Category			
Intrasexual competition among single women	Intrasexual competition	No	(p = .88, d = 0.04)	Cobey, Klipping, & Buunk (2013)[12]
Intrasexual competition among mated women		**Yes**	**(p = .01, d = 0.76)**	
Intrasexual competition among single and mated women	Intrasexual competition	Yes	*ns*	Piccoli et al. (2013)
Women's reports of own mate guarding behaviors	Mate guarding	**No**	**(p = .01, r = 0.25)**	Welling et al. (2012)[13]
Men's reports of partner's mate guarding behaviors		**No**	**(p < .01, r = 0.29)**	
Men's reports of own mate guarding behaviors		**No**	**(p < .01, r = 0.28)**	
Women's reports of partner's mate guarding behaviors		No	(p = .14, r = 0.15)	
Men's ratings of own attractiveness	Male partner attractiveness	**Yes**	**(p < .05, d = 0.56)**	Cobey, Buunk, et al. (2013)
Had at least one extra-pair partner in past year	Extra-pair behavior	No	(p = .48)	Klapilova et al. (2014)[14]
Number of extra-pair partners in past year among women with at least one partner		**Yes**	**(p = .09)**	
Had at least one extra-pair one night stand in past year		No	(p = .31)	
Number of extra-pair one night stands in past year among women with at least one partner		**Yes**	**(p = .01)**	

Note: HC denotes HC users and NHC denotes non-users. For mate choice studies, HC and NHC refer to use at relationship initiation. Results that are significant (p < .05) or marginally significant (p < .1) are bolded. Unless otherwise specified, analyses do not include any control variables.

1. When controlling for vocal masculinity preference, age, and relationship status, NHC > HC (p = .01).
2. When controlling for facial masculinity preference, age, and relationship status, NHC > HC (p > .28).
3. Average of ratings of men as short-term and long-term partners (responses did not significantly differ between the two contexts).
4. Responses assessed at high-fertility only.
5. Results remained significant when controlling for age, partnership status, and whether participant was a UK resident.

Table 5 (*continued*)

6. Analyses presented limited to women currently in their relationship. Results for women not still in their relationship reported in text of paper. Results including control variables reported in text of paper.
7. Results controlling for current HC use, interaction between current HC use and HC use at relationship initiation, non-sexual satisfaction, relationship length, SES, age, and whether participant had children.
8. Results controlling for current HC use, interaction between current HC use and HC use at relationship initiation, sexual satisfaction, relationship length, SES, age, and whether participant had children.
9. When controlling for sexual activity within the past week and relationship with most recent sexual partner, these results diminish.
10. When splitting the sample by relationship status, jealousy levels non-significantly higher among non-users than users (p = .65, d = 0.11) for single women (n = 16) and non-significantly lower among non-users than users (p = .15, d = -0.43) for women in a relationship (n = 13).
11. Interaction between current HC use and HC use at relationship initiation significant (p = .05), see congruency section. When controlling for congruency, current use is no longer a significant predictor of jealousy.
12. When collapsing across relationship status, differences between HC users and non-users were non-significant (p =.23, d = 0.23).
13. Pattern of results remains when separately controlling for age, relationship satisfaction, relationship commitment, and sociosexuality.
14. Results are controlling for sexual satisfaction, relationship length, age, and parity.

Table 5. Studies examining differences in mate preferences, mate choices, women's attractiveness, and other variables related to relationship functioning between HC users and non-users. The NHC greater column denotes whether the outcome variable was higher among non-users than among HC users. The significance and effect size column denotes (when available) the exact p value and the size of the effect (Cohen's d for continuous outcome variables and correlation coefficient r (equivalent to phi) for dichotomous outcome variables or non-parametric tests, or partial eta squared for analyses of covariance).

Table 6

Studies Documenting Potential Confounds with Hormonal Contraceptive Use

Outcome variable	Significant or marginally significant difference?	Direction	Significance and effect size	Citation
Relationship status variables				
Currently involved in a relationship	**Yes**	**HC > NHC**	**($p < .001$, $r = .31$)**	Jones et al. (2005)
	Yes	**HC > NHC**	**($p < .01$, $r = .4$)**	Little et al. (2002)
	Yes	**HC > NHC**	**($p = .08$, $r = .23$)**	Piccoli et al. (2013)
	No	HC < NHC	($p = .85$, $r = -.06$)	Roberts et al. (2008)
	Yes	**HC > NHC**	**($p < .001$, $r = .4$)**	Smith et al. (2009)
	Yes	**HC > NHC**	**($p = .01$, $r = .35$)**	Schwarz & Hassebruak (2008)
Relationship length	**Yes**	**HC < NHC**	**($p < .001$)**	Klapilova et al. (2014)
	No	HC < NHC	($p = .37$, $d = -0.19$)	Welling et al. (2012)
Female relationship satisfaction	No	HC < NHC	($p = .47$, $d = -0.15$)	Welling et al. (2012)
Male partner relationship satisfaction	No	HC > NHC	($p = .37$, $d = 0.19$)	Welling et al. (2012)
Female commitment	No	HC > NHC	($p = .21$, $d = 0.26$)	Welling et al. (2012)
Male partner commitment	No	HC > NHC	($p = .55$, $d = 0.12$)	Welling et al. (2012)
Number of lifetime committed relationship partners	No	not reported	($p = .81$)	Pipitone & Gallup (2008)
Age at first date	**Yes**	**HC < NHC**	**($p = .07$)**	Klapilova et al. (2014)
Sexual experience and attitudes variables				
Number of lifetime sexual partners	No	not reported	($p = .47$)	Klapilova et al. (2014)
	No	not reported	($p = .39$)	Pipitone & Gallup (2008)
Number of lifetime sexual partners controlling for age	**Yes**	**HC > NHC**	**($p = .003$)**	Little et al. (2002)
Number of lifetime one-night stands	No	not reported	($p = .24$)	Klapilova et al. (2014)
Age at first sexual intercourse	**Yes**	**HC < NHC**	**($p = .07$)**	Klapilova et al. (2014)

Table 6 (*continued*)

Outcome variable	Significant or marginally significant difference?	Direction	Significance and effect size	Citation
Sexual experience and attitudes variables				
Engaged in sexual activity in the past week	**Yes**	**HC > NHC**	**($p < .01$)**	Geary et al. (2001)
Most recent sexual partner someone they had just met or an acquaintance (vs. serious dating partner)	**Yes**	**HC < NHC**	**($p < .05$)**	Geary et al. (2001)
Interest in short-term (vs. long-term) relationships	**Yes**	**HC < NHC**	**($p = .03, d = -0.04$)**	Smith et al. (2009)
Female sociosexuality	No	HC > NHC	($p = .28, d = 0.23$)	Welling et al. (2012)
Male partner sociosexuality	No	HC > NHC	($p = .11, d = 0.33$)	Welling et al. (2012)
Self-rated attractiveness				
Self-rated attractiveness	No	not reported	($p = .93, d = 0.01$)	Smith et al. (2009)
	No	HC < NHC	($p = .74, d = -0.06$)	Vukovik et al. (2008)
Self-rated physical attractiveness	No	not reported	($p = .44$)	Roberts et al. (2008)
Self-rated facial attractiveness	No	not reported	($p = .82$)	Roberts et al. (2008)
Self-rated physical attractiveness, warmth, and confidence	No	not reported	(p's > .1)	Little et al. (2002)
Demographic variables				
Age	No	HC = NHC	($p = .99, d = 0.0$)	Jones et al. (2005)
	Yes	**HC < NHC**	**($p < .001$)**	Klapilova et al. (2014)
	Yes	**HC > NHC**	**($p = .05, d = 0.55$)**	Little et al. (2013) Study 1
	No	HC < NHC	($p = .51, d = -0.19$)	Piccoli et al. (2013)
	No	HC < NHC	($p = .28, d = -0.35$)	Pipitone & Gallup (2008)
	No	HC > NHC	($p = .42$)	Vukovik et al. (2008)
	No	HC < NHC	($p = .64, d = -0.1$)	Welling et al. (2012)
Had at least one child	**Yes**	**HC < NHC**	**($p < .001$)**	Klapilova et al. (2014)

Table 6 (*continued*)

Outcome variable	Significant or marginally significant difference?	Direction	Significance and effect size	Citation
		Demographic variables		
BMI	No	HC > NHC	(p = .28, d = 0.31)	Piccoli et al. (2013)
UK Residency	Yes	HC < NHC	(p < .001, r = -.14)	Jones et al. (2005)
Catholic religious affiliation	No	HC < NHC	(p = .17, r = -.18)	Piccoli et al. (2013)

Note: HC denotes HC users and NHC denotes non-users. Results that are significant (p < .05) or marginally significant (p < .1) are bolded.

Table 6. Studies from the review that assessed potential confound variables and reported results for HC users and non-users separately. The significant of marginally significant difference column denotes whether HC users statistically significantly (p < .05) or marginally significantly (p < .1) differed from non-users on that outcome variable. The direction column and the significance and effect size column denote (when available) the direction of the significant or non-significant difference, the exact p value and the size of the effect (Cohen's d for continuous outcome variables and correlation coefficient r (equivalent to phi) for dichotomous outcome variables).

Table 7

Potential Confounds with Hormonal Contraceptive Use in a Nationally Representative Sample of Contraceptive Users 15 to 44 Years of Age.

Characteristic	Breakdown	Percent using hormonal pill or 3- month injectable	Percent using other form of contraception [1]
Age	15–19 years	63.5	36.5
	20–24 years	53.1	46.9
	25–29 years	40.3	59.7
	30–34 years	27	73
	35–39 years	20.3	79.8
	40–44 years	12.2	87.8
Marital and cohabiting status	Currently married	22.4	77.6
	Currently cohabiting	36.9	63.1
	Never married, not cohabiting	51.7	48.3
Parity	0 births	58.6	41.4
	1 birth	34	66
	2 births	17.7	82.3
	3 or more births	10.2	89.8
Education	No high school diploma or GED	16.6	83.4
	High school diploma or GED	21.3	78.7
	Some college, no bachelor's degree	26.1	73.9
	Bachelor's degree or higher	35.4	64.6
Poverty level income	0% –149%	23.8	76.2
	150% –299%	23.3	76.7
	300% or more	35.7	64.3
Race and Hispanic origin	Hispanic	23.9	76.1
	White, single race	34.8	65.2
	Black, single race	28.4	71.6
	All other single race and multiple race	21.4	78.6

1. Other forms of contraception include the condom, male and female sterilization, and IUDs. An unspecified small percentage of this category may include hormonal contraceptive users (e.g. women using the hormonal IUD).

Table 7. Prevalence of hormonal contraceptive use as a function of demographic characteristics among women in the nationally representative 2006-2008 National Survey of Family Growth from Mosher & Jones (2010). The sample is limited to women aged 15- 44 who are currently using some form of contraception. The percent using hormonal pill or 3-month injectable denotes the percentage of women using the two most common forms of hormonal contraception (oral contraception and the hormonal injection (i.e. depo-provera) among women currently using contraception. The percent using other form of contraception denotes the percent of women using all other forms of contraception.

CHAPTER III:

An Investigation of MHC-Based Mate Choice among Hormonal Contraceptive Users and Non-Users

Abstract

The Major Histocompatibility Complex (MHC) is a suite of genes that play an important role in immune functioning, and researchers hypothesize that there are adaptive benefits for choosing an MHC dissimilar romantic partner. Past work has found that women not using hormonal contraceptives (non-users) prefer MHC dissimilar others, but that women who use hormonal contraceptives (HC users) prefer MHC similar others (Wedekind, Seebeck, Bettens, & Paepke, 1995; Wedekind & Furi, 1997), leading to the hypothesis that hormonal contraceptive use will cause women to choose MHC similar, and thus genetically incompatible, partners. We provide the first direct test of this hypothesis by genotyping both members of 274 couples (90 from a college sample and 184 from a community sample) at the MHC region, and analyzing whether couples in which the female partner was a HC user at relationship initiation are more MHC similar than are couples in which the female partner was a non-user. Contrary to the hypothesis, we found that the degree of MHC similarity within a couple did not significantly differ between HC users and non-users. This result remained robust to the inclusion of a number of moderators and covariates. In all the analyses, the only statistically significant difference between HC users and non-users was significantly higher degrees of MHC similarity among non-users than HC users in the community sample, opposite of what would be expected. These results suggest that hormonal contraceptives do not cause women to choose MHC similar partners as some scholars have argued they might.

An Investigation of MHC-Based Mate Choice among Hormonal Contraceptive Users and Non-Users

Recently, a number of scholars have argued that hormonal contraceptives might cause women to choose genetically incompatible romantic partners which could have a number of negative downstream consequences on their relationship and on the health of any children that result from the relationship (Alvergne & Lummaa, 2010; Boero, 1996; Havlicek & Roberts, 2009; Roberts, Cobey, Klapilova, & Havlicek, 2013; Roberts, Gosling, Carter, & Petrie, 2008; Roberts, Miner, & Shackelford, 2010; Roberts, Klapilova, Little, Burriss, Jones, DeBruine, Petrie, & Havlicek, 2012; Voilrath & Milinski, 1995; Wedekind, Seebeck, Bettens, & Paepke, 1995). These hypotheses are supported by research documenting differences in genetic-based scent preferences between women who use hormonal contraceptives (HC users) and women who do not (non-users) (Wedekind et al., 1995; Wedekind & Furi, 1997; but see Roberts et al., 2008). In addition, a recent study examining women's assessments of their romantic partner as a function of whether they were HC users or non-users when their relationship began provides indirect evidence supporting the notion that HC users might choose genetically incompatible partners (Roberts et al., 2012). This study found that the assessments of HC users at relationship initiation differed from those of non-users in ways that were consistent with the hypothesis that hormonal contraceptive use led women to choose genetically incompatible partners. However, the current study is the first to directly examine whether genetic compatibility within a couple is in fact associated with women's use of hormonal contraceptives at relationship initiation.

The Major Histocompatibility Complex (MHC) is a suite of genes that code for cell surface markers used to detect pathogens that have invaded a host's body. In humans and other animals, evolutionary processes may favor complex cell surface markers because pathogens

cannot easily mimic them, thus giving hosts an advantage in the battle against rapidly evolving pathogens (e.g., Hughes & Nei, 1988; 1989; Penn, Damjanovich, & Potts, 2002). MHC alleles are expressed co-dominantly (both paternally- and maternally-inherited alleles are expressed). Therefore, individuals whose parents are dissimilar at MHC loci (i.e. they do not have the same MHC alleles as each other) will have more complex cell surface markers than will individuals whose parents are similar, conferring them an advantage in defending themselves against pathogens (Penn et al., 2002). The number of alleles in the population is greater for MHC loci than it is for any other loci in vertebrates (Penn, 2002), so sharing MHC alleles with another individual could indicate close kinship. Therefore, preferences for MHC-dissimilar individuals might also function to avoid inbreeding and the deleterious consequences that come with it (Penn & Potts, 1999). Given these strong selection pressures, a straightforward evolutionary hypothesis is that organisms will prefer MHC-dissimilar others as mates.

In non-human animals, this hypothesis has largely been supported (reviewed in Penn, 2002; Penn & Potts, 1999; Piertney & Oliver, 2006). In a number of different species including mice, songbirds, and salmon, organisms prefer to mate with MHC-dissimilar others. The relative paucity of homozygote births in some populations provides additional evidence of MHC-disassortative mating (Hedrick, 1990).

In humans, this hypothesis has only received mixed support. The first two studies to examine MHC-based scent preferences in humans found that, like other species, women preferred the scent of MHC-dissimilar others (Wedekind et al., 1995; Wedekind & Furi, 1997). However, this was only true of women who were not using hormonal contraceptives—HC users preferred the scent of MHC-similar others. Subsequent studies produced mixed results (see Table 8). For example, a third study did not find evidence of MHC-based scent preferences for either

HC users or non-users, or that the preferences of these two groups of women significantly differed (Roberts et al., 2008). Nevertheless, the idea that hormonal contraceptives might change women's hypothesized adaptive preferences for MHC-dissimilar others to preferences for MHC-similar others has received much attention in the academic literature, as has the idea that this will cause HC users to choose MHC-similar romantic partners (Alvergne & Lummaa, 2010; Cobey, Roberts, & Buunk, 2013; Havlicek & Roberts, 2009; Roberts et al., 2008; Roberts et al., 2010; Roberts et al., 2012; Roberts et al., 2013; Wedekind et al., 1995).

The evidence for MHC-based mate choice in humans is also mixed (see Table 9). Some studies find that couples are more MHC dissimilar than would be expected by chance (e.g. Giphart & D'Amoro, 1983; Ober, Weitkamp, Cox, Dytch, Kostyu & Elias, 1997), but others find that couples are no more dissimilar than expected by chance (e.g. Hedrick & Black, 1997; Pollack, Wysocki, Beauchamp, Braun, Callaway & Dupont, 1982) or are more similar than expected by chance (e.g. Israeli, Kristt, Nardi, & Klein, 2014). The studies investigating MHC-based mate choice varied in a number of important ways which could account for some of the mixed evidence. For example, the participant population varied greatly between the studies. In some studies the participant population was ethnically homogenous and had relatively few MHC alleles (e.g. Ober et al., 1997), whereas the participant population in others were ethnically heterogeneous and genetically diverse (e.g. Rosenberg Cooperman & Payne, 1983; see Population column in Table 9).

Another source of variation between studies that might account for some of the mixed results is the percentage of female participants using hormonal contraceptives at relationship initiation (see also Havlicek & Roberts, 2009). If HC users choose MHC-similar partners while non-users choose MHC-dissimilar partners, including both groups of women in a sample without

differentiating between the two could produce the appearance of no MHC-based mate choice. Similarly, studies that differed in the proportion of women who were HC users (vs. non-users) at relationship initiation might then also differ in the proportion of couples that are MHC similar (vs. dissimilar). Only one study explicitly commented on their participants' hormonal contraceptive use (Ober et al., 1997), but based on demographic trends in hormonal contraceptive use in different populations (see the footnotes in Table 9), some of the studies on MHC-based mate choice very likely included women who were HC users at relationship initiation, whereas other studies were unlikely to have included these women. The percentage of women who were HC users at relationship initiation in each study is unknown but likely differs between studies, potentially accounting for some of the mixed results between studies. However, in order to address whether this hypothesis is plausible, we first need to document whether hormonal contraceptive use at relationship initiation is in fact associated with the degree of MHC similarity within a couple.

Finally, one recent study provided indirect evidence consistent with the hypothesis that HC users will choose more MHC-similar partners than will non-users (Roberts et al., 2012). In the study, researchers asked women whether they were HC users or non-users when their relationship with the father of their first child began and then asked women to rate their satisfaction with their partner along various dimensions of sexuality previously found to vary as a function of MHC sharing within a couple (Garver-Apgar, Gangestad, Thornhill, Miller, & Olp, 2006). For example, women rated how satisfied they were with the extent to which their partner aroused them because Garver-Apgar and colleagues (2006) found that the more MHC similar a woman was to her partner, the less satisfied she was on this dimension. As they predicted, Roberts and colleagues (2012) found that HC users at relationship initiation reported being

significantly less sexually satisfied than non-users, consistent with the hypothesis that higher degrees of MHC similarity are associated with less sexual satisfaction and that HC users will choose more MHC-similar partners than non-users. However, the actual degree of MHC similarity between couples was not assessed, so the study cannot provide direct evidence that the HC users in their sample actually chose more MHC-similar partners than non-users.

The current study is the first to fill this gap in the literature by directly examining whether hormonal contraceptive use at relationship initiation is associated with the degree of MHC sharing within couples. To do this, we recruited both members of heterosexual romantic couples, assessed whether the female partner was a HC user or non-user at relationship initiation, genotyped both members of the couple at the three most commonly studied MHC loci (A, B, and DRB1), and examined how many alleles the members of the couple shared. This allowed us to examine whether MHC similarity within a couple was higher if the female partner used hormonal contraceptives at relationship initiation than if she did not. We additionally ran a number of follow-up analyses to see whether this relationship was influenced by theoretically-relevant moderators.

Methods

Participants

Participants came from two independent samples of couples recruited in the Los Angeles area. Sample 1 (college sample) consisted of 90 couples who were part of a broader study on hormones and attraction at UCLA. Four couples were married, one couple was engaged, eight couples were cohabiting, and all other couples were dating. Sample 2 (community sample) consisted of 184 newly-engaged couples (entering their first marriage) who were part of a broader longitudinal study on marriage. For full demographic information, see Table 10.

Participants could skip any questions they did not wish to answer and some questions were only assessed in one sample, so the *n*'s for specific analyses are sometimes lower than the total *N* (see Table 10).

The larger studies these samples came from included an additional 448 couples not reported in this paper. Couples were excluded either because both members of the couple did not provide a sample to be genotyped (25 from Sample 1, 76 from Sample 2), the female partner did not respond to the question assessing hormonal contraceptive use at relationship initiation (20 from Sample 1), or we could not determine with high confidence the female partner's hormonal contraceptive use at relationship initiation (53 from Sample 2, see *Measures* section). Couples excluded from the analyses did not significantly differ from those included in male or female age, relationship length, or degree of MHC similarity (*p's* > .59).

Procedures

Both members of the couple separately completed a survey containing questions for all the predictor and control variables (see *Measures* section). Participants from Sample 1 completed a paper surveys in the lab and participants from Sample 2 completed an online survey at home. In our analyses, we only used responses from the female participants. Both members of the couple then provided samples to be genotyped. Participants from Sample 1 provided a saliva sample using Oragene® saliva kits in the lab. Participants from Sample 2 provided cheek swabs at home and mailed their completed kits back to the lab. Buccal samples were collected using Whatman FTA Elute Cards (GE Healthcare UK Limited, Buckinghamshire, UK; gelifesciences.com/whatman). FTA elute cards contain an inert dye that changes from purple to white indicating the location of a colorless sample of saliva. All participants were provided detailed instructions on how to self-deliver a buccal sample. Instructions directed participants to

swab the inner cheek for 30 seconds on each side and then to apply the sample, without rubbing, to a disc shape on the collection card until it turned white. Finally, participants were compensated for their time with either a cash payment or, for Sample 1, course research credit.

Measures

Hormonal contraceptive use at relationship initiation. For Sample 1, we assessed hormonal contraceptive use at relationship initiation with a single item: "Were you taking any form of hormonal contraception when you first became romantically interested in your current partner?" For Sample 2, we coded hormonal contraceptive use at relationship initiation using women's responses to the following five questions: "Are you currently taking any form of hormonal contraception?" "If so, how long have you been taking it?" "Have you previously taken hormonal contraception at any other time during your current relationship?" "If yes, please indicate when and how long you used it," and "When did you first realize that you were romantically interested in your partner [please indicate month and year]?" Two independent coders (blind to the couple's MHC similarity) used women's reports of when they became romantically interested in their partner and their history of hormonal contraceptive use to classify whether women were HC users or non-users at relationship initiation, or whether this could not be classified with certainty. Discrepancies between coders were re-coded by a third independent coder. Cases where coders did not have high confidence in their classification of a woman as a HC user or non-user, or where there was disagreement between coders (e.g. one coder classified a woman as a HC user and the other as uncertain) were classified as uncertain and excluded from analyses.

Control variables. We collected information on a number of additional variables to assess whether the relationship between hormonal contraceptive use at relationship initiation and

MHC similarity was influenced by theoretically-relevant moderators. Based on recent work suggesting that the congruency between a woman's current hormonal contraceptive use and her use at relationship initiation predicts relationship relevant outcomes (Cobey, Roberts, & Buunk, 2013; Roberts, et al., 2013; Roberts, Little, Burriss, Cobey, Klapilová, Havlíček, Jones, DeBruine, & Petrie, 2014), for both samples, we assessed current hormonal contraceptive use using the item, "Are you currently taking any form of hormonal contraception?" We coded the variable change in hormonal contraceptive use as same if a woman's hormonal contraceptive use at relationship initiation and current use matched and different if they did not match. Women whose partners do not match their MHC preferences might be less likely to remain in their relationship, suggesting that relationship length, or the association between relationship length and change in hormonal contraceptive use might influence the degree of MHC similarity among HC users and non-users in our sample. Therefore, we assessed relationship length in Sample 1 using the item, "How long have you been in your current romantic relationship [please indicate months and years]?" and in Sample 2 by calculating the difference between the date women completed their survey and the date on which they reported they first realized they were romantically interested in their partner**.**

The importance a woman places on the degree of MHC sharing between herself on her partner might depend on whether she is sexually active with her partner, the extent of her sexual activity prior to meeting her partner, or the importance she places on sex and commitment in a relationship. Therefore, we asked several questions regarding women's sexual experience and attitudes. We assessed whether women had had sexual intercourse with their partner in Sample 1 using the item, "Have you ever had sexual intercourse with your current romantic partner?" and in Sample 2 using the item "When did you first engage in sexual activity with your partner?" to

which women could respond "I have not experienced this event." We assessed women's sociosexual attitudes by averaging together items rated on a scale from 1 (*strongly disagree*) to 7 (*strongly agree*). For Sample 1, the items were the three attitudinal items from the original Sociosexual Orientation Inventory (from Simpson & Gangestad, 2000). For Sample 2, the items were: "Sex without love is highly unsatisfactory," "It would be difficult for me to enjoy having sex with someone I do not know very well," "I could easily imagine myself enjoying one night of sex with someone I would never see again (reverse coded)," "I would not enjoy sex without any emotional commitment at all," and "I do not need to respect or love someone in order to have sex with them (reverse coded)." For Sample 1 only, we assessed number of lifetime sexual partners with the item, "In your life so far, with how many different people have you had sexual intercourse?" For Sample 1 only, we also assessed how important it was to women that their partner turned them on sexually using the item, "How important is this attribute is to you [in a romantic partner]: The extent to which he 'turns me on' sexually." This item was rated on a scale from 1 (*not at all important*) to 9 (*extremely important*).

The degree of MHC similarity within a couple might depend on the ethnicity of the members of the couple (e.g. Rosenberg et al., 1983). Therefore, we examined women's ethnicity and whether they were the same ethnicity as their partners. In both samples, women selected their race/ethnicity from the following categories: African-American, Asian, Caucasian, Hispanic, and Other/Multi-racial. Analyses controlling for race/ethnicity only include women who identified as Asian, Caucasian, or Hispanic due to the small percent of women identifying as another ethnicity. We coded couples as mono-racial if both members of couple selected the same race/ethnicity, bi-racial if the members of the couple selected different races/ethnicities, and missing/unknown if either member of the couple had missing data for the race/ethnicity

item, or selected their race/ethnicity as other/Multi-racial. Analyses controlling for whether the couple was mono- or bi-racial do not include women coded as missing/unknown.

Women who are more attractive might be better able to choose a partner who suits their preferences, so degree of MHC similarity in a couple might depend on how physically attractive a woman is. Women might also trade-off MHC compatibility for a partner who has other desirable physical characteristics (e.g. is physically attractive). Therefore, for both samples, we assessed women's self-rated attractiveness and their ratings of their partner's attractiveness by averaging together the following items (edited for each target): "Members of the opposite sex notice [my partner/me]," "Members of the opposite sex are attracted to [my partner/me]," and "Members of the opposite sex are interested in [my partner/me]." Items were rated on a scale from 1 (*strongly disagree*) to 7 (*strongly agree*).

Genotyping

The UCLA Immunocenetics Center (UIC) handled the typing for both Samples. The UIC performed intermediate resolution HLA-A, B and DRB1 typing by the PCR-Sequence Specific Oligonucleotide typing method using LABType® SSO Luminex reagents purchased from One Lambda, Inc. LABType®. This method applies Luminex technology to the reverse SSO DNA typing method. Target DNA was first PCR-amplified using locus-specific primers (Exon 1-3 for class I genes and Exons 1-2 for class II genes). The PCR product was biotinylated, which allowed it to be detected using R-Phycoerythrin-conjugated Strepavidin (SAPE). Each PCR product was denatured and allowed to hybridize to complementary DNA probes conjugated to fluorescently coded addressable microspheres. After washing the beads, bound amplified DNA from the test sample was tagged with SAPE. A flow analyzer, the LABScan 100, identified the fluorescent intensity of phycoerythrin on each microsphere. The assignment of HLA typing is

based on the reaction pattern compared to patterns associated with published HLA gene sequences. Any ambiguous combinations of alleles were resolved by Sequenced Based Typing or Sequence Specific Primer amplification using commercial kits purchased from One Lambda and Invitrogen. Ten percent of the HLA alleles were resolved at high resolution and the remaining were reported at intermediate resolution using NMDP codes. The molecular typing was converted to serological equivalency for data analysis. To ensure that samples were typed correctly, 12% of the couples from Sample 2 provided a second buccal sample to be typed. In all cases, the re-sampled typing was identical to the original typing.

Data Analyses

We calculated couple similarity scores by counting how many alleles both members of the couple shared (out of 2) at each of the three loci (potential range: 0 to 6). Thus, higher numbers indicate a couple is more MHC similar. Prior to analyses, we collapsed Samples 1 and 2 and standardized all continuous control variables. In our initial analyses, we entered MHC similarity as the outcome variable and hormonal contraceptive use at relationship initiation as the between-subjects predictor. For follow-up analyses, we individually added the categorical control variables as additional between-subjects predictors and the continuous control variables as covariates. Even if the interaction between the categorical control variable and HC use was non-significant, we ran follow-up analyses splitting the file along the levels of the control variable. Similarly, even if the interaction between the continuous covariate and HC use was non-significant, we report the results of the main effect of HC use controlling for the covariate. Finally, to examine whether MHC similarity within a couple was influenced by the association between congruency in women's HC use and relationship length, we ran analyses examining whether HC use at relationship initiation significantly predicted MHC similarity when

controlling for current HC use and relationship length, and whether the three-way interaction between HC use at relationship initiation, current HC use, and relationship length significantly predicted MHC similarity.

We analyzed the data using analyses of variance and covariance (ANOVAs and ANCOVAs) in SPSS (17.0). However, MHC similarity within couples was not normally distributed (see Table 11), violating the assumptions of ANOVA and ANCOVA. Given our sample size, analyses involving ANOVA and ANCOVA should be robust to this non-normality under the Central Limit Theorem, but to be conservative we ran additional analyses using Poisson regression in Stata (v13). We included the exposure option to account for the maximum possible number of shared alleles (6) and obtained post-estimation predicted counts of the number of shared alleles among HC users and non-users. Poisson regressions are used for count data in which there are many observations of zero and few observations at the tail end of the distribution, matching the pattern our data produced. Poisson models assume that the mean and the variance of the data are the same and that the data follows a Poisson distribution. Analyses revealed that our data met these assumptions (M = 1.03, variance = 0.91, Goodness of Fit test: χ^2 = 294.94, $p > .05$). The results of the Poisson analyses were nearly identical to those obtained using ANOVAs. Therefore, for ease of interpretation, we report the results of the ANOVA analyses in the body of the paper. The full results including all control analyses for both the ANOVA and the Poisson regression analyses are reported in Tables 12 and 13.

Results

Table 11 presents the frequency of MHC sharing among couples in the sample overall and separately for HC users and non-users at relationship initiation. The amount of sharing within couples was relatively low, and no couple shared all 6 alleles.

Contrary to the hypothesis that HC users would be more MHC similar to their partner than non-users, we found that HC users shared *fewer* alleles with their partner than non-users (HC users: $M = 0.9$, $SD = 1.05$; non-users: $M = 1.07$, $SD = 0.91$), although this difference was not statistically significant, $F(1, 272) = 1.72$, $p = .19$, $d = .17$)[13]. Our follow-up analyses involving control variables never revealed statistically significant results in the predicted direction. With all the controls, HC users were never statistically significantly more similar to their partners than were non-users (see Tables 12 and 13). In fact, the majority of the time, HC users were less similar to their partners than were non-users and this difference was occasionally statistically significant. However, these statistically significant results should be interpreted with caution. We found 2 statistically significant and 2 marginally statistically significant effects, which is almost identical to the number of significant and marginally significant effects predicted by chance alone when running 34 analyses with an alpha of .05 for statistical significance and .10 for marginal significance.

When controlling for both current HC use and relationship length, HC use at relationship initiation remained non-significant in the non-predicted direction, $F(1, 269) = 0.74$, $p = .39$. However, the three-way interaction between HC use at relationship initiation, current HC use and relationship length was significant $F(1, 265) = 3.92$, $p = .049$. To clarify this relationship, we separated women by HC use congruency and correlated relationship length with MHC similarity. Contrary to the predicted pattern of results, we found that among stable HC users, the correlation between relationship length and MHC similarity was significant and negative ($r = -.28$, $p = .03$, $n = 62$), and that the correlation was non-significant among all other groups of women (women

[13] The Poisson regression similarly revealed that HC users were non-significantly ($p = .22$) less similar to their partners relative to non-users (HC user predicted count = 0.9, *SEM* = 0.11, non-user predicted count = 1.07, *SEM* = 0.07).

who began HC use: r = .09, p = .47, n = 68; stable non-users: r = -.003, p = .97, n = 133; women who ceased HC use: r = .17, p = .64, n = 10).[14]

Discussion

This study found no evidence in support of the hypothesis that women who use hormonal contraceptives choose more MHC similar partners than women who do not use hormonal contraceptives. We ran numerous follow-up analyses to see if the predicted results could be found in certain conditions or when controlling for potentially relevant confounds. For example, women's mate preferences might only reflect their mate choices among highly attractive women with the bargaining power to obtain partners possessing the qualities they prefer. If women who change their use of hormonal contraception no longer prefer their partner and end the relationship (Roberts et al., 2013), the predicted pattern of effects might only be observed among women whose use of hormonal contraceptives remains unchanged, or among new relationships. Although we found a significant interaction between HC use at relationship initiation, current HC use, and relationship length, follow-up analyses revealed that the pattern differed from what one would predict if HC use increased women's tendency to prefer and choose MHC similar partners. If couples were more likely to break up if their degree of similarity did not match women's preferences, one would predict that as the relationship length increased, degree of MHC similarity would decrease among stable non-users and women who ceased HC use, whereas one would predict that as relationship length increased, degree of MHC similarity would

[14] The Poisson regression similarly revealed that HC use at relationship initiation was not a significant predictor of MHC similarity when controlling for current HC use and relationship length (p = .4), but that the three-way interaction between current use, use at relationship initiation, and relationship length was significant (p = .04). Tests of the simple effects revealed that the associations between relationship length and MHC similarity were nearly identical to those produced by the correlations reported above. The slope between relationship length and MHC similarity was marginally significant and negative among women who were stable HC users (b = -0.45, p = .06), non-significant and positive among women who became HC users (b = 0.68, p = .24), non-significant and negative among women who were stable non-users (b = -0.09, p = .3), and non-significant and positive among women who ceased HC use (b = 0.68, p = .27).

increase among stable HC users and women who initiated HC use. Instead, we found that relationship length was significantly and negatively correlated with MHC similarity among stable HC users, but not significantly correlated with MHC similarity among the other groups of women. As shown in Table 10, HC users and non-users differed along a number of variables, so it was important to control for these variables to ensure these confounds were not masking a true effect. However, in all of our follow-up analyses we never found evidence in favor of the hypothesis that hormonal contraceptives will cause women to choose MHC similar partners.

Regardless of the pattern of results found, it is important to note that they can only provide information on whether hormonal contraceptive use at relationship initiation is associated with MHC similarity—not whether hormonal contraceptive use was the *cause* of that similarity. This is because our study (like all other studies investigating hormonal contraceptive use and mate preferences or mate choices) was not experimental. In order to truly provide evidence for the causal hypotheses many scholars have made about the influence of hormonal contraceptives on women's mate preferences and choices, researchers will need to randomly assign women to use or not use hormonal contraceptives. Without doing this, it is impossible to establish that between-group differences are due to women's use of hormonal contraceptives rather than other factors that co-vary with hormonal contraceptive use. Indeed, as Table 10 shows, in our sample HC users and non-users did differ along a number of variables that might also influence women's mate preferences and choices.

Although in the animal literature there is fairly robust evidence of MHC-dissociative preferences, the evidence in humans is much more mixed. Our results suggest that the prevalence of hormonal contraceptive use in many populations does not account for the mixed evidence of disassortative mating preferences in humans. Although a full discussion of the reasons for this

mixed evidence is beyond the scope of this paper, given the ethnic and genetic heterogeneity our samples came from and the low frequency of allele sharing among our couples, it might be that individuals are likely to find a relatively genetically dissimilar partner (in this population) without specifically choosing them for their dissimilarity. In other populations, however, this might not be the case.

In conclusion, we found no support for the hypothesis that hormonal contraceptives will cause women to choose MHC similar (and therefore potentially genetically incompatible) romantic partners. Across numerous analyses, women who were HC users at relationship initiation were not more MHC similar to their romantic partners than non-users. However, we only assessed MHC sharing at three loci, so it is possible that different results would have been obtained had we assessed sharing at other MHC loci. In addition, our sample was recruited from a large, ethnically diverse city. It is possible that we might have obtained different results in a different population. Therefore, our failure to obtain results that support the hypothesis that HC use will cause women to choose more MHC similar partners does not prove this hypothesis to be false. It does, however, suggest that scholars should refrain from continuing to speculate that the hypothesis is true until it receives empirical support.

Table 8

Studies Assessing MHC-based Preferences in Humans

Studies	Alleles	Donors		Raters			Units of analysis	Preferences (Direction and significance)		
		Male *n*	Female *n*	NHC *n*	HC *n*	Male *n*		NHC	HC	Men
Scent Preferences										
Wedekin et al. (1995)	A, B, DRB1	44	0	31	18	0	Donors	**Dissimilarity (*p* = .04)**	**Similarity (*p* = .02)**	N/A
							Raters	**Dissimilarity (*p* = .03)**	Similarity (*p* = .34)	N/A
Wedekin & Furi (1997)	A, B, DRB1	4	2	32	26	68	Donors	Dissimilarity[5] (*p* =.07)	Similarity[5] (*p* = .29)	Dissimilarity[5] (*p* = .07)
Jacob et al. (2002)	A, B, C, DRB1, DQB1	6	0	49	0	0	Raters	**Similarity (*p* = .002)**	N/A	N/A
Thornhill et al. (2003)	A, B, DRB1	56[1]	48[2]	65	0	77	Donors	Similarity[5] (*ns*)	N/A	**Dissimilarity[5] (*p* = .04)**
							Raters	Similarity[5] (*ns*)	N/A	Dissimilarity[5] (*ns*)
Santos et al. (2005)	A, B	29[1]	29[2]	29[3]		29	N/A[4]	Neither[6] (*ns*)		Neither (*ns*)
Roberts et al. (2008) Session 1	A, B, DRB1	97	0	110	0	0	Raters	Similarity[7] (*p*'s > .68)	N/A	N/A
Roberts et al. (2008) Session 2	A, B, DRB1	97	0	60	40	0	Raters	Dissimilarity[8] (*p*'s > .53)	Dissimilarity[9] (*p*'s > .5)	N/A
Facial Preferences										
Roberts et al. (2005)	A, B, DRB1	75	0	92[3]		0	Donors	**Similarity (*p* =.03)**		N/A
							Raters	Similarity (*p* =.08)		N/A

Note: Significant results ($p < .05$) are bolded. NHC = Non hormonal contraceptive users, HC = Hormonal contraceptive users

Footnotes:

1. Only rated by female participants.
2. Only rated by male participants.
3. Study did not differentiate between HC and NHC.
4. Results are from $\chi 2$ analyses.
5. *p* values are from directed tests as recommended by Rice and Gaines (1994).
6. Their $\chi 2$ analysis revealed a significant association between ratings (pleasant, indifferent, or unpleasant) and number of shared alleles, but follow-up analyses revealed this association was driven by ratings of indifferent, and the associations for pleasant and unpleasant were non-significant.
7. Reported results are for the entire sample. In follow-up analyses looking at the "core" sample, women non-significantly preferred dissimilarity (*p*'s > .56).
8. Reported results are for the entire sample. In follow-up analyses looking at the "core" sample, preferences for dissimilarity were also non-significant, (*p*'s > .98).
9. Reported results are for the entire sample. In follow-up analyses looking at the "core" sample, pleasantness ratings revealed a non-significant preference for dissimilarity ($p = .51$), but desirability ratings revealed a non-significant preference for similarity ($p = .57$).

Table 9

Studies Assessing MHC-based Mate Choice in Humans

Study	Couples *N*	Alleles	Results	Population	Female HC use
Pollack et al. (1982)	61	A, B, C, DR, DQ	*NS*	Caucasian couples in the US	Likely some HC users[3]
Rosenberg et al. (1983)	1017	A, B	Assortative[1]	Ethnically diverse couples in the US	Likely some HC users[3]
Nordlander et al. (1983)	845	A, B	*NS*	Swedish parents and Swedish couples testing for kidney transplants	Likely some HC users[4]
Giphart & D'Amoro (1983)	3000	A, B, C	Disassortative for specific allele combinations	Dutch parents	Likely some HC users[5]
Sans et al. (1994)	183	A, B, C	*NS*	Caucasian couples in Uruguay seeking paternity tests	Likely some HC users[6]
Jin et al. (1995)	542	A, B, DR	*NS*	Caucasian couples in the US	Likely some HC users[3]
Ober et al. (1997)	411	A, B, C, DR, DQ	Disassortative	Hutterites in the US (a Caucasian, inbred, ethnically homogenous population with a limited repertoire of MHC alleles)	Non-users[7]
Hedrick & Black (1997)	194	A, B	*NS*	South Amerindian couples from 11 remote tribes	Unlikely any HC users[8]
Ihara et al. (2000)	450	A, B, C, DR, DQ	*NS*	Japanese couples	Unlikely any HC users[9]
Garver-Apgar et al. (2006)	48	A, B, DR	*NS*	Couples in the US (primarily Caucasian and Hispanic)	Likely some HC users[3]
Chaix et al. (2008)	30	Whole MHC region	Disassortative[2]	Couples in Utah with Northern and Western European ancestry	Likely some HC users[3]
	30	Whole MHC region	*NS*	African couples from the Yoruba population in Nigeria	Unlikely any HC users[10]
Khankhanian et al. (2010)	930	Whole MHC region A, B, C, DR, DQA1, DQB1, DPA1, DPB1	Assortative Assortative for Class I alleles Disassortative for Class II alleles	Caucasian parents in the US who have a child with multiple sclerosis	Unlikely any HC users[11]
Kim et al. (2013)	698	Whole MHC region A, B, C, DR, DQA1, DQB1, DPA1, DPB1	*NS* *NS*	Bulgarian parents who have a child with schizophrenia	Unlikely any HC users[12]
Israeli et al. (2014)	1310	A, B, DR	Assortative	Jewish couples in Israel, who were either unmarried parents involved in paternity suits, or were seeking treatment for recurrent spontaneous abortions	Unlikely any HC users[13]

Note: Female HC use denotes whether female members of the couples might have been using hormonal contraceptives at relationship initiation. Details on how this was determined are presented in the footnotes.

Table 9 (*continued*)

Footnotes:

1. Evidence of assortative mating goes away when looking just within ethnic group.
2. See also commentary on these results (Derti et al., 2010; Derti & Roth, 2012; Laurent & Chaix, 2012 a, b).
3. A large proportion of women in the US use hormonal contraception (it is the most popular form of contraception); prevalence of hormonal contraceptive use in the US has been between 14 and 27% since 1965 (Mosher et al., 2004; Mosher & Westoff, 1982; United Nations, 2011). Prevalence of hormonal contraceptive use in the US has been between 23 and 27% since 1981.
4. A large proportion of women in Sweden use hormonal contraception (it is the most popular form of contraception), and this has been the case since they were introduced in 1964 (Larsson et al., 1997).
5. A large proportion of women in the Netherlands use hormonal contraception (it is the most popular form of contraception); prevalence of hormonal contraceptive use in the Netherlands has been between 26 and 49% since 1969 (United Nations, 2011).
6. A large proportion of women in Uruguay use hormonal contraceptives. Prevalence of hormonal contraceptive use during the time the data was collected (the data for the study was collected between 1983 and 1989, contraceptive prevalence data is from 1986) was 43% (United Nations, 2011).
7. Women in this population do not use hormonal contraceptives (Ober et al., 1997).
8. Population was indigenous tribes from regions with low levels of hormonal contraceptive use (United Nations, 2011).
9. Prevalence of hormonal contraceptive use in Japan has been less than 2% since 1950 (United Nations, 2011).
10. Prevalence of hormonal contraceptive use in Nigeria has been less than 6% since 1981 (United Nations, 2011).
11. Most couples in this study met their partner before the 50's and 60's (Khankhanian et al., 2010), and the oral contraceptive pill did not receive FDA approval until 1960.
12. Prevalence of hormonal contraceptive use in Bulgaria has been between 2 and 10% since 1976 (United Nations, 2011).
13. The prevalence of hormonal contraceptive use among married women is only 13%, and is likely lower among unmarried women (Okun, 1997; United Nations, 2011).

Table 10

Descriptive Statistics

Categorical Variables								
		Frequency (Valid %)					Between-group differences ($\chi 2$ test)	
Variable	Category	Entire Sample	Non-users	HC users	College Sample	Community Sample	Non-users vs HC users	College vs Community
Hormonal contraceptive use at relationship initiation	User	72 (26.3%)	*N/A*	*N/A*	10 (11.1%)	62 (33.7%)	*N/A*	$p < .001$
	Non-user	202 (73.7%)	*N/A*	*N/A*	80 (88.9%)	122 (66.3%)		
Current hormonal contraceptive use	User	130 (47.4%)	68 (33.7%)	62 (86.1)	17 (18.9%)	113 (61.4%)	$p < .001$	$p < .001$
	Non-user	144 (52.6%)	134 (66.3%)	10 (13.9%)	73 (81.1%)	71 (38.6%)		
Change in hormonal contraceptive use	Same	196 (71.5%)	134 (66.3%)	62 (86.1%)	75 (83.3%)	121 (65.8%)	$p < .01$	$p < .01$
	Changed	78 (28.5%)	68 (33.7%)	10 (13.9%)	15 (16.7%)	63 (34.2%)		
Change in hormonal contraceptive use (by category)	Stable user	62 (22.6%)	*N/A*	62 (86.1)	6 (6.7%)	56 (30.4%)	*N/A*	$p < .001$
	Stable non-user	134 (48.9%)	134 (66.3%)	*N/A*	69 (76.7%)	65 (35.3%)		
	Stopped using	10 (3.6%)	*N/A*	10 (13.9%)	4 (4.4%)	6 (3.3%)		
	Started using	68 (24.8%)	68 (33.7%)	N/A	11 (12.2%)	57 (31%)		
Whether participants had had sex with partner	Yes	211 (84.7%)	145 (81%)	66 (94.3%)	74 (82.2%)	137 (86.2%)	$p < .01$	$p = .41$
	No	38 (15.3%)	34 (19%)	4 (5.7%)	16 (17.8%)	22 (13.8%)		
	Missing	25	23	2	0	25		
Race	African American	11 (4%)	8 (4%)	3 (4.2%)	4 (4.4%)	7 (3.8%)	$p < .001$	$p < .001$
	Asian	58 (21.2%)	54 (26.7%)	4 (5.6%)	32 (35.6%)	26 (14.1%)		
	Caucasian	145 (52.9%)	91 (45%)	54 (75%)	24 (26.7%)	121 (65.8%)		
	Hispanic	31 (11.3%)	25 (12.4%)	6 (8.3%)	11 (12.2%)	20 (10.9%)		
	Other/ Multiracial	24 (8.8%)	20 (9.9%)	4 (5.6%)	14 (15.6%)	10 (5.4%)		
	Missing	5 (1.8%)	4 (2%)	1 (1.4%)	5 (5.6%)	0 (0%)		
Mono/Biracial	Same Race	173 (75.2%)	119 (72.1%)	54 (83.1%)	46 (71.9%)	127 (76.5%)	$p = 0.08$	$p = .47$
	Different Races	57 (24.8%)	46 (27.9%)	11 (16.9%)	18 (28.1%)	39 (23.5%)		
	Missing/ Unknown	44	37	7	26	18		

Table 10 (*continued*)

Continuous Variables							
	Mean (*SD*)					Between-group differences (Independent samples *t*-tests)	
Variable	Entire Sample	Non-users	HC users	College Sample	Community Sample	Non-users vs HC users	College vs Community
Female partner age (n = 268)	25.42 (4.58)	24.82 (4.61)	27.09 (4.08)	20.75 (3.07)	27.59 (3.4)	p < .001	p < .001
Male partner age (n = 268)	27.01 (5.75)	26.14 (5.54)	29.46 (5.66)	21.86 (4.05)	29.61 (4.61)	p < .001	p < .001
Relationship length (n = 273)	36.72 (30.75)	37 (33.05)	35.94 (23.31)	19.37 (18.12)	45.11 (32.09)	p = .77	p < .001
SOI attitudes (n = 274)	5.72 (1.42)	5.76 (1.44)	6.6 (1.37)	5.59 (1.44)	5.78 (1.41)	p = .42	p = .29
Number of lifetime sex partners (n = 89)	2.51 (2.86)	2.22 (2.67)	4.8 (3.39)	2.51 (2.86)	*N/A*	p = .04	*N/A*
Importance of partner turning them on (n = 86)	7.48 (1.66)	7.45 (1.69)	7.67 (1.5)	7.48 (1.66)	*N/A*	p = .72	*N/A*
Male partner attractiveness (n = 274)	5.4 (1.12)	5.35 (1.14)	5.53 (1.03)	5.02 (1.23)	5.58 (1.01)	p = .24	p < .001
Female partner attractiveness (n = 262)	4.93 (1.3)	4.96 (1.26)	4.84 (1.4)	4.89 (1.21)	4.94 (1.33)	p = .48	p = .8

Table 11

Number of Couples (and Percentage) with Shared Alleles

	Number of Shared Alleles						
Sample	0	1	2	3	4	5	6
Full Sample	96 (35%)	96 (35%)	62 (22.6%)	18 (6.6%)	2 (0.7%)	0	0
Non-users	63 (31.2%)	74 (36.6%)	53 (26.2%)	11 (5.4%)	1 (0.5%)	0	0
HC Users	33 (45.8%)	22 (30.6%)	9 (12.5%)	7 (9.7%)	1 (1.4%)	0	0

Table 12*a*

Analyses Including Categorical Control Variables using Analysis of Variance

Variable	Is there a significant interaction between HC use at relationship initiation and moderator?	Follow-up analyses	HC use at relationship formation significant predictor?	Results in theory consistent direction?
Study source	**Marginally (p = .07)**	College sample (HC n = 10; NHC n = 80)	No (p = .28, d = -0.37)	Yes
		Community sample (HC n = 62; NHC n = 122)	**Yes (p = .04, d = 0.32)**	No
Current hormonal contraceptive use	No (p = .44)	Current HC users (HC n = 62; NHC n = 68)	No (p = .77, d = 0.05)	No
		Current non-users (HC n = 10; NHC n = 134)	No (p = .46, d = 0.25)	No
Change in hormonal contraceptive use	No (p = .92)	HC use same (HC n = 62; NHC n = 134)	No (p = .15, d = 0.22)	No
		HC use different (HC n = 10; NHC n = 68)	No (p = .62, d = 0.17)	No
Whether women had had sex with partner	No (p = .94)	Women who had had sex with partner (HC n = 66; NHC n = 145)	No (p = .28, d = 0.16)	No
		Women who had not had sex with partner (HC n = 4; NHC n = 34)	No (p = .85, d = 0.12)	No
Race	No (p = .97)	Asian women (HC n = 4; NHC n = 54)	No (p = .78, d = 0.15)	No
		Hispanic women (HC n = 6; NHC n = 25)	No (p = .67, d = 0.2)	No
		White women (HC n = 54; NHC n = 91)	No (p = .12, d = 0.27)	No
Whether couple was mono or multi-racial	No (p = .39)	Monoracial couples (HC n = 54; NHC n = 119)	No (p = .2 , d = 0.2)	No
		Multi-racial couples (HC n = 11; NHC n = 46)	**Marginally (p = .09, d = 0.58)**	No

Note: HC denotes hormonal contraceptive users, NHC denotes non-user. Analyses that are statistically significant (p < .05) or marginally significant (p < .1) are bolded.

Table 12*b*

Analyses Including Categorical Control Variables using Poisson Regression

Variable	Is there a significant interaction between HC use at relationship initiation and moderator?	Follow-up analyses	HC use at relationship formation significant predictor?	Results in theory consistent direction?
Study source	**Marginally (p = .07)**	College sample (HC n = 10; NHC n = 80)	No (p = .32)	Yes
		Community sample (HC n = 62; NHC n = 122)	**Marginally (p = .05)**	No
Current hormonal contraceptive use	No (p = .48)	Current HC users (HC n = 62; NHC n = 68)	No (p = .76)	No
		Current non-users (HC n = 10; NHC n = 134)	No (p = .34)	No
Change in hormonal contraceptive use	No (p = .98)	HC use same (HC n = 62; NHC n = 134)	No (p = .19)	No
		HC use different (HC n = 10; NHC n = 68)	No (p = .61)	No
Whether women had had sex with partner	No (p = .93)	Women who had had sex with partner (HC n = 66; NHC n = 145)	No (p = .29)	No
		Women who had not had sex with partner (HC n = 4; NHC n = 34)	No (p = .83)	No
Race	No (p = .96)	Asian women (HC n = 4; NHC n = 54)	No (p = .81)	No
		Hispanic women (HC n = 6; NHC n = 25)	No (p = .63)	No
		White women (HC n = 54; NHC n = 91)	No (p = .14)	No
Whether couple was mono or multi-racial	No (p = .31)	Monoracial couples (HC n = 54; NHC n = 119)	No (p = .22)	No
		Multi-racial couples (HC n = 11; NHC n = 46)	No (p = .12)	No

Note: HC denotes hormonal contraceptive users, NHC denotes non-user. Analyses that are statistically significant ($p < .05$) or marginally significant ($p < .1$) are bolded.

Table 13*a*

Analyses Including Continuous Control Variables using Analysis of Covariance

Variable	Is there a significant interaction between HC use at relationship initiation and moderator?	Controlling for moderator, is HC use at relationship initiation significant?	Controlling for moderator, are results in theory consistent direction?
Relationship length (HC n = 72; NHC n = 201)	No (p = .21)	No (p = .16, d = 0.18)	No
SOI Attitudes (HC n = 72; NHC n = 202)	No (p = .65)	No (p = .19, d = 0.2)	No
Number of lifetime sex partners (College sample only; HC n = 10; NHC n = 79)	No (p = .12)	No (p = .2, d = -0.28)	Yes
How important it is that their partner turns them on (College sample only; HC n = 9; NHC n = 77)	**Yes (p = .05)**[1]	No (p = .27, d = -0.52)	Yes
Male partner attractiveness (HC n = 72; NHC n = 202)	No (p = .6)	No (p = .19, d = .18)	No
Female partner attractiveness (HC n = 71; NHC n = 181)	No (p = .24)	No (p = .19, d = .19)	No

Note: HC denotes hormonal contraceptive users, NHC denotes non-user. Analyses that are statistically significant ($p < .05$) or marginally significant ($p < .1$) are bolded.

Footnotes:

1. Follow-up analyses revealed that among HC users at relationship initiation, how important it was that their partner turned them was marginally significantly negatively correlated MHC similarity (p =.06, r = -.64, n =9). Among non-users, how important it was that their partner turned them was not significantly correlated with MHC similarity (p =.6, r =-.06, n =77).

Table 13*b*

Analyses Including Categorical Control Variables using Poisson Regression

Variable	Is there a significant interaction between HC use at relationship initiation and moderator?	Controlling for moderator, is HC use at relationship initiation significant?	Controlling for moderator, are results in theory consistent direction?
Relationship length (HC n = 72; NHC n = 201)	No (p = .19)	No (p = .19)	No
SOI Attitudes (HC n = 72; NHC n = 202)	No (p = .64)	No (p = .21)	No
Number of lifetime sex partners (College sample only; HC n = 10; NHC n = 79)	No (p = .2)	No (p = .47)	Yes
How important it is that their partner turns them on (College sample only; HC n = 9; NHC n = 77)	No (p = .16)	No (p = .17)	Yes
Male partner attractiveness (HC n = 72; NHC n = 202)	No (p = .79)	No (p = .22)	No
Female partner attractiveness (HC n = 71; NHC n = 181)	No (p = .21)	No (p = .22)	No

Note: HC denotes hormonal contraceptive users, NHC denotes non-user. Analyses that are statistically significant (p < .05) or marginally significant (p < .1) are bolded.

Chapter IV: Cycle Shifts in Attraction among Naturally Cycling Women as Compared with Women Using Hormonal Contraceptives: A Daily Diary Investigation

Abstract

A number of studies have documented shifts across the ovulatory cycle in women's attractions toward their own romantic partner and toward men other than their partner among women who do not use hormonal contraceptives. Other research examining cycle shifts in women's mate preference has found that shifts observed among naturally cycling women are absent among hormonal contraceptive users. This raises the possibility that hormonal contraceptive users will also not experience shifts across the cycle in their attractions toward their own romantic partner or toward men other than their partner. We test this hypothesis using daily diary methods. Fifty six women currently involved in a romantic relationship (24 naturally cycling women, 32 women using hormonal contraceptives) completed daily online surveys for 35 days assessing their current attraction to and behaviors toward their romantic partner and men other than their partner (producing 1,366 observations). Replicating previous research, among naturally cycling women we found cycle shifts in extra-pair attraction contingent on women's ratings of how sexually attractive their partner was. Follow-up analyses using hormone tests to verify proximity to ovulation within the fertile window showed that the influence of partner sexual attractiveness on women's extra-pair attraction strengthened as the estimated day of ovulation (and the day of peak fertility) approached. Extending previous research, as predicted, we found no such shifts among women using hormonal contraceptives. These results provide further evidence consistent with the hypothesis that changes in women's sexual attractions across the cycle are the result of changes in women's reproductive hormones across the cycle. In addition, these results are consistent with the hypothesis that hormonal contraceptives might influence relationship dynamics by eliminating cycle shifts in women's preferences and attractions.

Cycle Shifts in Attraction among Naturally Cycling Women as Compared with Women Using Hormonal Contraceptives: A Daily Diary Investigation

Consistent with the ovulatory shift hypothesis, a substantial body of evidence has documented changes in women's mate preferences and attractions across the ovulatory cycle (reviewed in Gildersleeve, Haselton, & Fales, 2014; Larson, Pillsworth, & Haselton, 2012). Hormonal contraceptives eliminate ovulation and suppress the changes in women's reproductive hormones across the cycle (Fleischman, Navarrete, & Fessler, 2010; Frye, 2006). This leads to the straightforward prediction that women who use hormonal contraceptives (HC users) will not experience cycle shifts in preferences and attractions documented among women who do not use hormonal contraceptives (naturally cycling women). Studies that have examined cycle shifts in mate preferences among naturally cycling women as compared with HC users support this prediction (reviewed in Chapter II).

Here we extend previous research by examining cycle shifts in women's attractions toward their own romantic partner and men other than their partner in both naturally cycling women and HC users. This extension contributes to the literature in two important ways. First, HC users serve as a quasi-control group for studying cycle shifts in attraction, thereby offering the potential to further demonstrate that cycle shifts observed among naturally cycling women are due to shifts in reproductive hormones across the cycle. Second, although there are many demonstrations that naturally cycling women experience shifts in mate preferences across the cycle, whereas HC users do not, no study has yet examined whether this pattern will also be observed when examining women's attractions to their romantic partner and other men. This extension is crucial for understanding the implications of HC use for women's relationship dynamics.

Ovulatory Shifts in Women's Preferences and Attractions

Throughout human evolutionary history, sexual intercourse could only result in conception if it occurred on one of the few high-fertility days of the cycle leading up to and including the day of ovulation (Wilcox, Dunson, Weinberg, Trussell, & Baird, 2001). Therefore, the costs and benefits of many mating decisions were greatest on these few fertile days of the cycle. It is likely, therefore, that women possess adaptations that differently guide their mating decisions depending on fertility within the cycle. The ovulatory shift hypothesis predicts that one such change is an increase on high relative to low fertility days of the cycle in women's sexual attraction to male characteristics historically linked with genetic quality (Gangestad & Thornhill, 1998; Gangestad, Thornhill& Garver-Apgar, 2005; Gildersleeve, et al., 2014). The ovulatory shift hypothesis further predicts that these shifts in preferences will occur primarily when women evaluate men's sexiness or attractiveness as a short-term mate and not when women evaluate men's attractiveness as a long-term mate (a context in which other characteristics, such as kindness and possession of resources, are relatively more important in a mate).

One implication of these shifts in preferences is that women's attractions to their primary relationship partner and other men could also shift across the cycle. If women's primary male partners possess the characteristics that women particularly prefer at high fertility within the cycle then they might experience an increase in attraction to *their own partner* on high relative to low fertility days of the cycle. If women's primary male partners *do not* possess the characteristics that women particularly prefer at high fertility within the cycle then they might experience an increase in attraction to *other men* on high relative to low fertility days of the cycle (e.g. Pillsworth & Haselton, 2006).

A growing body of literature supports the ovulatory shift hypothesis. A recent meta-analytic review of 96 effects in 50 studies found robust increases in women's preferences for characteristics putatively associated with high genetic quality ancestrally on high- relative to low-fertility days of the cycle (Gildersleeve et al., 2014). Furthermore, these increases were largest when women evaluated men's attractiveness as a short-term mate and absent when women evaluated men's attractiveness as a long-term mate (Gildersleeve et al., 2014).

In parallel with these findings, several studies have found that women experience increased attraction to men other than their primary partners ("extra-pair attraction") on high- relative to low-fertility days of the cycle, but only if their partners lack the qualities women particularly prefer on fertile days of the cycle (reviewed in Larson, Pillsworth, & Haselton, 2012). Some studies have also found shifts in women's attraction to their own partners ("in-pair attraction") across the cycle, but only if their partners possess the qualities women particularly prefer on fertile days of the cycle (reviewed in Larson et al., 2012).

Despite this large body of mutually-reinforcing evidence, some authors have asserted that there is no compelling evidence of cycle shifts in preferences or desires (e.g., Harris, Pashler, & Mickes, in press). These authors speculate that the published evidence is a product of either publication bias or "*p*-hacking" – the practice of running numerous statistical analyses and selectively reporting only the ones that "work" (Simmons, Nelson, & Simonsohn, 2012). These authors have called for direct replication studies that use the exact same measures and methods as have been used in previous research (preventing the problem of the analytic flexibility that would allow for *p*-hacking). The study we report here does in fact use identical measures to those used in prior research (Pillsworth & Haselton, 2006; Larson et al., 2012).

In addition, as noted above, the inclusion of HC users in this study offers a comparison group that could provide especially strong evidence for cycle shifts in women's attractions. If there are genuine shifts across the ovulatory cycle reflecting shifts in fertility and reproductive hormones, these shifts should be observed only among naturally cycling women. As reviewed in Chapter II, the evidence resoundingly supports this pattern in studies examining shifts in women's mate preferences across the cycle (see Chapter II, Table 2). The current study examined whether this pattern would also hold for shifts in women's attractions in the context of their on-going relationships. .

Much of the research on the effects of hormonal contraceptives on relationship dynamics has focused on the negative effects hormonal contraceptives might have (e.g. Alvergne & Lummaa, 2010; Cobey, Klipping, & Buunk, 2013; Cobey, Roberts, & Buunk, 2013; Puts & Pope, 2013; Roberts et al., 2014; Welling, 2013; Welling, Puts, Roberts, Little, & Burriss, 2012). However, if hormonal contraceptives eliminate increases in attraction to extra-pair men at high relative to low fertility within the cycle, hormonal contraceptive use might have relationship-protective effects.

Current research

In the current research, we set out to replicate and extend previous studies documenting moderated cycle shifts in women's extra-pair and in-pair attraction (reviewed in Larson et al., 2012) by additionally investigating moderated cycle shifts in extra-pair and in-pair behaviors, and by including HC users as a quasi-control group. Because the characteristics historically associated with high genetic quality are sexually attractive to women, following previous research we used women's ratings of how sexually attractive their partner was as our moderating variable (Haselton and Gangestad, 2006; Larson et al., 2012; Larson, Haselton, Gildersleeve, &

Pillsworth, 2013; Pillsworth and Haselton, 2006). To determine whether our results were robust, we also ran exploratory analyses using alternative partner rating moderators and analyses including a number of control variables (reported in the Appendix).

In addition to examining cycle shifts in women's attractions, we sought to understand the possible implications of these cycle shifts by examining whether changes in attraction are reflected in changes in behavior. Previous research on cycle shifts in women's extra-pair attractions has sometimes included items assessing extra-pair behaviors (e.g. women's flirtation with men other than their partner) in their measures of extra-pair attractions (Haselton & Gangestad, 2006; Larson et al., 2012). Other research has focused solely on women's extra-pair attractions (Gangestad et al., 2005; 2010; Garver-Apgar et al., 2006). Previous research examining women's in-pair attractions have not included items assessing women's sexual behaviors directed at their partners (Gangestad et al., 2005; 2010; Garver-Apgar et al., 2006; Larson et al., 2012; Pillsworth & Haselton, 2006). One recent study found that women were more likely to initiate sexual behavior with their partner at high relative to low fertility (Roney & Simmons, 2013), but this study did not investigate the moderating effect of partner sexual attractiveness.

We did not have strong predictions about links between attractions and behaviors. On one hand, one might predict that women's attractions translate to their behaviors. On the other, behavior is constrained in ways that attraction is not. For example, a woman highly committed to her relationship might lack the motivation to act on her attractions toward men other than her partner. Alternatively, a woman might be motivated to engage in extra-pair activity but simply lack the opportunity to do so. Because extra-pair sexual activity is a low base-rate event, we investigated whether women engaged in a more modest form extra-pair behavior: flirting with

another man. In-pair sexual activity is a much higher base-rate event. Therefore, we investigated female initiated in-pair sexual activity.

Predictions. We designed a study assessing women's attractions and behaviors throughout the cycle. We predicted that HC use, fertility, and partner sexual attractiveness would interact to predict extra-pair attraction and behaviors. Specifically, we predicted there would be moderated cycle shifts in attraction and behaviors among naturally cycling women, but no such shifts among HC users. Among naturally cycling women, we predicted that extra-pair attraction and behaviors would be greater at high relative to low fertility among women with less sexually attractive partners, whereas it would not change across the cycle (or would be diminished at high relative to low fertility) among women with more sexually attractive partners. We additionally predicted that HC use, fertility, and partner sexual attractiveness would interact in predicting in-pair attraction and behaviors. Specifically, we again predicted there would be moderated cycle shifts in attraction and behaviors among naturally cycling women, but no such shifts among HC users. Among naturally cycling women, we predicted that in-pair attraction and behaviors would be diminished at high relative to low fertility among women with less sexually attractive partners, whereas it would not change across the cycle (or would be heightened at high relative to low fertility) among women with more sexually attractive partners. Previous research found that cycle shifts in in-pair attraction are less robust than shifts in extra-pair attraction (Larson et al., 2012). Therefore, predictions about shifts in extra-pair attraction are stronger than those about in-pair attraction. In addition, because women may lack the motivation or opportunity to act on their attractions, we predicted that shifts in desires would be stronger than shifts in behaviors.

Methods

Participants

Participants were 56 couples currently involved in a heterosexual romantic relationship. However, because our focus was on associations between women's fertility and sexual attractions and behaviors, we only report data from our female participants in this paper[15]. Three women were married to their partner, one was engaged to her partner, ten women lived with their partner but were not married or engaged, and 42 women were exclusively dating their partner but not cohabiting. Mean relationship length was two years (24.48 months, *SD* = 23.58 months, range = 1– 123 months). The mean age was 21.71 years (*SD* = 4.66, range = 18–46). Twenty women self-identified as Asian, 18 as Caucasian, seven as Hispanic, four as Middle Eastern, one as African American, and six as multiple ethnicities. Twenty four women were naturally cycling, and 32 were HC users (three used the Nuva ring and all other women used a combined oral contraceptive). Participants were recruited from the UCLA campus and participated for cash payment or credits toward course research requirements. Further descriptive information, including information on male participants, is provided in Appendix Tables 2a and 2b.

Only women whose partner lived in the local area and slept in the same bed as her at least two nights a week, on average, were eligible to participate in order to ensure that women were regularly in contact and interacting with their partner. Following previous research on cycle shifts (e.g. Pillsworth & Haselton, 2006; Larson et al., 2013), naturally cycling women were only eligible to participate if they were not pregnant or breastfeeding a child, had not used any form of hormonal contraception within the past three months, and had regular menstrual cycles of an

[15] The data reported herein come from a larger study investigating cycle shifts among both women and their partners across a variety of dimension, such as women's feelings about their relationship, women's attractiveness, and men's feelings about their relationship, and men's mate guarding behaviors. These items are beyond the scope of this paper and will be reported elsewhere.

average length. Hormonal contraceptive users were only eligible to participate if they were using a form of hormonal contraception that contained both a progestin and an estrogen component because the hormonal effects of progestin-only formulations (e.g. the progestin shot or the hormonal IUD) differ from those of combined forms (e.g. Frye, 2006), and are not common among college-aged women (Mosher & Jones, 2010). Finally, both naturally cycling women and HC users needed state that they had no plans to change their hormonal contraceptive status within the next month in order to be eligible to participate in the study.

An additional 23 women participated in the study but did not complete at least one questionnaire meeting the inclusion criteria detailed in the Data Processing section of the Appendix. Responses from these women were included when standardizing the continuous moderator variables, but they were not included in any analyses presented in the results section. Descriptive information on women excluded from analyses as well as comparisons between the women included and excluded from the analyses are provided in Appendix Tables 2a and 2b.

Procedure

Participants completed a screening interview over the phone to determine eligibility, one in-lab session, up to 35 online questionnaires at home, and a final in-lab debriefing session. Naturally cycling women also completed five at-home mid-stream urine tests measuring women's levels of LH to hormonally verify ovulation. During the initial in-lab session, women provided informed consent and completed the initial questionnaire, which contained the items used to assess women's perceptions of their partner's sexual attractiveness. At the initial in-lab session, women who were naturally cycling also received materials and instructions for completing the LH tests. At the initial session, we gave all participants verbal, one-on-one instructions for completing the daily questionnaires and stressed the importance of following

instructions exactly. We instructed participants to complete the questionnaire every night just before they went to bed, to refrain from discussing the questions on the questionnaire or their responses with their partner, and to complete the questionnaire in private. We told participants to skip questionnaires they had not completed instead of completing them at a later date. To further encourage participants to complete their questionnaires on time, we (falsely) told them they would not be compensated for questionnaires completed the next day. As an incentive to complete the majority of the questionnaires, women were given an extra bonus ($11 or one research credit) if they completed at least 30 of the 35 daily questionnaires. Starting the day after their initial in-lab session, we sent participants an email containing the link to the online daily questionnaire for 35 consecutive nights. All the daily questionnaires were identical and contained the items assessing our outcome measures. Overall, compliance was high: the average number of surveys completed per woman was 30.56 (median = 32, mode = 35, range = 10–35). At the debriefing session, we interviewed participants to collect information used to determine whether any of their responses needed to be excluded from analyses (e.g. because of failure to comply with instructions or change in HC use). Finally, all participants were fully debriefed and paid or granted research credits.

The Appendix contains further information on the procedures for determining when women needed to complete their LH tests and the instructions for completing the tests and recording their results. The Appendix also contains information on the items from the initial questionnaire assessing alternative partner ratings moderators, control variables, and demographic information, and the items from the daily questionnaires pertaining to control variables. Full information on all the questions asked during the debriefing interview is also presented in the Appendix.

Measures

Partner sexual attractiveness. We assessed women's perceptions of how sexually attractive their partner was to other women using the same four item measure used in previous studies examining moderated cycle shifts in attraction (Haselton and Gangestad, 2006; Larson et al., 2012; Pillsworth and Haselton, 2006). Women responded to the following two items on a scale from 1 (*much less*) to 7 (*much more*): "How attractive do women find your partner's face, compared with most men?" and "How attractive do women find your partner's body, compared with most men?" Women responded to the next two items on a scale from 1 (*lowest 5%*) to 5 (*highest 5%*) in response to instructions to rate their partner as others would rate him, compared with other men his age: "Qualities of a good short-term partner" and "Sexy." Scores for all items were standardized and then averaged together ($\alpha = 0.74$).

Extra-pair attraction. We assessed women's attraction to men other than their partners using a three item measure containing items used in previous research or adapted from items used in previous research (Gangestad et al., 2005; 2010; Garver-Apgar et al., 2006; Haselton & Gangestad, 2006; Larson et al., 2012; Pillsworth & Haselton, 2006).Women responded to the following three items on a scale from 1 (*far less than usual*) to 7 (*far more than usual*) in response to instructions to rate how much they engaged in the following feelings or behaviors over the past 24 hours relative to how things generally are: "Felt sexual attraction toward a man other than your partner," "Noticed attractive men around campus or around town," and "Fantasized about sex with someone other than your partner." Scores for all items were averaged together ($\alpha = 0.9$).

Extra-pair behavior. We assessed women's flirtatious behavior toward men other than their partner using one item adapted from items used in previous research (Haselton &

Gangestad, 2006; Larson et al., 2012). Women responded to the following item on a scale from 1 (*0 times*) to 5 (*10+ times*) in response to instructions to indicate how many times they engaged in the behavior over the past 24 hours: "Flirted with a man other than your partner."

In-pair attraction. We assessed women's attraction toward their own partner using a four items measure containing items used in previous research or adapted from items used in previous research (Gangestad et al., 2005; 2010; Garver-Apgar et al., 2006; Larson et al., 2012; Pillsworth & Haselton, 2006). Women responded to the following four items on a scale from 1 (*far less than usual*) to 7 (*far more than usual*) in response to instructions to rate how much they engaged in the following feelings or behaviors over the past 24 hours relative to how things generally are: "Felt sexual attraction toward your partner," "Noticed that your partner looked attractive," "Felt attracted to your partner's natural scent (i.e. not the scent of a product he uses)," and "Fantasized about sex with your partner." Scores for all items were averaged together (α = .88).

In-pair behavior. We assessed women's sexual behavior toward their partner using a one item measure. Women responded to the following item on a scale from 1 (*0 times*) to 5 (*10+ times*) in response to instructions to indicate how many times they engaged in the behavior over the past 24 hours: "Initiated sexual activity with your partner (by "sexual activity" we mean mutually voluntary sexual activity involving genital contact even if intercourse or orgasm did not occur)."

Data Processing

Prior to analyzing the data, we coded women's position within the menstrual cycle when each questionnaire was completed in order to estimate women's fertility throughout their participation (or, for HC users, the fertility they would have had if they were naturally cycling

based on their day in the cycle). For both naturally cycling women and HC users, we coded their forward cycle day (FCD; the number of days from previous menstrual onset) using women's reports of their previous menstrual onset provided at the initial session, and their reports of menstrual onset while completing the daily questionnaires. In line with previous research (e.g. Gangestad & Thornhill, 1998; Thornhill & Gangestad, 1999), using women's FCD, we assigned a conception risk to each observation using actuarial data from Wilcox et al. (2001). Conception risk is the average probability that unprotected sex will result in conception on each day of the cycle, and indicates estimated fertility within the cycle[16].

Fertility increases leading up to the day of ovulation even within the fertile window—the day of ovulation and the five days beforehand (Wilcox, Weinberg, & Baird, 1995), suggesting that cycle shifts might be particularly pronounced the closer to ovulation an observation is (see Bryant & Haselton, 2009; Haselton et al., 2007). Therefore, among naturally cycling women who experienced an LH surge, we used the date of the LH surge to estimate their proximity to ovulation within the fertile window. Because LH surges approximately 48 hours prior to ovulation (Geurmandi et al., 2001), we assigned the date two days after the date of LH surge as 0, and counted each previous day until 5 days before ovulation, at which time conception risk returns to almost 0 (Wilcox et al., 1995).

The Appendix contains the full information on our data processing, including information on the control variables we coded for, how we handled repeat observations, and reasons for excluding observations (e.g. change in HC use, multiple observations on the same day). In the

[16] Some previous cycle studies using daily diary methods categorized observations as high or low fertility (or high fertility, low fertility, and menstrual) and analyzed data using fertility as a categorical predictor variable (e.g. Haselton & Gangestad, 2006; Miller, Tybur, & Jordan, 2007). However, before processing the data we chose to instead use conception risk as a continuous predictor variable because this allowed us to retain all our observations (categorical assignments of fertility require excluding observations from the days falling between the high and low fertility windows) and allowed us to account for the full range in fertility across the cycle.

Appendix we also provide further details on the coding of women's position within the ovulatory cycle and how we determined whether each questionnaire was completed on a high quality cycle day or whether it should be excluded from analyses. We also provide information on the number of observations excluded based on each exclusion criterion.

Data Analyses

The final sample of observations eligible for inclusion was 451 observations from 24 naturally cycling women and 915 observations from 32 HC users. The average number of observations per woman was 24.38 (median = 28, mode = 35, range = 2–35). Analyses involving proximity to ovulation within the fertile window contained 61 observations from 10 women.

We tested our predictions using multilevel mixed-effects linear regression with observations nested within participants and random intercepts at both the observation and the participant level (Stata 13.1), and estimated the parameters via restricted maximum likelihood. Conception risk was entered as a predictor at the observation level (Level 1), and hormonal contraceptive use and partner sexual attractiveness were entered at the participant level (Level 2). Prior to running analyses, we standardized partner sexual attractiveness. Hormonal contraceptive use was dummy coded.

For our analyses, we estimated all main effects, two-way interactions, and the three-way interaction between conception risk, hormonal contraceptive use, and partner sexual attractiveness as displayed in Equation 1 below (presented first at the two separate levels for ease of interpretation and then as the full model). We tested whether the gamma coefficient associated with the three-way interaction between hormonal contraceptive use, conception risk, and partner sexual attractiveness ($\gamma 13$) was significant. A significant $\gamma 13$ coefficient indicated that the interaction between conception risk and partner sexual attractiveness predicting the outcome

variable was different between naturally cycling women and hormonal contraceptive users. Because hormonal contraceptive use was dummy coded, the gamma coefficient associated with the interaction between conception risk and partner sexual attractiveness ($\gamma 12$) provided the simple effects test among naturally cycling women of whether the influence of conception risk on the outcome variable depended on levels of partner sexual attractiveness. To obtain this simple effects test among HC users, we re-ran analyses changing the reference group to HC users. If the three-way interaction between hormonal contraceptive use, conception risk, and partner sexual attractiveness was significant, we graphed the slope of conception risk in predicting the outcome variable separately for naturally cycling women and HC users at the mean of partner sexual attractiveness, and at one and two standard deviations above and below the mean.

Equation 1:

Level-1 model (observations):

$$Yij = \delta 0j + \delta 1j(\text{Conception risk}) + eij$$

Level-2 model (participants):

$$\delta 0j = \gamma 00 + \gamma 01(\text{HC use}) + \gamma 02(\text{Partner sexual attractiveness}) + \gamma 03(\text{HC use*Partner sexual attractiveness}) + u0j$$

$$\delta 1j = \gamma 10 + \gamma 11(\text{HC use}) + \gamma 12(\text{Partner sexual attractiveness}) + \gamma 13(\text{HC use*Partner sexual attractiveness}) + u1j$$

Full model:

$$Yij = \gamma 00 + \gamma 01(\text{HC use}) + \gamma 02(\text{Partner sexual attractiveness}) + \gamma 03(\text{HC use*Partner sexual attractiveness}) + \gamma 10(\text{Conception risk}) + \gamma 11(\text{HC use* Conception risk}) + \gamma 12(\text{Partner sexual attractiveness* Conception risk}) + \gamma 13(\text{HC use*Partner sexual attractiveness * Conception risk}) + u0j + u1j(\text{Conception risk}) + eij$$

If conception was a significant predictor among naturally cycling women, we next ran analyses substituting conception risk with proximity to estimated ovulation within the fertile window. Because only naturally cycling women experience an LH surge, for these analyses we removed hormonal contraceptive use as a predictor, as shown in the equation below. We tested

whether the gamma coefficient associated with the two-way interaction between proximity to estimated ovulation and partner sexual attractiveness (γ12) was significant. A significant γ12 coefficient indicated that the influence of proximity to estimated ovulation on the outcome variable depended on levels of partner sexual attractiveness. If the two-way interaction between proximity to estimated ovulation and partner sexual attractiveness was significant, we graphed the slope of proximity to estimated ovulation in predicting the outcome variable at the mean of partner sexual attractiveness and at one and two standard deviations above and below the mean.

Equation 2:

Level-1 model (observations):

$$Yij = \delta 0j + \delta 1j(\text{Proximity to estimated ovulation}) + eij$$

Level-2 model (participants):

$$\delta 0j = \gamma 00 + \gamma 01(\text{Partner sexual attractiveness}) + u0j$$

$$\delta 1j = \gamma 10 + \gamma 11(\text{Partner sexual attractiveness}) + u1j$$

Full model:

$$Yij = \gamma 00 + \gamma 01(\text{Partner sexual attractiveness}) + \gamma 10(\text{Proximity to estimated ovulation}) + \gamma 11(\text{Partner sexual attractiveness}^* \text{ Proximity to estimated ovulation}) + u0j + u1j(\text{Proximity to estimated ovulation}) + eij$$

Results[17]

Extra-Pair Attraction

The three-way interaction between HC use, conception risk, and partner sexual attractiveness predicting women's extra-pair attraction was statistically significant ($p = .04$). Among naturally cycling women, the interaction between conception risk and partner sexual attractiveness was statistically significant and negative ($b = -3.54$, $p = .004$). As shown in Figure 1, the interaction was such that women whose ratings of partner sexual attractiveness were relatively low experienced an increase in extra-pair attraction as conception risk increased,

[17] Methods and results from additional analyses involving control variables and alternative partner attractiveness moderators for all outcome variables can be found in the Appendix.

whereas women whose ratings of partner sexual attractiveness were relatively high experienced a decrease in extra-pair attraction as conception risk increased. In contrast, among HC users, the interaction between conception risk and partner sexual attractiveness was not statistically significant (b = -0.6, p = .37).

Because the two-way interaction between conception risk and partner sexual attractiveness predicting extra-pair attraction was statistically significant among naturally cycling women, we next ran analyses substituting conception risk with proximity to estimated ovulation within the fertile window. The two-way interaction between estimated number of days to ovulation and partner sexual attractiveness predicting extra-pair attraction was statistically significant (b = 0.11, p = .04). As shown in Figure 2, as the estimated day of ovulation approached and fertility increased, women whose ratings of partner sexual attractiveness were relatively low experienced an increase in extra-pair attraction, whereas women whose ratings of partner sexual attractiveness were relatively high experienced a decrease in extra-pair attraction.

Extra-Pair Behavior

The three-way interaction between HC use, conception risk, and partner sexual attractiveness predicting women's extra-pair behavior was not statistically significant (p = .3). Among naturally cycling women, the interaction between conception risk and partner sexual attractiveness was not statistically significant (b = -1.08, p = .14). Among HC users, the interaction between conception risk and partner sexual attractiveness was also not statistically significant (b = -0.21, p = .61).

In-Pair Attraction

The three-way interaction between HC use, conception risk, and partner sexual attractiveness predicting women's in-pair attraction was not statistically significant (p = .2).

Among naturally cycling women, the interaction between conception risk and partner sexual attractiveness was marginally-statistically significant and positive (b = 2.46, p = .09). As shown in Figure 3, the interaction was such that women whose ratings of partner sexual attractiveness were relatively low experienced a decrease in in-pair attraction as conception risk increased, whereas women whose ratings of partner sexual attractiveness were relatively high experienced an increase in in-pair attraction as conception risk increased. However, as Figure 3 shows, unlike the pattern of results seen for women's extra-pair attraction, the slope of conception risk in predicting women's in-pair attraction was not significant when women's ratings of partner sexual attractiveness were one standard deviation either above or below the mean. Among HC users, the interaction between conception risk and partner sexual attractiveness was not statistically significant (b = 0.32, p = .7).

Because the two-way interaction between conception risk and partner sexual attractiveness predicting in-pair attraction was marginally significant among naturally cycling women, we next ran analyses substituting conception risk with proximity to estimated ovulation within the fertile window. The two-way interaction between estimated number of days to ovulation and partner sexual attractiveness predicting in-pair attraction was not statistically significant (b = -0.01, p = .82).

In-Pair Behavior

The three-way interaction between HC use, conception risk, and partner sexual attractiveness predicting women's in-pair sexual behavior was not statistically significant (p = .34). Among naturally cycling women, the interaction between conception risk and partner sexual attractiveness was not statistically significant (b = -0.01, p = .99). However, contrary to our predictions, among HC users, the interaction between conception risk and partner sexual

attractiveness was marginally statistically significant (b = 2.09, p = .05). As shown in Figure 4, this unpredicted interaction was such that women whose ratings of partner sexual attractiveness were relatively low experienced a decrease in in-pair behavior as the conception risk equivalent (i.e. the conception risk they would have had if they were naturally cycling) increased, whereas women whose ratings of partner sexual attractiveness were relatively high experienced an increase in in-pair behavior as the conception risk equivalent increased. However, as Figure 4 shows, unlike the pattern of results seen for women's extra-pair attraction, the slope of the conception risk equivalent in predicting women's in-pair behavior was not significant when women's ratings of partner sexual attractiveness were one standard deviation either above or below the mean.

Discussion

Consistent with the ovulatory shift hypothesis, we found evidence of moderated cycle shifts in women's extra-pair attractions among naturally cycling women but not among women using hormonal contraceptives. These findings for naturally cycling women directly replicate previous research. Moreover, the finding that these shifts were absent HC users provides further evidence that alternative explanations for cycle shifts (such as flexibility in analytic procedures that allow researchers to capitalize on chance) do a poor job of explaining the evidence. A number of pieces of evidence bolster our confidence in our findings. First, in analyses examining possible effects of proximity to ovulation, we found that the influence of partner sexual attractiveness on extra-pair attraction was heightened as fertility increased *even within the fertile window*. In addition, in follow-up analyses reported in the Appendix, we found that these results were robust to the inclusion of control variables, and that a similar pattern of effects was found when substituting women's ratings of their partner's sexual attractiveness for other measures

hypothesized to have indicated genetic quality ancestrally (e.g., body masculinity). Overall, although the methods of the study preclude causal conclusions about effects of hormonal states in HC users and non-users, the results are strongly consistent with the hypothesis that changes in reproductive hormones across the cycle are the cause of cycle shifts in attraction among naturally cycling women, and that hormonal contraceptives eliminate such shifts.

Results of analyses involving in-pair attraction were less clear, consistent with previous research documenting that these cycle shifts might not be as robust as shifts in extra-pair attraction (Larson et al., 2012). We found some evidence for moderated cycle shifts in women's feelings of in-pair attraction among naturally cycling women, such that women whose partners were less sexually attractive experienced a decrease in in-pair attraction at high relative to low fertility, whereas the reverse was true among women with more sexually attractive partners. However, this effect was not statistically significant, nor was it robust to the inclusion of control variables. Why cycle shifts in women's attraction toward their own partner are less robust than shifts in attraction toward men other than their partner is unclear, and is a question for future research.

Similarly, we did not find strong evidence of cycle shifts in either extra-pair or in-pair behaviors. We found statistically significant effects in some analyses involving simple effects and the alternative moderators, but these results were not consistent across analyses and did not appear robust. The fact that behavior is constrained in ways that attraction is not might account for these differences. In addition, we only assessed one in-pair behavior and one extra-pair behavior. Therefore, we might have found better evidence of cycle shifts if we had measured a greater range of behaviors women might have engaged in. In future research, measuring factors that might constrain women's behaviors such as women's motivations (e.g. attitudes regarding

fidelity) and opportunities (e.g. whether they spent time with attractive men) could lead to a better understanding of the conditions in which women's desires translate into their behaviors

Differences in shifts across the cycle between naturally cycling women and HC users provides further information on associations between hormonal contraceptive use and women's relationship dynamics. Shifts in extra-pair attraction among naturally cycling women but not HC users suggests that the two groups of women might differ primarily at high fertility. Because cycle shifts among naturally cycling women were moderated by partner sexual attractiveness, differences across the cycle between naturally cycling women and HC users might further depend on partner sexual attractiveness. For example, among naturally cycling women with average partners, feelings of extra-pair attraction did not change across the cycle (see Figure 1), suggesting that these women might not differ from HC users in extra-pair attraction. However, among naturally cycling women with below average partners, extra-pair attraction increased at high fertility. Therefore, these women might differ from HC users at high but not low fertility. This suggests that future research comparing naturally cycling women to HC users should not only account for cycle position, but also needs to account for partner sexual attractiveness.

This lack of cycle shifts in attraction among HC users also suggests that hormonal contraceptives might have positive or negative effects, depending on partner sexual attractiveness. Among women with less attractive partners, eliminating the mid-cycle boosts in extra-pair attraction might serve to protect the relationship from relationship. However, naturally cycling women with more attractive partners experienced a decrease in extra-pair attraction at high fertility, so eliminating this mid-cycle decrement in extra-pair attraction might have negative effects. However, as with all research in this area, results are correlational; therefore

they merely provide evidence *consistent with* these causal hypotheses rather than direct evidence for them.

In conclusion, we replicated past research documenting moderated cycle shifts in women's extra-pair attraction among naturally cycling women with less sexually attractive partners, but found no such shift among HC users. This nuanced pattern of results is consistent with the hypothesis that cycle shifts are the product of changes in reproductive hormones across the cycle, and that hormonal contraceptives eliminate cycle shifts by suppressing variations in reproductive hormones. These results suggest that differences in relationship dynamics between naturally cycling women and HC users might depend on women's position within the cycle and on characteristics of their partners.

Figure 1. Three-way Interaction between HC use, Conception Risk, and Partner Sexual Attractiveness Predicting Extra-Pair Attraction

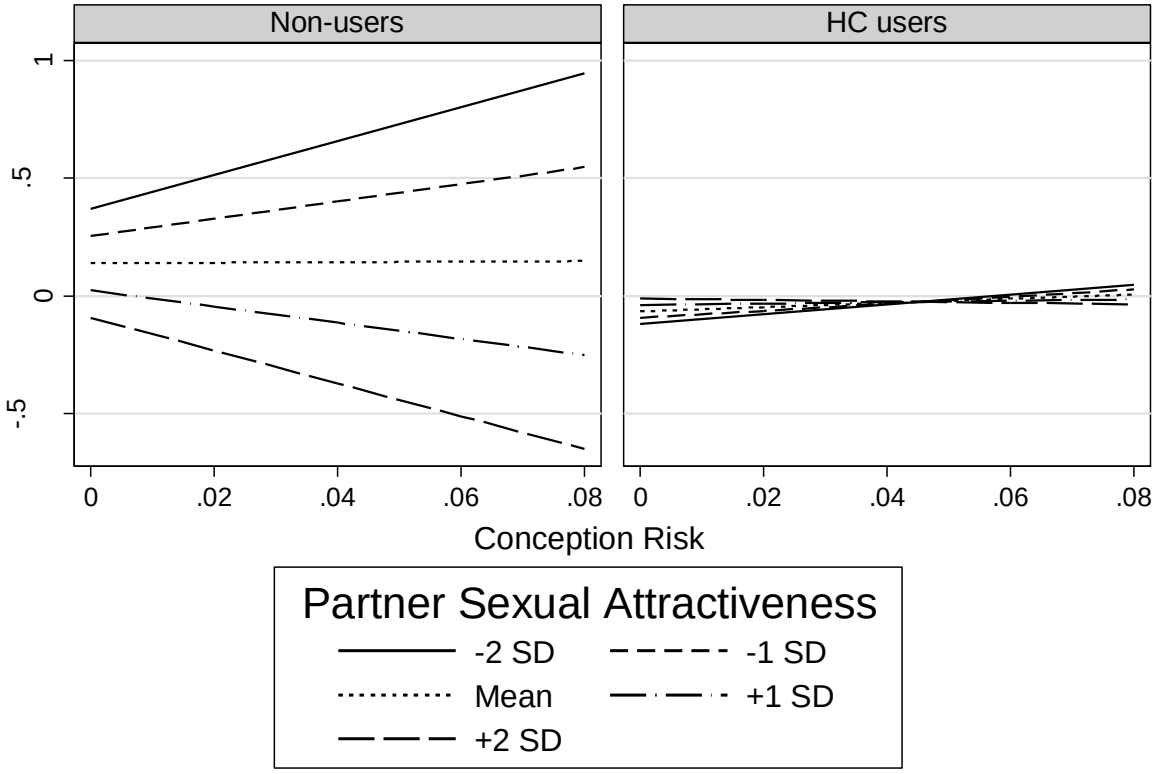

Figure 1. Three-way Interaction between HC use, Conception Risk, and Partner Sexual Attractiveness Predicting Extra-Pair Attraction. Linear relationship between conception risk and extra-pair attraction as a function of partner sexual attractiveness (at the mean and one and two standard deviations above and below the mean) among naturally cycling women (Non-users) and HC users (HC users). Among naturally cycling women, for women whose ratings of partner sexual attractiveness were below average (-1 SD), conception risk was a statistically significant positive predictor of extra-pair attraction (p = .02). For women whose ratings of partner sexual attractiveness were average (at the mean), conception risk was not a statistically significant predictor (p = .9). For women whose ratings of their partner were above average (+1 SD), conception risk was a statistically significant negative predictor (p = .03). In contrast, among HC users, conception risk was not a statistically significant predictor of extra-pair attraction for women whose ratings of their partner's sexual attractiveness were below average (-1 SD), average (at the mean), or above average (+1 SD).

Figure 2. Two-way Interaction between Estimated Days to Ovulation and Partner Sexual Attractiveness Predicting Extra-Pair Attraction.

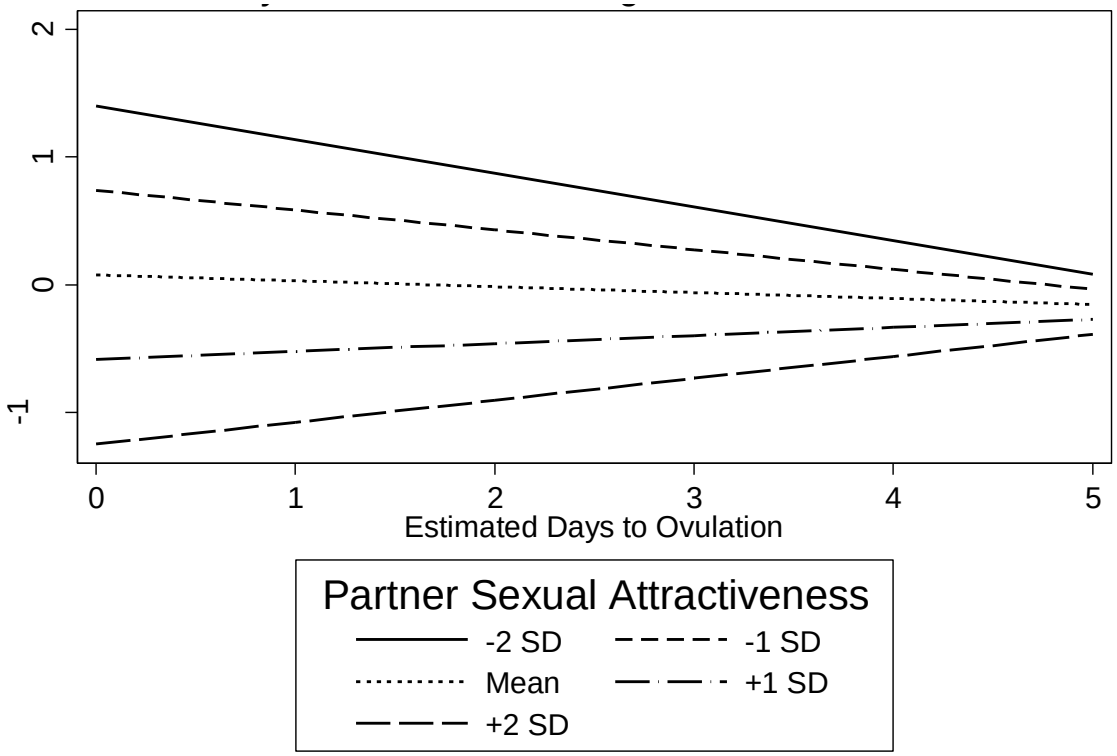

Figure 2. Two-way Interaction between Estimated Days to Ovulation and Partner Sexual Attractiveness Predicting Extra-Pair Attraction. Linear relationship between estimated days to ovulation (Day 0 represents peak fertility) and extra-pair attraction as a function of partner sexual attractiveness (at the mean and one and two standard deviations above and below the mean) among naturally cycling women. On the estimated day of ovulation, when fertility is highest, partner sexual attractiveness significantly predicted extra-pair attraction (p = .04). Five days before the estimated day of ovulation, when fertility within the fertile window is lowest, partner sexual attractiveness did not significantly predict extra-pair attraction (p = .7).

Figure 3. Three-way Interaction between HC use, Conception Risk, and Partner Sexual Attractiveness Predicting In-Pair Attraction

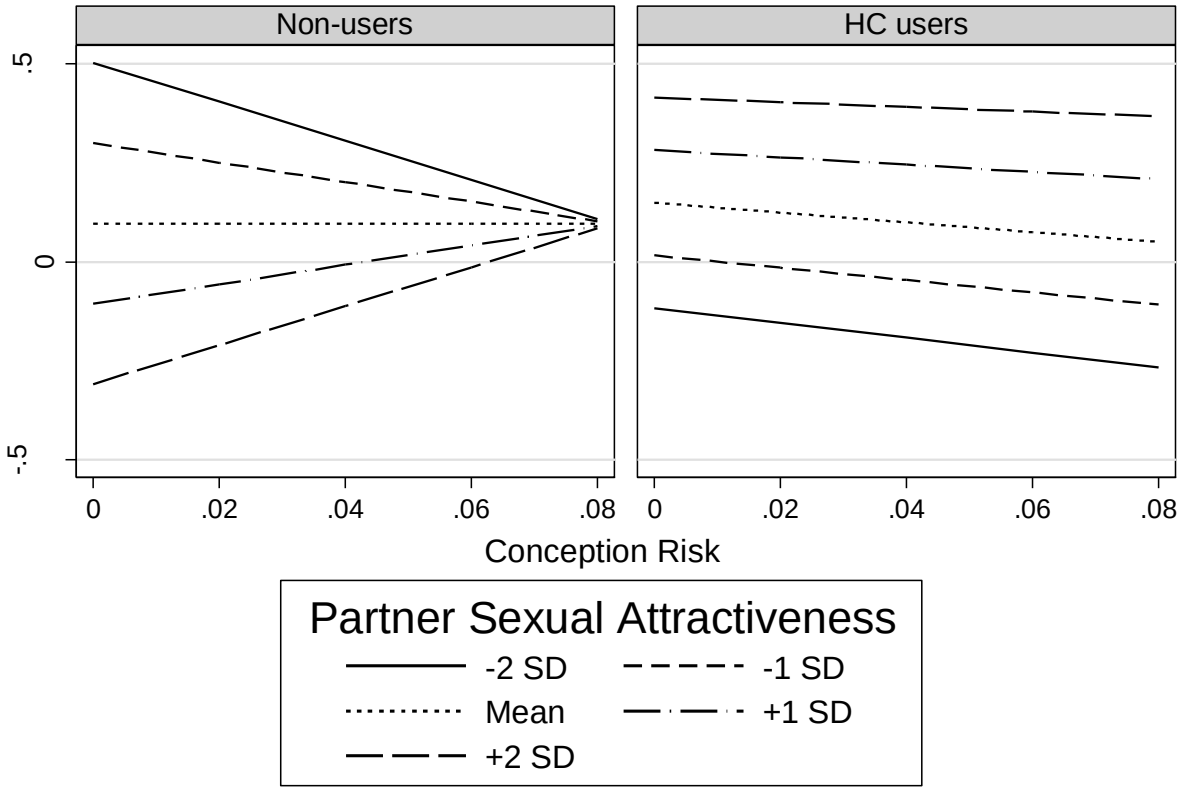

Figure 3. Three-way Interaction between HC use, Conception Risk, and Partner Sexual Attractiveness Predicting In-Pair Attraction. Linear relationship between conception risk and in-pair attraction as a function of partner sexual attractiveness (at the mean and one and two standard deviations above and below the mean) among naturally cycling women (Non-users) and HC users (HC users). Conception risk was not a statistically significant predictor of in-pair attraction for either naturally cycling women or HC users whose ratings of their partner's sexual attractiveness were below average (-1 SD), average (at the mean), or above average (+1 SD).

Figure 4. Three-way Interaction between HC use, Conception Risk, and Partner Sexual Attractiveness Predicting In-Pair Sexual Behavior

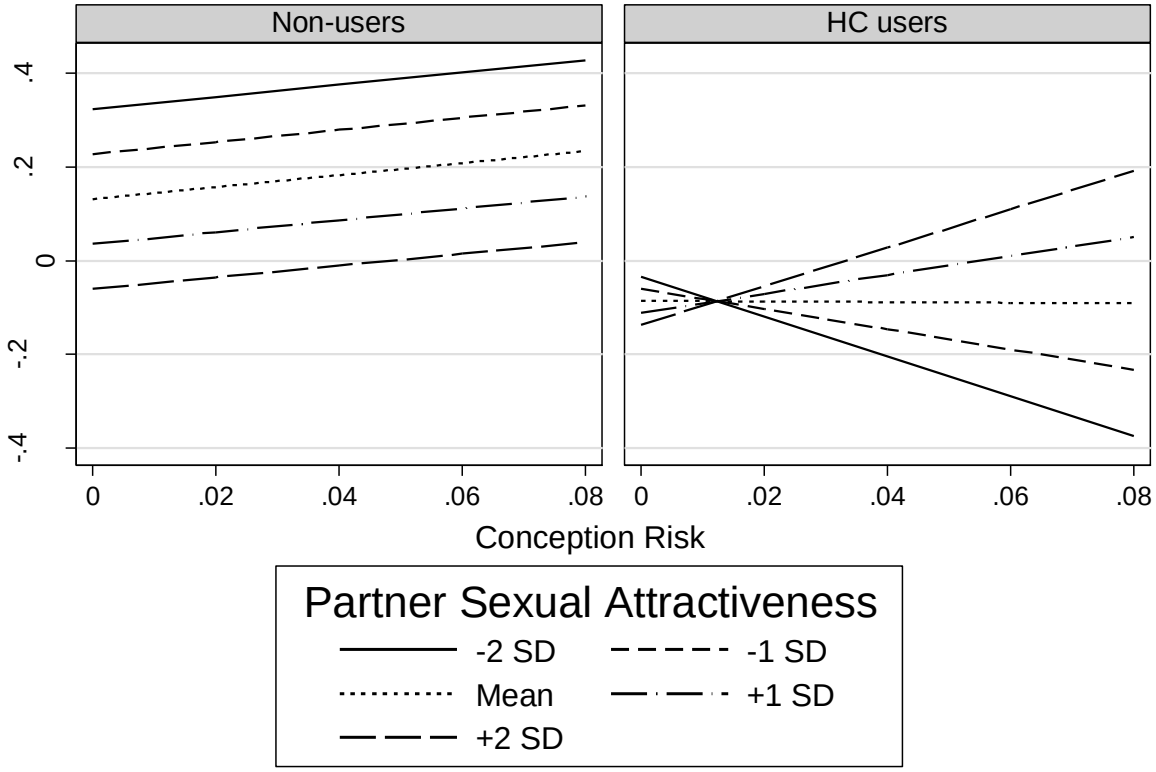

Figure 4. Three-way Interaction between HC use, Conception Risk, and Partner Sexual Attractiveness Predicting In-Pair Sexual Behavior. Linear relationship between conception risk and in-pair sexual behavior as a function of partner sexual attractiveness (at the mean and one and two standard deviations above and below the mean) among naturally cycling women (Non-users) and HC users (HC users). Conception risk was not a statistically significant predictor of in-pair behavior for either naturally cycling women or HC users whose ratings of their partner's sexual attractiveness were below average (-1 SD), average (at the mean), or above average (+1 SD).

Appendix: Additional Information on Methods and Additional Results from Chapter IV

In this Appendix we include further details on the procedures of the study, the measures and rational for control items or exclusionary items, the measures and rational for alternative partner attractiveness moderators, our coding procedures, and our criteria for including observations in the study. We also include the results of the follow-up analyses involving the control variables and the alternative moderators.

To rule out the possibility that the results reported in the body of the paper were not due to potential confounding variables that might differ between HC users or non-users (e.g. sexual history), variables that might vary day to day and influence women's attractions and behaviors (e.g. mood), or variables that might influence a woman's ability to experience attractions and behaviors (e.g. time spent with partner, day of the week), we included items in the initial questionnaire and the daily questionnaires assessing a variety of potential confounding variables, and ran follow-up analyses controlling for these variables.

To examine whether moderated cycle shifts were limited to women's ratings of partner sexual attractiveness or whether other items assessing characteristics historically associated with high genetic quality would also moderate cycle shifts, we ran exploratory analyses including two alternative moderators. Because many of the preferences for which there are robust cycle shifts in preferences are related to masculinity, especially in men's bodies (Gildersleeve et al., 2014), and women find masculine and muscular men sexually attractive (Frederick & Haselton, 2007), we included an item measuring women's perceptions of how masculine, muscular, and strong their partner was. To address the possibility that women's ratings of partner sexual attractiveness might reflect a reporting bias, we also ran analyses using women's partner's self-ratings of sexual attractiveness as a moderator. Although men's self reports might also be biased,

converging results between women's ratings and their partner's ratings provides further confidence in our conclusions.

Methods

Procedure

The initial questionnaire contained items used to assess women's ratings of their partner's muscularity and items regarding potential between-woman control variables, in addition to the items used to assess women's ratings of their partner's sexual attractiveness. Women's partners also come in (separately from their partner) for an initial session during which they completed a questionnaire containing the items used to assess men's ratings of their own sexual attractiveness. The daily questionnaires contained items regarding potential within-woman control variables, questions regarding whether women had gotten their period that day, whether they had taken an LH test that day and if so what the results were, and whether women had anything noteworthy to report about the day in addition to items assessing the outcome measures. At the debriefing session, we assessed women's compliance with the daily questionnaire instructions, women's guesses about the purpose of the study and the function of the LH tests, asked women if they had changed their hormonal contraceptive status during the study, used emergency hormonal contraception during the study (if naturally cycling), or skipped hormonal contraceptive pills (if a HC user). HC users provided their hormonal contraceptives and we recorded the brand, type of hormones used, dose of hormones, and what number of pills the woman had taken.

LH tests. Following previous research (e.g. Gangestad et al., 2002; Gildersleeve et al., 2012; Haselton, Mortezaie, Pillsworth, Bleske-Rechek, & Frederick, 2007; Larson et al., 2012; Larson et al., 2013; Lieberman, Pillsworth, & Haselton, 2011), we asked naturally cycling

women to complete five at-home mid-stream urine tests. These tests document the surge in LH that occurs 24–48 hours prior to ovulation (Fehring, Schneider, & Raviele, 2006) and have been shown to be 97% concordant with ovulation confirmed via ultrasound (Guermandi, Vegetti, Bianchi, Uglietti, Ragni, & Crosignani, 2001). These tests are commercially available and we removed any packaging that indicated the purpose of the tests prior to distributing them to our participants. At the initial in-lab session we interviewed naturally cycling women to obtain the information used to determine the dates on which they would complete their LH tests. At the initial session we also gave naturally cycling women their LH tests and instructions on completing them. Based on the dates of previous menstrual onset and average cycle length women reported during the initial session interview, we estimated the date of women's next menstrual onset. An LH surge is observed, on average, 14 days prior to next menstrual onset (Fehring et al., 2006), so we assigned women to complete one LH test per day starting 16 days prior to menstrual onset and ending 12 days prior to menstrual onset. We sent women reminder emails each morning they were asked to take an LH test. We recorded the results of the LH tests in three ways. First, we asked women to report the results of their LH tests on their daily questionnaire; second, we asked women to photograph their test results and send the photograph to the lab via email; and third, we asked women to save their tests in the baggies we provided and return them to the lab when they had completed all 5. Based on these results, two independent researchers coded whether there was evidence of an LH surge and the date of the LH surge.

Measures

Between woman control items. We assessed a number of items that might differ between HC users and naturally cycling women, and should therefore be controlled for in the

analyses. As Appendix Table 2 shows, only sexual behaviors with partners, relationship temperature items, and hormonal contraceptive use at relationship initiation statistically significantly differed between HC users and naturally cycling women. Sexual behaviors with partner was a five-item measure ($\alpha = 0.84$) assessing how sexually responsive women were with their partner. Women responded to the following two items on a scale from 1 (*never*) to 5 (*very often*) in response to instructions to report how often they engaged in the following behaviors within the past six months: "I want to have sex with my partner," "I try to please my partner sexually," "I refuse to have sex with my partner (reverse scored)," "With my partner, I am a willing and enthusiastic sexual partner," and "I am not sexually responsive to my partner (reverse scored)," (see also Garver-Apgar et al., 2006). Relationship temperature was the average of three items ($\alpha = 0.85$) asking women to rate the "temperature" of their sexual relationship with their partner, their mutual attraction with their partner, and the emotional intensity of their relationship on a scale from 0% ("*freezing*") to 100% ("*blazing*"). Women reported whether they were using hormonal contraceptives when their relationship with their partner began. Although responses differed significantly between current HC users and naturally cycling items, we could not run analyses including this item as a control variable because none of the naturally cycling women used hormonal contraceptives at relationship initiation. However, we did include women's sexual behaviors with their partner and the temperature items in the control analyses.

Other items assessed as potential control measures that did not differ significantly between naturally cycling women and HC users included relationship status, relationship length, cohabitation with partner, age, race/ethnicity, whether women had ever had sexual intercourse with their partner, women's long-term mating orientation, short-term mating orientation, and sexual history (assessed via the Multidimensional Sociosexual Orientation Inventory ; Jackson &

Kirkpatrick, 2007), and women's ratings of relationship satisfaction and commitment (assessed via the Rusbult Investment Model Scale; Rusbult, Martz, & Agnew, 1998). Although these items did not significantly differ between naturally cycling women and HC users, we included relationship length as a control variable and ran analyses excluding women who had never had sexual intercourse with their partner because these items might play an important role in women's attractions and behaviors.

Partner attractiveness alternative moderators. At the initial session, we assessed women's perceptions of how muscular, masculine, and strong their partner was compared to other men using a three item measure. Women responded to the following two items on a scale from 1 (*lowest 5%*) to 5 (*highest 5%*) in response to instructions to rate their partner as others would rate him, compared to other men his age: "Muscular" and "Masculine." Women responded to the following item on a scale from 1 to 99: "My partner is physically stronger than ____%." Scores for the three items were standardized and then averaged together ($\alpha = 0.78$). We assessed women's partner's perceptions of how sexually attractive women found them using a four item measure identical to the measure used to assess women's ratings of their partner except for changed pronouns. Men responded to the following two items on a scale from 1 (*much less*) to 7 (*much more*): "How attractive do women find your face, compared with most men?" and "How attractive do women find your body, compared with most men?" Men responded to the next two items on a scale from 1 (*lowest 5%*) to 5 (highest 5%) in response to instructions to rate their partner as others would rate him, compared with other men his age: "Qualities of a good short-term partner" and "Sexy." Scores for all items were standardized and then averaged together ($\alpha = 0.78$). The pairwise correlations between these measures and women's ratings of

their partner's sexual attractiveness are presented in Appendix Table 3. These correlations suggest that the three measures were tapping similar, but not identical, constructs.

Within-women control variables. Every daily questionnaire contained questions assessing how much time women had spent with their partner over the past 24 hours (excluding time they were asleep) and whether they had slept in the same bed as their partner. Women rated their mood in a 15-item questionnaire used in previous daily questionnaire studies (Cranford, Shrout, Iida, Rafeli, Yip, & Boldger, 2006). Women responded to the following items assessing on a scale from 1 (*not at all*) to 7 (*extremely*) in response to instructions to rate the extent to which they had felt or experienced the feelings or emotions over the past 24 hours. Anger was the average of the following three items: angry, resentful, and annoyed ($\alpha = 0.88$). Anxiety was the average of the following three items: anxious, on edge, and uneasy ($\alpha = 0.84$). Depressed was the following four items: sad, hopeless, discouraged, and blue ($\alpha = 0.88$). Fatigued was the following three items: fatigued, worn out, and exhausted ($\alpha = 0.9$). Vigorous was the following two items: cheerful and lively ($r = 0.71$, $p < .001$). Because all of these items might influence day to day variations in women's attractions and behaviors, we included them in our analyses as control variables.

Data Processing

Prior to analyzing the data, we coded for two additional control variables, we coded whether there was a reason to exclude a particular questionnaire, and we coded cycle information used to determine whether data points were eligible for inclusion in the analyses. To account for the fact that women's responses might change over the course of the study as a function of completing the questionnaire repeatedly, we coded how many questionnaires women had completed previous to the current questionnaire. Because past research found that whether a

questionnaire was completed on a weekday or a weekend was a significant predictor of women's sexual desire and activity (Roney & Simmons, 2013), we coded whether each questionnaire was completed on a weekday (Sunday through Thursday) or a weekend (Friday and Saturday).

Questionnaires that were completed before noon were coded as being completed the previous day (unless a questionnaire had already been completed that day). If questionnaires were completed twice in one day and the previous day's questionnaire was missing, the first questionnaire was coded as being completed the previous day (10 observations). If the previous day's questionnaire was not missing, the second questionnaire was categorized as a repeat and excluded from analyses (3 observations). In their daily questionnaires, women could report whether anything noteworthy had occurred. Two women reported that they had broken up with their partner. For both of these women, we excluded from the analyses all questionnaires completed after the date the relationship ended (19 observations from each woman). At the debriefing interview, women reported whether they had changed their use of hormonal contraceptives or whether they had taken emergency hormonal contraception during the study. One woman reported that she had stopped using hormonal contraception during the study, therefore we excluded from analyses all questionnaires completed after the date she stopped using hormonal contraception (11 observations). Two women reported that they had used emergency hormonal contraception while participating in the study. One woman remembered the date she had done so and all questionnaires completed after this date were excluded from the analyses (11 observations). The other woman could not remember the date but thought it was near the beginning of the study, so all her questionnaires were excluded from the analyses (25 observations).

For naturally cycling women, in addition to coding their forward cycle day, we also coded their reverse cycle day for each questionnaire (RCD; the number of days from subsequent menstrual onset) using women's reports of menstrual onset while completing the daily questionnaires and their report of next menstrual onset after completion of the study. Three naturally cycling women failed to report the date of next menstrual onset after completion of the study, so for these women we estimated this date based on their average cycle length and the date of their previous menstrual onset. Based on these numbers and the RCD of women's LH surge if a surge was observed, we coded whether each questionnaire was completed on a day we had high quality cycle data from and was therefore eligible for inclusion in the analyses. We set very conservative criteria and classified high quality cycle data as days in a cycle that was between 25 and 32 days long (based on the average cycle length and the standard deviation among reproductive aged women reported in studies reviewed by Fehring and colleagues (2006), encompassing data from hundreds of women and thousands of menstrual cycles), and in a cycle in which women either experienced an LH surge between RCD 12 and 16 (the average and standard deviation of date of LH surge in previous research reviewed in Fehring et al., 2006), or she did not experience an LH surge but did not take all LH tests within the days a surge would be expected to occur. This resulted in the exclusion of 743 observations from 33 women.

For HC users, in addition to coding their FCD, we also coded their RCD using their reports of menstrual onset while completing the daily questionnaires. Because we failed to ask HC users to report the date of next menstrual onset after completion of the study, this date was estimated using the methods described for naturally cycling women. In the initial questionnaire, HC users reported which brand of hormonal contraceptives they were using and when they had started using their current package of pills (or how long ago they had inserted a new Nuva ring).

At the debriefing session, women brought in the packaging for their hormonal contraception and we confirmed the brand women used, the type and dose of hormones they contained, the number of active vs. inactive pills they contained, and when they had started using their current package of pills. Based on this information, we coded which pill women were on each day they completed a questionnaire, and whether they had taken all their pills or whether they skipped their placebo pills (which 5 women did). Because skipping the placebo pills extends the menstrual cycle, the FCD and RCD of women using HCs without taking the placebo (or of women who take formulations that do not contain placebo pills each month) no longer correspond to the FCD and the RCD of naturally cycling women. Therefore, to be conservative, we excluded questionnaires taken on cycles in which women missed their placebo pills. This resulted in the exclusion of 134 data points from 5 women. One HC user did not get her period despite taking her placebo pills, so because her FCD and RCD did not correspond to those of other HC users, to be conservative we dropped the questionnaires from this cycle from all analyses (12 observations). Two women did not provide enough information in either the initial session or the debriefing session to determine whether they had taken their placebo pills or where in the cycle they were, so all questionnaires from these women were excluded from analyses (46 observations total). In total, we excluded 183 observations from 8 women.

Data Analyses

Prior to running analyses, we standardized all continuous control variables, women's ratings of their partner's masculinity, and men's ratings of their own sexual attractiveness. We ran separate analyses for each control variable. Between-woman control variables were added at Level 2 (see Equation 3) below, whereas within-woman control variables were added at Level 1 (see Equation 4 below). We did not estimate interactions involving the control variables. In all

analyses involving the control variables, we again tested whether the gamma coefficient associated with the three-way interaction between hormonal contraceptive use, conception risk, and partner sexual attractiveness (γ13) the simple effects tests of the interaction between conception risk and partner sexual attractiveness for naturally cycling women and HC users (γ12) changed with the inclusion of control variables. For analyses involving the alternative partner attractiveness moderators, we re-ran analyses substituting women's ratings of partner sexual attractiveness in Equation 1 found in the body of the paper with women's ratings of partner muscularity and male partner ratings of their own sexual attractiveness.

Equation 3:

Level-1 model (observations):

$$Yij = \delta 0j + \delta 1j(\text{Conception risk}) + eij$$

Level-2 model (participants):

$$\delta 0j = \gamma 00 + \gamma 01(\text{HC use}) + \gamma 02(\text{Partner sexual attractiveness}) + \gamma 03(\text{HC use*Partner sexual attractiveness}) + \gamma 04\ (\text{Between-woman control}) + u0j$$

$$\delta 1j = \gamma 10 + \gamma 11(\text{HC use}) + \gamma 12(\text{Partner sexual attractiveness}) + \gamma 13(\text{HC use*Partner sexual attractiveness}) + u1j$$

Full model:

$$Yij = \gamma 00 + \gamma 01(\text{HC use}) + \gamma 02(\text{Partner sexual attractiveness}) + \gamma 03(\text{HC use*Partner sexual attractiveness}) + \gamma 04\ (\text{Between-woman control}) + \gamma 10(\text{Conception risk}) + \gamma 11(\text{HC use* Conception risk}) + \gamma 12(\text{Partner sexual attractiveness* Conception risk}) + \gamma 13(\text{HC use*Partner sexual attractiveness * Conception risk}) + u0j + u1j(\text{Conception risk}) + eij$$

Equation 4:

Level-1 model (observations):

$$Yij = \delta 0j + \delta 1j(\text{Conception risk}) + \delta 2j(\text{Within-woman control}) + eij$$

Level-2 model (participants):

$$\delta 0j = \gamma 00 + \gamma 01(\text{HC use}) + \gamma 02(\text{Partner sexual attractiveness}) + \gamma 03(\text{HC use*Partner sexual attractiveness}) + u0j$$

$$\delta 1j = \gamma 10 + \gamma 11(\text{HC use}) + \gamma 12(\text{Partner sexual attractiveness}) + \gamma 13(\text{HC use*Partner sexual attractiveness}) + u1j$$

$$\delta 2j = \gamma 20 + u2j$$

Full model:

$$Yij = \gamma 00 + \gamma 01(\text{HC use}) + \gamma 02(\text{Partner sexual attractiveness}) + \gamma 03(\text{HC use*Partner sexual attractiveness}) + \gamma 10(\text{Conception risk}) + \gamma 11(\text{HC use*Conception risk}) + \gamma 12(\text{Partner sexual attractiveness*Conception risk}) + \gamma 13(\text{HC use*Partner sexual attractiveness*Conception risk}) + \gamma 20(\text{Within-woman control}) + u0j + u1j(\text{Conception risk}) + u2j(\text{Within-woman control}) + eij$$

Results

Extra-Pair Attraction

After adding the control variables, the three-way interaction between HC use, conception risk, and partner sexual attractiveness predicting women's extra-pair attraction remained statistically significant in all analyses. In addition, the simple effects two-way interaction between conception risk and partner sexual attractiveness among naturally cycling women remained statistically significant in all analyses, and the simple effects two-way interaction between conception risk and partner sexual attractiveness among HC users remained non-statistically significant in all analyses,.

The three way interaction between HC use, conception risk, and women's ratings of partner muscularity was not statistically significant (p = .25). However, among naturally cycling women, the interaction between conception risk and women's ratings of partner muscularity was statistically significant and negative (b = -2.34, p = .04). Mirroring the pattern observed for women's ratings of sexual attractiveness, the interaction was such that women whose ratings of partner muscularity were relatively low experienced an increase in extra-pair attraction as conception risk increased, whereas women whose ratings of partner muscularity were relatively high experienced a decrease in extra-pair attraction as conception risk increased. In contrast, among HC users, the interaction between conception risk and women's ratings of partner muscularity was not statistically significant (b = -0.82, p = .19).

The three way interaction between HC use, conception risk, and male partner ratings of their own sexual attractiveness predicting women's extra-pair attraction was statistically

significant (p = .007). Among naturally cycling women, the interaction between conception risk and men's ratings of their own sexual attractiveness was again statistically significant and negative (b = -5.16, p = .001), and among HC users, the interaction between conception risk and partner sexual attractiveness was again not statistically significant (b = -0.57, p = .4).

Extra-Pair Behavior

After adding the control variables, the three-way interaction between HC use, conception risk, and partner sexual attractiveness predicting women's extra-pair behavior remained non-significant in all analyses.

The three way interaction between HC use, conception risk, and women's ratings of partner muscularity predicting women's extra-pair behavior was not statistically significant (p = .98). Among naturally cycling women, the interaction between conception risk and women's ratings of partner muscularity was not statistically significant (b = -0.92, p = .18). However, contrary to our predictions, among HC users the interaction between conception risk and women's ratings of partner muscularity was statistically significant and negative (b = -0.94, p = .01). This unpredicted interaction was such that women whose ratings of partner muscularity were relatively low experienced an increase in extra-pair behavior as the conception risk equivalent (i.e. the conception risk they would have had if they were naturally cycling) increased, whereas women whose ratings of partner muscularity were relatively high experienced a decrease in extra-pair behavior as the conception risk equivalent increased.

The three way interaction between HC use, conception risk, and male partner ratings of their own sexual attractiveness predicting women's extra-pair behavior was not statistically significant (p = .1). However, among naturally cycling women, the interaction between conception risk and men's ratings of self sexual attractiveness was statistically significant, and

negative (b = -1.9, p = .04). Like the pattern of results observed for extra-pair attraction, the interaction was such that women whose partner's ratings of his own sexual attractiveness were relatively low experienced an increase in extra-pair behavior as conception risk increased, whereas women whose partner's ratings of his own sexual attractiveness were relatively high experienced a decrease in extra-pair behavior as conception risk increased. In contrast, among HC users, the interaction between conception risk and partner sexual attractiveness was not statistically significant (b = -0.22, p = .59).

In-Pair Attraction

After adding the control variables, the three-way interaction between HC use, conception risk, and partner sexual attractiveness predicting women's in-pair attraction remained non-significant in all analyses. The simple effects two-way interaction between conception risk and partner sexual attractiveness among naturally cycling women remained marginally statistically significant in some analyses, but was non-significant when controlling for survey number, relationship length, vigor, depression, anxiety, anger, and when excluding women who had not had sexual intercourse with their partner. The simple effects two-way interaction between conception risk and partner sexual attractiveness among HC users remained non-statistically significant in all analyses.

The three way interaction between HC use, conception risk, and women's ratings of partner muscularity predicting women's in-pair attraction was marginally statistically significant (p = .06). Among naturally cycling women, the interaction between conception risk and women's ratings of partner's muscularity was positive and statistically significant (b = 3.18, p = .02). Mirroring the pattern of results seen for women's ratings of partner sexual attractiveness, the interaction was such that women whose ratings of partner muscularity were relatively low

experienced a decrease in in-pair attraction as conception risk increased, whereas women whose ratings of partner muscularity were relatively high experienced an increase in in-pair attraction as conception risk increased. In contrast, among HC users, the interaction between conception risk and women's ratings of partner muscularity was not statistically significant (b = 0.2, p = .78).

The three way interaction between HC use, conception risk, and male partner ratings of their own sexual attractiveness predicting women's in-pair attraction was marginally statistically significant (p = .07). Among naturally cycling women, the interaction between conception risk and men's ratings of self sexual attractiveness was again positive but not statistically significant (b = 2.76, p = .14). Among HC users, the interaction between conception risk and partner sexual attractiveness was negative but also not statistically significant (b = -0.97, p = .24).

In-Pair Behavior

After adding the control variables, the three -way interaction between HC use, conception risk, and partner sexual attractiveness predicting women's in-pair sexual behavior remained non-significant in all analyses. The simple effects two-way interaction between conception risk and partner sexual attractiveness among naturally cycling women remained non-significant in all analyses. The simple effects two-way interaction between conception risk and partner sexual attractiveness among HC users remained marginally statistically significant in some analyses, but was non-significant when controlling for whether women had slept in the same bed as their partner, and the interaction became statistically significant when controlling for vigor and survey number.

The three way interaction between HC use, conception risk, and women's ratings of partner muscularity predicting women's in-pair sexual behavior was not statistically significant (p = .87). Among naturally cycling women, the interaction between conception risk and women's

ratings of partner muscularity was not statistically significant (b = 1.22, p = .5). Among HC users, the interaction between conception risk and women's ratings of partner muscularity was also not statistically significant (b = 1.56, p = .11).

The three way interaction between HC use, conception risk, and male partner ratings of their own sexual attractiveness predicting women's in-pair sexual behavior was not statistically significant (p = .27). Among naturally cycling women, the interaction between conception risk and men's ratings of self sexual attractiveness was not statistically significant (b = 2.62, p = .28). Among HC users, the interaction between conception risk and partner sexual attractiveness was also not statistically significant (b = -0.3, p = .77).

Appendix Table 2a

Descriptive Statistics: Categorical Variables

		Frequency (Valid %)			Between-group differences ($\chi 2$ test)	Frequency (Valid %)	Between-group differences ($\chi 2$ test)	Frequency (Valid %)
Variable	Category	Sample included in analyses	Non-users	HC users	Non-users vs HC users	Sample excluded	Included vs excluded	Total sample
HC Use	Non-user	24 (42.86%)			-	18 (78.26%)	p = .004	42 (53.16%)
	HC user	32 (57.14%)				5 (21.74%)		37 (46.84%)
Relationship status	Casually dating	0 (0%)	0 (0%)	0 (0%)	p = .48	2 (8.7%)	p = .01	2 (2.53%)
	Exclusively dating	52 (92.86%)	22 (91.67%)	30 (93.75%)		15 (65.22%)		67 (84.81%)
	Engaged	1 (1.79%)	0 (0%)	1 (3.13%)		1 (4.35%)		2 (2.53%)
	Married	3 (5.36%)	2 (8.33%)	1 (3.13%)		5 (21.74%)		8 (10.13%)
Living with partner	Yes	14 (25%)	7 (29.17%)	7 (21.88%)	p = .53	11 (50%)	p = .03	25 (32.05%)
	No	42 (75%)	17 (70.83%)	25 (78.13%		11 (50%)		53 (67.95%)
Female race/ethnicity	African American	1 (1.79%)	1 (4.17%)	0 (0%)	p = .38	0 (0%)	p = .72	1 (1.27%)
	Asian	20 (35.71%)	10 (41.67%)	10 (31.25%)		11 (47.83%)		31 (39.24%)
	Caucasian	18 (32.14%)	5 (20.83%)	13 (40.63%)		4 (17.39%)		22 (27.85%)
	Hispanic	7 (12.5%)	3 (12.5%)	4 (12.5%)		4 (17.39%)		11 (13.92%)
	Middle Eastern	4 (7.14%)	3 (12.5%)	1 (3.13%)		1 (4.35%)		5 (6.33%)
	Multi-ethnic	6 (10.71%)	2 (8.33%)	4 (12.5%)		3 (13.04%)		9 (11.39%)
Male race/ethnicity	African American	2 (3.57%)	2 (8.33%)	0 (0%)	p = .27	0 (0%)	p = .7	2 (2.56%)
	Asian	16 (28.57%)	8 (33.33%)	8 (25%)		7 (31.82%)		23 (29.49%)
	Caucasian	21 (37.5%)	6 (25%)	15 (46.88%)		9 (40.91%)		30 (38.46%)
	Hispanic	8 (14.29%)	3 (12.5%)	5 (15.63%)		3 (13.64%)		11 (14.1%)
	Middle Eastern	2 (3.57%)	2 (8.33%)	0 (0%)		2 (9.09%)		4 (5.13%)
	Other ethnicity	2 (3.57%)	1 (4.17%)	1 (3.13%)		1 (4.55%)		3 (3.85)
	Multi-ethnic	5 (8.93%)	2 (8.33%)	3 (9.38%)		0 (0%)		5 (6.41%)
Sexually experienced	Sexually experienced	52 (92.86%)	21 (87.5%)	31 (96.88%)	p = .18	23 (100%)	p = .19	75 (94.94%)
	Not experienced	4 (7.14%)	3 (12.5%)	1 (3.13%)		0 (0%)		4 (5.06%)
HC use at relationship initiation	Non-user	43 (76.79%)	24 (100%)	19 (59.38%)	p < .001	16 (69.57%)	p = .27	19 (24.05%)
	HC user	13 (23.21%)	0 (0%)	13 (40.63%)		6 (26.09%)		19 (24.05%)
	Can't remember	0 (0%)	0 (0%)	0 (0%)		1 (4.35%)		1 (1.27%)
HC congruency	Same- continuous non-user	24 (42.86%)	N/A	13 (40.63%)	-	14 (64.64%)	p = .001	38 (48.72%)
	Same-continuous HC user	13 (23.21%)	24 (100%)	N/A		2 (9.09)		15 (19.23%)
	Different- began using	19 (33.93%)	0 (0%)	19 (59.38%)		2 (9.09)		21 (26.92%)
	Different- stopped using	0 (0%)	N/A	N/A		4 (18.18%)		4 (5.13%)

Appendix Table 2b

Descriptive Statistics: Continuous Variables

Variable	Mean			Between-group differences (*t*-tests)	Mean	Between-group differences (*t*-tests)	Mean
	Sample included in analyses	Non-users	HC users	Non-users vs HC users	Sample excluded	Included vs excluded	Total sample
Female age[1]	21.71	22.1	21.43	$p = .63$	23.39	$p = .22$	22.17
Male age[2]	20.62	20.17	20.92	$p = .28$	23.64	$p = .003$	21.34
Relationship length	24.48	29.42	23.14	$p = .45$	31.35	$p = .31$	26.48
Sexual behaviors with partner	5.31	5.09	5.48	$p = .01$	5.26	$p = .71$	5.3
Age at first intercourse	17.79	18.14	17.55	$p = .4$	17.74	$p = .93$	17.77
Number of lifetime sexual partners	3.96	2.86	4.71	$p = .21$	3.96	$p = .99$	3.96
Short-term mating orientation	2.89	2.86	2.91	$p = .14$	2.4	$p = .1$	2.74
Long-term mating orientation	6.64	6.56	6.71	$p = .26$	6.56	$p = .47$	6.62
Temperature of sexual relationship	80.18	83.12	76.25	$p = .07$	78.26	$p = .61$	79.62
Temperature of mutual attraction	84.28	88.12	79.17	$p = .01$	84.35	$p = .99$	84.3
Temperature of emotional intensity	86.78	83.75	89.06	$p = .15$	88.26	$p = .67$	87.22
Mean of temperature items	83.76	79.72	86.77	$p = .03$	83.62	$p = .98$	83.71
Relationship satisfaction	5.92	5.72	6.08	$p = .25$	6.05	$p = .64$	5.96
Relationship commitment	6.07	6.08	6.07	$p = .98$	6.35	$p = .22$	6.15
Ratings of partner sexual attractiveness (z-scored)	0.03	-0.04	0.09	$p = .5$	-0.08	$p = .53$	0
Ratings of partner's muscularity (z-scored)	0	-0.04	0.06	$p = .7$	0	$p = .98$	0
Male partner ratings of own sexual attractiveness (z-scored)	-0.04	-0.19	0.06	$p = .2$	0.12	$p = .41$	0

Footnotes 1. Eight women did not respond to this question. 2. Eleven men did not respond to this question.

Appendix Table 3

Correlations Between Partner Ratings Moderators

Full sample			
Variable	**1**	**2**	**3**
1) Women's ratings of partner sexual attractiveness	1.0	0.49***	0.21
2) Women's ratings of partner muscularity		1.0	0.4**
3) Male partner's ratings of own sexual attractiveness			1.0
Naturally cycling women			
Variable	**1**	**2**	**3**
1) Women's ratings of partner sexual attractiveness	1.0	0.56***	0.12
2) Women's ratings of partner muscularity		1.0	0.3
3) Male partner's ratings of own sexual attractiveness			1.0
HC users			
Variable	**1**	**2**	**3**
1) Women's ratings of partner sexual attractiveness	1.0	0.41*	0.35†
2) Women's ratings of partner muscularity		1.0	0.64***
3) Male partner's ratings of own sexual attractiveness			1.0

Note: †$p < .1$, *$p < .05$, **$p < .01$, ***$p < .001$

Appendix Table 3. Correlations Between Partner Ratings Moderators. Bivariate correlations (Pearson's *r*) between partner rating moderators among the full sample of participants, and separately among naturally cycling women and HC users.

CHAPTER V:

Summary and Conclusions

Summary and Conclusions

In the three body chapters of my dissertation, I reviewed and synthesized past research examining associations between hormonal contraceptive use and variables related to women's mate choice and relationship functioning, I provided the first test of whether hormonal contraceptive use at relationship initiation is associated with MHC similarity among couples, and I examined whether cycle shifts in attraction observed among naturally cycling women were absent among HC users.

In Chapter II, my review documented that some of the claims that had been made about effects of hormonal contraceptives (e.g. that they will cause weaker preferences for masculinity) were unsubstantiated by the data, although there was robust evidence that hormonal contraceptive users do not experience the cycle shifts in mate preferences and attractiveness seen among naturally cycling women. I noted that there was evidence that hormonal contraceptive users and non-users might differ along potentially confounding variables, and that this possibility has not been fully addressed in many studies. I furthermore argued that because none of the studies used experimental methods, researchers should be careful not to suggest that there is evidence for a causal influence of hormonal contraceptive use on women's mate choices and relationship functioning. I ended with suggestions of how future research could improve upon what has already been done.

In Chapter III, I addressed one of the primary concerns about hormonal contraceptive use – that it will cause women to choose MHC similar (and thus genetically incompatible) partners. I found that contrary to predictions, women who were using hormonal contraceptives when they met their partner were not more MHC similar to their partners than were women who were not using hormonal contraceptives when they met their partner. If anything, the pattern trended in the

opposite direction. Although our failure to support the hypothesis that hormonal contraceptive users will choose MHC similar partners does not prove this hypothesis to be false, it does suggest that researchers should refrain from suggesting the hypothesis is true until it has received empirical support.

In Chapter IV, I found that cycle shifts in extra-pair attraction contingent on partner sexual attractiveness were present among naturally cycling women and absent among HC users. These results provide further evidence consistent with the hypothesis that cycle shifts among naturally cycling women are the result of changes in reproductive hormones across the cycle, and the hypothesis that by suppressing variation in women's endogenous reproductive hormones, hormonal contraceptives will eliminate cycle shifts in women's attractions, preferences, and desires. In addition, these results suggest that relationships dynamics might differ between naturally cycling women and HC users, depending on cycle phase and partner sexual attractiveness.

In conclusion, although there are some differences between hormonal contraceptive users and non-users, these differences appear limited in scope, and the conclusions the literature can support are not nearly as strong as the conclusions some scholars have made regarding the detrimental effects of hormonal contraceptive use, such as the claims presented in the introduction.

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