HORMONAL MEDICATIONS AND PARTNER ODOR PREFERENCES

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Abstract

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The ability to recognize kin through the olfactory sense has important survival and evolutionary implications when choosing mates. Failing to recognize kin when making a choice of whom to mate with can lead to an increase in detrimental genetic outcomes in offspring. Previous studies have indicated that normally ovulating heterosexual women and men prefer the body odor of those with dissimilar immune systems than those with similar immune systems. The use of hormonal contraceptives has shown a preference for similar immune system odors. The current study examines whether the use of hormonal medications predicts preference for body odor. Importantly, this research consists to a diverse population, that goes beyond the heteronormative parameters of previous work and addition of hormonal medications other than just the combined oral contraceptive pill. Originally, this study was designed to take biological samples, but the COVID-19 pandemic forced a change to an online survey. In a sample of 282 participants, male, female and non-binary, there were no differential effects of hormonal medication use between sexes. These results suggest that any effect of hormonal medications would not depend on the sex of the person.

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Introduction

Our perception of body odor plays an important role in our choice of mates and maintaining relationships (Mahmut & Croy, 2019; VanHatten, Cunningham & White, 2019; Roberts, et al., 2014). Olfactory cues provide information about an individual's genetic compatibility, physical health, lifestyle, and may even communicate aspects of personality to some degree (Porter 1998; Porter & Schaal 2003; Pandey & Kim, 2011; Pause 2012; Roberts & Havlíček, 2012; Hold & Schleidt, 1977). Some studies have shown that the use of hormonal contraceptives may disrupt these odor preferences, at least among heterosexual women (Allen, Havlíček, Wiliams & Roberts, 2019; Milinski & Wedekind, 2001; Sorokowska, et al., 2018). The original aim of this thesis was to explore the hormonal mechanisms of these possible disruptions in a broader sample using actual odor samples, unfortunately, the COVID-19 pandemic rendered this type of longitudinal, in-person project requiring biological samples untenable. Therefore, the importance of odor cues and general partner odor preferences are explored here in a broader sample (i.e., all hormonal medication use and a sample more representative of the diversity of society) using survey-based measures.

Chemical Communication

Individuals use odorants and other substances to transmit information between one another through chemical communication. Non-human animals have shown specialized behavior for depositing scents produced by specialized glands. These chemical signals can inform other organisms of a species identity, subspecies and individuals, territorial boundaries, dominance status and fear. For example, the harvester ant, *Pogonomyrmex badius*, communicates alarm through odor, the fire ant, *Solenopsis saevissima*, leaves a trail of odor to recruit others of its species, and the gypsy moth, *Porthetria dispar*, uses odor as a sex attractant (Bossert & Wilson, 1963).

Although chemical communication has been widely studied in insects, this form of communication is of vital importance among mammals as well. Recently fossil mammalian skulls, analyzed using high resolution X-ray computed tomography, showed that the brain evolved special features that improved ability to analyze the complex olfactory environment (Pandey & Kim, 2011; Rowe, et. al., 2011). Because humans have fewer olfactory receptor cells and functional olfactory receptor genes compared to other mammals (Schaal & Porter, 1991; Young, 2002), the role of olfactory signaling in human behavior is often overlooked, particularly in comparison to studies of visual abilities. However, humans too emit volatile and non-volatile molecules in a complex array known as body odor – which is influenced by immune status (e.g., Moshkin et al., 2012; Olsson et al., 2014), diet (e.g., Fialova et al., 2013; Havlíček & Lenochova, 2006), stress (Dalton et al., 2013) and genetic information (e.g., Havlíček & Roberts, 2009). This body odor likely serves an analogous signaling function to odor cues in other animals (Comfort, 1971) and is important for both within-sex and between-sex chemosingnaling (Lübke & Pause, 2015). Indeed, the billion-dollar perfume industry highlights the important role olfactory cues play in our social lives (Lübke & Pause, 2015).

Studies on chemosensory communication in humans generally focus on four areas demonstrating behavioral and/or physiological consequences of perception by the receiver: emotional cognition, menstrual cycle synchronicity, kin recognition, and mate selection (Pause, 2012). The detection of emotional contagion and danger is the most recently detected area of human chemosensory signaling. Such stress-related signals show an association with immediate withdrawal behavior and avoidance of the source of the odor. The automatic priming of motor systems from signal avoidance through the perception of stress related chemical signals is received from conspecifics (Pause, 2012). While the evolutionary significance of and evidence for menstrual cycles synchronizing is still debated (McClintok, 1971; Wilson, Kiefhaber & Gravel, 1991; Yang & Schank, 2006; Ziomkiewicz, 2006), studies have shown that endocrine status can be influenced by chemical signals from conspecifics. Exposure to the sweat of females collected during the follicular phase shortens the menstrual cycle of other females, whereas exposure to sweat samples from females in the ovulatory phase lengthens the cycle (Jacob et. al., 2002; Schank, 2001). Kin recognition is an important social skill and family members have been shown to favor pro-social behavior to promote inclusive fitness (Hamilton, 1964). Kin recognition’s importance has led to numerous studies that have shown that siblings can recognize other siblings by smell, newborns can identify their mothers chemosensorily, parents can identify their children the same way, and even unrelated people can match family members by smell (Porter 1998; Porter and Schaal 2003).

Most critically for the current work, chemosensory signals also play a critical role in sexual communication among most living organisms (reviewed in Johansson & Jones, 2007; Lubke and Pause, 2015) and appear to influence perceptions of attractiveness and facilitate mate choice and partner formation in humans (Lubke and Pause, 2015).

Body Odor & Mate Preferences

Olfaction plays a key role in mate choice among many species (Johansson & Jones, 2007). Several studies in the mate-preferences literature have focused on the importance of body odor cues in human mating (e.g., Herz & Cahill, 1997; Lobmaier et al., 2018; Sergeant et al., 2005) and early research demonstrated that body odor is a critical aspect of overall physical attractiveness (Foster, 2008; Franzoi & Herzog, 1987; Roberts et al., 2011; Sergeant et al., 2005). For example, using the Romantic Interest Survey (Herz & Inzlicht, 2002), Sergeant and colleagues (2005) found olfactory characteristics to be extremely important for mate selection, above other physical and social characteristics, in a moderate sample of males and females. Similarly, using the Body Esteem Scale (BES) and two variations assessing personal standards of attractiveness for opposite and own gender, Franzoi and Herzog (1987) found that body scent was a critical aspect of attractiveness. Body odors have also been found to directly impact sexual arousal or interest (Bensafi et al., 2003), especially among females (Havlíček et al., 2008; Herz & Cahill, 1997; Herz & Inzlicht, 2002). For example, Herz and Cahill (1997) surveyed 166 females and found that olfactory information was reported to be the single most important variable in mate choice and most able to affect sexual desire negatively.

There is also convincing evidence that body odor attractiveness is correlated with other aspects of attractiveness when considering a potential mate, suggesting that body odor may influence mate preferences in many ways. Roberts and colleagues' (2011) video-recorded and photographed young males and collected body odor samples, then had them judged by a group of females. The males who were rated highest in non-verbal behavior attractiveness in the videos also rated highest in attractive body odor. Investigating the connection between human body odor and asymmetry, Rikowski and Grammer (1999) compared ratings of these categories from 16 males and 19 females. There was a positive correlation between attractiveness and sexiness of body odor for female subjects and a negative relationship between body asymmetry and smell for males. Further investigation by Thornhill and Gangestad (1999) found that normally ovulating females found more attractive the body scent of males who have greater bilateral symmetry. To determine if males can identify if a female was fertile by scent, Singh and Bronstad (2001) asked females with regular menstrual cycles and not taking hormonal contraceptives to wear a T-shirt for three days during their ovulatory phase and a different T-shirt for three days during their non-ovulatory phase. Males rated the shirts worn during ovulation as more sexy and pleasant than the shirts worn during non-ovulation, indicating odor may be a cue to ovulation.

The Major Histocompatibility Complex (MHC) & Mate Preferences

One proposed explanation for the importance of these odor cues in mate preferences is regarding their ability to convey relevant genetic information for mate choice. The Major Histocompatibility Complex (MHC), a section of alleles in the human genome, has the important role in the immune system of recognizing foreign substances in a cell, surrounding them and moving them to the surface to be picked up and destroyed by T-cells - alsoknown as killer cells that directly kill virus-infected cells and cancer cells (Hedrick, 1994). These same alleles give a chemical signature or odor type in a form that bestows individuality (Wysocki et. al., 2004). It has been shown in several species that the Major Histocompatibility Complex (MHC) is associated with an individual's body odor profile. As such, body odor conveys important genetic information about a potential mate.

Research in both humans and non-human animals has shown evidence for MHC-dependent mate preferences whereby individuals generally prefer MHC type body odor dissimilar to their own (i.e., disassortative preferences for MHC). This preference for dissimilar MHC mates allows for offspring to have a more diverse immune system, preparing it to recognize more foreign substances and fight them off, increasing offspring survival. Thus, it is more advantageous to mate with MHC-dissimilar individuals compared to MHC-similar individuals. Additionally, when a mate is MHC-similar there is potentially a higher chance of relatedness between the two individuals, which can lead to many problems from inbreeding. MHC-similarity seems to be a major factor for mate selection in vertebrates (Boehm & Zufall 2006; Restrepo et al. 2006). During observations of mice breading to create an AKR-H-2^b congenic strain, one of the researchers working with Yamazaki (1976) observed homozygous H-2^b males being more interested in mating with heterozygous H-2^b:H-2^k females instead of those that are homozygous H-2^b. Another researcher, not knowing of the observation, came to a theoretical conclusion, at the same time, that Histocompatibility antigens could be olfactory self-markers to tell the difference between members of a population. A male mouse was caged with two congenic females in estrus until he mated with one of them. To be considered valid, the female not chosen was placed with another male to see if mating would occur thus ruling out the chance that the nonchosen female was not in estrus. The data showed that a mouse’s choice of mate is influenced by the alleles in the H-2 region locus. Also, strain preference was established in the first trial and there was no increase with experience. Another point shown in the study was the signal transmitted by the female was influenced by an H-2 linked gene because genetically identical males were able to distinguish different H-2 types between congenic females. There must also be a receptive gene in the males H-2 region due to congenic males of dissimilar H-2 types making different choices when presented with two of the same H-2 different females. The findings confirm that there are two linked genes, a female signal and male receptive, in the H-2 region governing mating preference from olfactory information (Yamazaki et al., 1976).

Many findings suggest heterozygous MHC-allele combinations will be superior during selective pressure from pathogens. Wedekind, et al., (1997), hypothesized that mate choice may be influenced such that preferences would lead to MHC-heterozygous offspring, or their complementary and epistatic effects may function under current environmental conditions to create specific combinations of alleles that would be beneficial. Humans also have sensitivity to odors that are MHC-correlated (Wedekind, et. al., 1995). This was tested by having two females and four males with common MHC-alleles, found in the population of the study, and unshaved armpits wear 100% cotton t-shirts for two nights while living an odor-neutral lifestyle, for five weeks, with the same people changing to new shirts each week. The shirts were presented each week to 63 males and 58 females, typed for their alleles at the MHC, to score the odor of the shirts for intensity and pleasantness. When possible, the females scored the odors two weeks after beginning menstruation, do to heightened odor-sensitivity at this time. To account for confounds caused by oral contraceptives, when asked, 45% of the females were taking them during the experiment. All six of the odors were scored similarly by all the participants for intensity. For pleasantness, relative scoring was very different between the smellers. In 14 female and 14 male tests the smeller was reminded of a current or former mate and these odors turned out to have less similar MHC-alleles with the smeller, showing a correlation of MHC with mate choice in the study. Furthermore, when comparing pleasantness to degree of MHC similarity separately for females on the pill, and males and females not on the pill, the data showed that females not on the pill and males prefer MHC dissimilar odors. An opposite preference was found on average for females on the pill toward MHC similarity but not a significant correlation with pleasantness. Finally, two different test series have shown a correlation between MHC linked genes and mate choice, body odor preference and odor production in humans, and because not everyone smells good to everyone, it depends on who smells who and their respective MHC (Wedekind, et.al., 1997).

Some human populations are MHC influenced when it comes to mate choice (Chaix, Cao & Donnelly, 2008). Most odor studies, on MHC-associated mate choice, show disassortative preferences with variation in the nature and strength of the effects (Havlíček & Roberts, 2009). Evidence has shown strong disassortative mating at MHC in random couples (Ihara et al., 2000). Females have sensitive olfactory systems allowing them to choose mates based on small differences in MHC alleles (Jacob et al., 2002).

MHC dissimilarity correlates with enhancing the desire to procreate, sexuality and partnership (Kromer et al., 2016).Whether for short- or long-term mating; MHC-dissimilar females will be preferred by males (Lie, Simmons & Rhodes, 2010). Genetic diversity, on the other hand, influenced males and females in either long- or short-term choices. Females preferred males with diversity at one MHC-loci and males preferred females with diversity at one non-MHC loci. It can be said that the MHC has a special role in human mate selection from this evidence and that preferences may work together to enhance an offspring's genetic diversity (Lie, Simmons & Rhodes, 2010). Genes in the MHC region may influence mate choice in humans. This means the phenotype of the female may have more say in who they choose to mate with (Ober et al., 1997).

Hormonal Contraceptives & Mate Preferences

Evidence is emerging that the use of combined oral contraceptive pills (COCs) may disrupt aspects of female's mating psychology and behaviors, including male's attraction to females (using or not using COCs), the menstrual cycles natural effect on the variation in mate preference, and competitiveness against other females for access to mates (Alvergne & Lummaa, 2010). Given the impact COC use may have on mating-related cognitions and behaviors, it is possible that COC use could also disrupt olfactory sensitivity and preferences. Indeed, studies have suggested that olfactory sensitivity may fluctuate across the menstrual cycle, peaking around fertility indicating a role of hormonal fluctuations in olfactory sensitivity. That female's olfactory sensitivity is linked to their menstrual cycle, leads one to see a connection between fertility and mate preference (Vierling & Rock, 1967).

These fertility-linked increases in olfactory sensitivity may be altered in females using COCs, given that hormonal contraceptives dramatically alter endogenous hormone cycling (Ferdenzi et al., 2020). A female's use of COCs can change mate preference for both sexes which could affect mate choice and reproductive outcomes (Alvergne & Lummaa, 2010). Some research has found that females taking COCs show a significant preference towards MHC similarity that is not evident in females not taking COCs. After being genotyped, 97, heterosexual normally cycling, females who were not pregnant or using any form of COCs rated the body odor of 97, heterosexual non-smoking males who were also genotyped, for pleasantness, desirability and intensity in the first session. In the second session, 3 months later, the same females rated the same odors, randomly, 37 of the females had begun taking COCs. Females in the COC group showed a significant shift in preference toward MHC similarity that was not the case in the first session (Roberts et al., 2008). Other work has found no evidence for MHC preferences in females on hormonal contraceptives but females not using hormonal contraceptives found similar MHC significantly less attractive than dissimilar MHC. Once genotyped, 58 females, 28 using COCs, rated cotton shirts that had been worn by 47 males who had also been genotyped, for attractiveness and intensity of odor. The females who were not using COCs found dissimilar MHC odor significantly more attractive than similar MHC (Sorowska et al., 2018). There is also an indication from the research that the use of COCs seem to reduce MHC dissimilarity preferences.

The Current Study

These previous studies investigating the impact of COC use on female's mate preferences indicate that the olfactory sense is important for choosing romantic partners and that the use of exogenous hormonal medications may influence the signaling we receive from this sense, potentially altering our choices. However, these studies have been relatively limited in scope in that they have only tested heterosexual females using the combined oral contraceptive pill (COCs). There are dozens of other steroidal hormonal medications that individuals may take for contraceptive purposes or other purposes. It is possible that these other medications may impact olfactory signaling as well, but this has yet to be tested. The current study assessed odor preferences for romantic relationships in a broader sample (i.e., no restrictions on sex or sexual orientation) with more diverse forms of exogenous hormones (i.e., COCs, other HCs, and other non-contraceptive steroidal medications). Importance of odor cues, preferences for odor dissimilarity in a partner, and preference for partner's natural body odor was assessed. I aimed to generalize the research in this area beyond heterosexual participants/partnerships and the combined oral contraceptive pill to generate a more representative understanding of the potential links between hormonal medication and the importance of odor cues for mate preferences in humans.

Hypothesis 1

Given that COCs disrupt odor preferences, I predict that there will be a significant difference in the reported importance of body odor when considering a partner in that people taking steroidal hormonal medication will place less importance on body odor than those not taking any exogenous hormones.

Hypothesis 2

Secondly, given that use of COCs disrupts MHC-signaling in particular; I predict there will be a significant difference in preferences for a partner smelling similar or dissimilar to us among people using steroidal hormonal medication and those not using it. Specifically, the strength of the preference for a partner who smells dissimilar to oneself should be higher in individuals not using steroidal hormonal medications compared to those who are using steroidal hormonal medications.

Hypothesis 3

To extend this, I will be asking if people prefer their partner's natural body odor or a perfume/deodorant. I predict that people taking steroidal hormonal medications will have a stronger preference for a perfume/deodorant than those not taking steroidal hormonal medications.

Methods

Participants

Two-hundred and eighty-two adults, all over the age of 18, participated in this study with 209 identifying as white/Caucasian, 17 as Black/African American, 21 as Hispanic/Latino/a, 18 as East Asian/Pacific Islander and 9 as Mixed ethnicity. Of these, 143 identified as female, 134 identified as male and 5 (1.8% of sample) identified as non-binary. It is estimated that 0.1% to 2% of the global population identify as non-binary (Goodman, et al. 2019); as such, the proportion of non-binary individuals within this sample is in keeping with global estimates. Within the sample, 190 were in a relationship and 92 were not. Within the sample, 50 participants reported using steroidal hormonal medications (10 male, 37 female, 3 non-binary) and 232 reported not using any steroidal hormonal medications (124 male, 106 female, 2 non-binary). Because participants were permitted to omit answering questions they did not want to answer, not everyone completed all the items for the variables of interest. Individual sample sizes are reported at the relevant analysis below.

Procedure

The data for this study was collected from an online convenience sample through Cal Poly Humboldt’s SONA system, faceresearch.org, and Mturk. The survey was identical regardless of the way it was accessed. Participants confirmed they were at least 18 years old and provided their ethnicity, sex (male, female or non-binary), and preferred partner sex (male, female, any (bisexual), none (asexual)), to start the survey. A series of questionnaires adapted from previous studies investigating odor cues in mate preferences (Herz & Inzlicht, 2002; Jern, 2018) was then presented.

Use of Hormonal Medication

Participants were asked to report whether they are currently taking any medication that impacts steroid hormone levels and, if so, to report the exact brand name of the medication.

Romantic Interest Survey (importance of odor cues)

This 18-Likert item survey was developed by Herz and Inzlicht (2002) to examine the relative importance of various social and physical traits in romantic attraction. Items are grouped into three sub-topics: “physical and social factors involved in selecting a potential lover” (includes a single question about the importance of smell when considering a potential partner); “better-than-average physical qualities” (questions are worded to determine the importance of various attributes when a potential partner is at least average on all, includes a single question about the importance of smelling better than average); “natural versus artificial fragrance quality” (includes four questions about the impact odor cues may have on sexual interest in a potential partner). To assess the importance of odor cues, the average of the 6 odor-relevant questions ($\alpha = .43$) was calculated for each participant.

Odor Similarity

To explore potential disassortative MHC-preferences, participants were asked if they generally prefer their partner to smell similar or dissimilar to themselves using a 1 (strongly prefer different smell) to 7 (strongly prefer similar smell) scale. Higher scores on this question reflect a stronger preference for similarity, while lower scores reflect a stronger preference for dissimilarity. Although this measure does not directly assess MHC dissimilarity, it is potentially linked to MHC cues and allowed me to explore my primary interest considering COVID restrictions during data collection.

Partner's Natural Body Odor

Participants were asked to report if they generally prefer a partner's natural body odor or perfume/deodorant using a 1 (strongly prefer a partner's natural body odor) to 7 (strongly prefer deodorant or perfume) scale.

Results

All data analysis was performed in R. There were three primary analyses investigating differences between hormonal medication users and non-users for: importance of odor cues, preference for partner smelling similar/dissimilar to oneself, and preference for partner's natural body odor or perfume/deodorant.

First the data for all three dependent variables was assessed for normality. Visual inspection of the histograms did not reveal any major concerns. The skew and kurtosis for all three variables was within the range of acceptable limits (skew: -0.46 – 0.55, kurtosis: 2.49 – 3.47) (Hair, 2009).

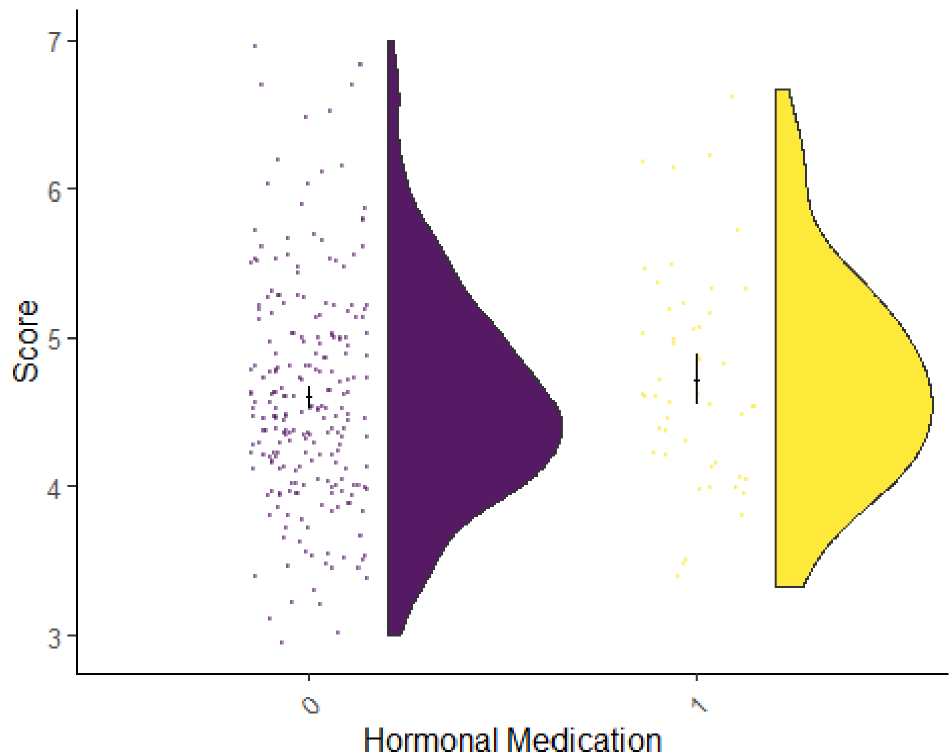
Due to the unequal sample size of hormonal medication users (N = 50) versus non-users (N = 232) in the full sample, Welch's independent samples t-tests were used to analyze the data for all between-group comparisons reported below.

Prediction 1: Importance of Odor Cues

Contrary to the predicted result, this test showed no difference in the reported importance of odor cues between those using hormonal medications (M = 4.60, SD = 0.73, N = 49) and those not using hormonal medications (M = 4.71, SD = 0.72, N = 231), t (0.474) = 1.006, p = 0.318, 95% CI = [-0.34, 0.11], d = 0.15. This is illustrated in figure 1. The sample size for this analysis was 280. A sensitivity analysis (performed using the *pwr2ppl* package in R) for the Welch's t-test showed a power of 0.16 to detect a difference in this sample.

Figure 1

Violin plot comparing odor importance between hormonal medication users (0) and non-users (1).

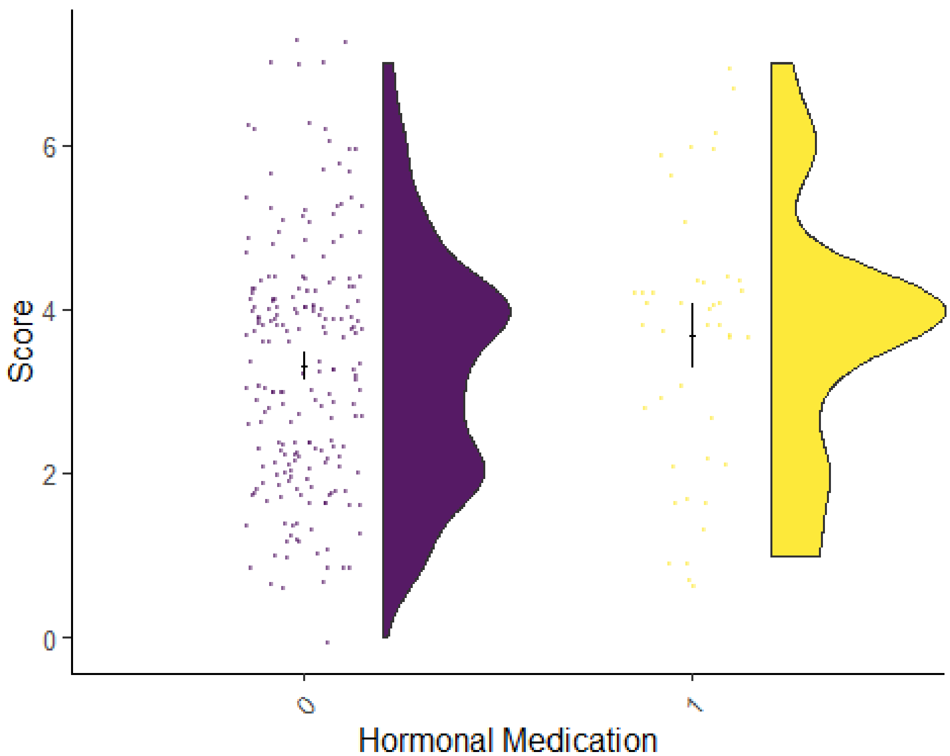


Prediction 2: Preference for Similarity of Odor

Again, there was no difference in preference for similar or dissimilar smelling partner between hormonal medication users (*M* = 3.30, *SD* = 1.47, *N* = 43) and those not using hormonal medication (*M* = 3.67, *SD* =1.60, *N* = 210), *t* (0.704) = 1.186, *p* = 0.241, 95% *CI* = [-0.84, 0.22], *d* = 0.15. This is illustrated in figure 2. The sample size for this analysis was 253. A sensitivity analysis (performed using the *pwr2ppl* package in R) for the Welch's t-test showed a power of 0.31 to detect a difference in this sample.

Figure 2

Violin plot comparing preference for similar or dissimilar smelling partner between hormonal medication users (0) and non-users (1).

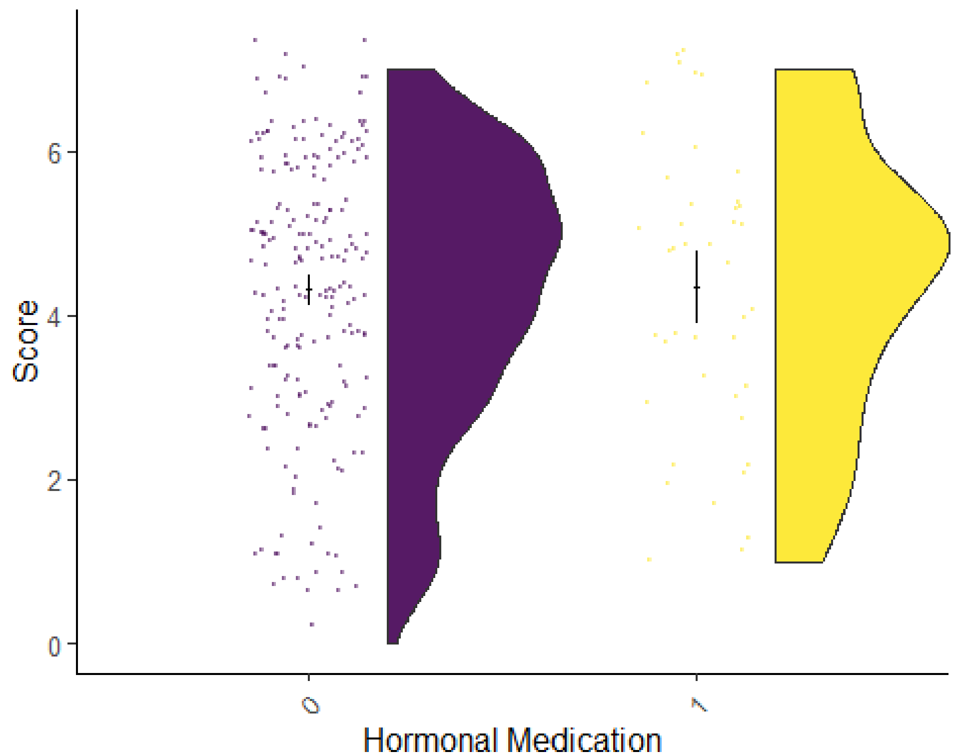


Prediction 3: Preference for Natural Body Odor

The analysis showed no difference in preference for natural body odor or a deodorant/perfume for the partner of those using hormonal medications (*M* = 4.31, *SD* = 1.64, *N* = 43) and those who are not using hormonal medications (*M* = 4.35, *SD* = 1.76, *N* = 209), *t* (1.724) = 0.054, *p* = 0.957, 95% *CI* = [-0.61, 0.58], *d* = 0.02. This is illustrated in figure 3. The sample size for this analysis was 252. A sensitivity analysis (performed using the *pwr2ppl* package in R) for the Welch's t-test showed a power of 0.05 to detect a difference in this sample.

Figure 3

Violin plot comparing preference for natural body odor or deodorant/perfume smelling partner between hormonal medication users (0) and non-users (1).



Exploratory Analyses

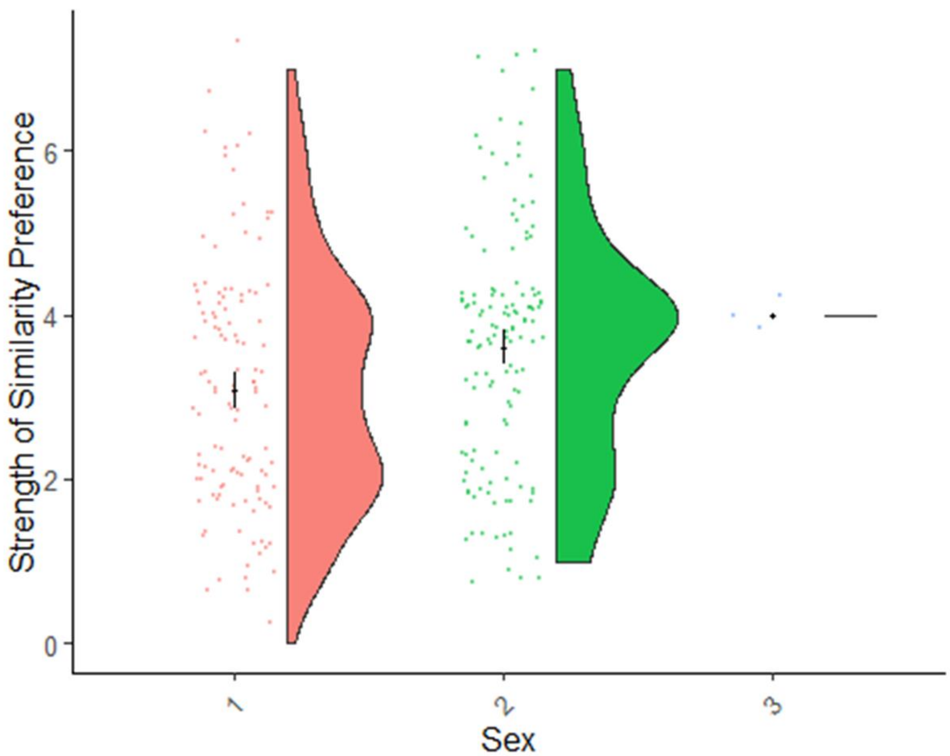
Many studies exploring odor preferences generally have used both male and female samples (Bensafi et al., 2003; Franzoi & Herzog, 1987; Havlicek et al., 2008; Sergeant et al., 2005) while studies on the hormonal effects on odor preferences have focused on female-only samples (e.g., Roberts et al., 2008; Lobmaier et al., 2018). To explore whether hormonal medications may have impacted participants' preferences differently based on their sex, 2x3 ANOVAs were run for each of the 3 dependent variables using the ez package in R. Hormonal medication use (2 levels: using, not using) and sex (3 levels: male, female, non-binary) served as between-subject factors for the analyses. However, this exploratory analysis should be interpreted very cautiously given the unequal cell sizes.

There were no significant interactions between sex and hormonal medication use for any of the variables (all $F < 1.11$, all $ps > .294$). This suggests that the use of hormonal medications does not have differential effects on female participants as compared to other sexes. Importantly, the results suggest future research needs to move beyond hormonal medication effects on females only.

A significant main effect of sex was observed for the odor similarity preference (F (2, 247) = 3.46, $p = .033$), but neither of the other variables (all $F < 1.36$, all $ps > .245$). Post-hoc pairwise comparisons using Bonferonni correction indicated that males showed a significantly greater preference for dissimilarity in partner odor than did females or non-binary participants. Females and non-binary participants did not differ in the strength of their reported preferences. This is illustrated in Figure 4. The sample size for this analysis was ($N = 282$). A sensitivity analysis (performed using the *pwr2ppl* package in R) for the ANOVA showed a power of 0.84 to detect a significant effect in this sample.

Figure 4

Violin plot comparing preference for similar or dissimilar smelling partner between males (1), females (2), and non-binary (3) participants.



Discussion

The aim of this study was to investigate potential differences in partner odor preferences between people taking hormonal medications and people who are not taking hormonal medications. Participants completed a questionnaire which asked about hormonal medication use, preference for a partner who smells similar or dissimilar to themselves and if they prefer their partner’s natural body odor or a perfume/deodorant. They also completed the Romantic Interest Survey (Herz and Inzlicht, 2002), which measures importance of odor in partner choice and other qualities. Three variables of interest were analyzed based on previous research: importance of odor cues, preference for partner smelling similar/dissimilar to oneself, and preference for partner’s natural body odor. Although I had predicted that individuals using steroidal hormonal medication would differ in their odor-related preferences compared to those not using hormonal medication, no significant group differences were found on any of the three odor variables measured here.

The way an individual’s personal scent is received by another individual is an important factor to the relationship between the two individuals. Many different signals conveying a variety of information is delivered by way of body odor making it paramount when choosing someone as a romantic partner. Evidence from previous studies indicate that olfactory characteristics are critical for mate attractiveness (Foster, 2008; Franzoi & Herzog, 1987; Roberts et al., 2011; Sergeant et al., 2005). Importantly, research on hormonal factors of mate preferences suggests that hormonal fluctuations can change olfactory sensitivity in humans (Alvergne & Lummaa, 2010). A study on the changes in olfactory sensitivity across the menstrual cycle, Gangestad and Thornhill (1998) found in a sample of normally ovulating women (*N* = 47) a significant preference for the scent of more symmetrical mates during the period of peak fertility. Therefore, I had predicted that people taking hormonal medications may differ in the reported importance of body odor signals when choosing a mate as compared to those who are not taking hormonal medications. While this relatively small sample (*N* = 47) of Gangestad and Thornhill (1998) found a difference in odor preference as hormone levels change across the menstrual cycle, our results did not find a change in the importance of odor for our sample (*N* = 280).

It should be stated that the experiments did have very differing methods. Whereas Gangestad and Thornhill (1998) conducted their test in person, the current work was completely online. When looking for changes to olfactory sensitivity or preferences the ability to have participants smell odors is crucial and our study was unable to accomplish this do to pandemic restrictions.

Odor cues should be important for mate preferences in part because they convey important health-related genetic information about a potential mate, namely cues to MHC composition, while individuals who smell dissimilar may be more likely to have a dissimilar MHC composition – the latter being preferable because it confers higher immune competency to offspring. Most odor studies show this disassortative preference in mate choice, including in humans (Havlíček & Roberts, 2009). However, a pivotal study in the human mate preferences literature (Wedekind, et. al., 1997) found that women not taking hormonal contraception (*N* = 32) preferred dissimilar smelling mates while women taking hormonal contraception (*N* = 26) preferred similar smelling mates – suggesting that the use of hormonal medications may alter these adaptive mate preferences. Corroborating this finding, Roberts et al., (2008), measured MHC-odor preferences in women before and after initiating the use of hormonal contraceptives (i.e., a within-subject design) and found evidence for shifting preferences toward MHC-similarity with the initiation of hormonal contraception. Though Roberts et al., (2008) did find a difference in preference for odor similarity as a function of hormonal medication in a relatively small sample (*N* = 37), our analysis showed no difference in preference for those taking hormonal medication (*N* = 43) compared to those not taking hormonal medication (*N* = 210).

It should be noted that there are several important differences between these previous studies of odor preferences and the current work. Namely, the method for assessing odor preferences differs. Both the Wedekind et al., (1997) and Roberts et al., (2008) studies had participants smell odor samples that were from genotyped donors and were able to assess MHC-similarity between the smeller and the donor directly. Due to the COVID-19 pandemic, this sort of biological sampling was not possible here, so the current study relied on online surveys asking if the person prefers their partner to smell similar or dissimilar to themselves. It is possible that participants struggled to answer this question because they are unaware of their own odor or how to compare the similarity of a partner's odor to their own. Notably, the longitudinal design of the Roberts et al., (2008) study is also a much more powerful way to investigate whether hormonal medication may impact these odor similarity preferences.

Exploratory analyses did find a significant main effect of sex for the odor dissimilarity variable. Interestingly, males reported a stronger preference for dissimilar smelling partners than either females or non-binary participants did. Wedekind et al., (1997) found preferences for MHC-dissimilarity among both males and females suggesting that using a more inclusive sample would further our understanding of the impact of hormones on odor preferences. Exploratory analyses included sex as a factor (3 levels: male, female, non-binary). There were no significant interactions between sex and hormonal medication use for any of the variables. This suggests that any hormonal medication caused differences would not be affected by the sex of the participant. Overall, there was no real impact of reported sex on any of the variables measured, although a small effect of sex was detected for the odor similarity variable. In the Wedekind, et al., (1997) study it was concluded that male raters were equal with non-pill using females which is contrary to the difference we found on the similarity variable. The difference between the two studies is most likely linked to the fact that the Wedekind, et al., (1997) study had MHC data available for grouping their participants and that type of biological data was unavailable for our study.

Finally, the present study also investigated preference for partner's natural body odor in those taking hormonal medication versus those not taking hormonal medication. To assess this, participants were simply asked if they prefer their partner's natural body odor or for them to wear a perfume/deodorant (strength of this preference was captured by a Likert-style rating). Human body odor signals information about a person's genetic makeup (Wedekind, et. al., 1997; Roberts, et al., 2008; Havlíček & Roberts, 2009), and research on perfume choice has shown that people tend to choose a perfume that enhances their own scent rather than “covering it up” (Sobotková et al., 2017). Again, the data showed no difference between those using hormonal medication and those not using it for this perfume preference. However, it is worth noting that this analysis had the lowest power .05 (5%) in the current study, indicating that a much larger sample would be needed to accurately answer whether there is a difference.

One of the aims of the current work was to expand our understanding of the potential impact of hormonal medications on odor preferences by broadening the type of data collected. Previous studies have relied exclusively on heterosexual females using the combined oral contraceptive pill. However, there are a wide variety of medications that impact sex/steroidal hormones and could, thus, affect odor preferences in anyone regardless of sex or sexual orientation. The current sample consisted of a relatively equal number of males and females, with a small sample identifying as non-binary. Although, quite small the non-binary sample equated 1.8% of the total sample which is in line with what is observed in the real world, between .5 – 2% depending on the country (Goodman, et al., 2019). Although I did not find any major patterns of sex impacting odor preferences generally, I was able to achieve my aim of testing these issues in a more diverse, representative sample.

The current study also generalized to any hormonal medications, rather than restricting to the combined oral contraceptive pill. There are hundreds of medications that impact steroidal hormones and thus, could have some impact on odor preferences. However, it could be the case that people are mis-categorizing their hormonal profile.

Many people may be taking medications that have steroidal hormones in them without knowing. While there are the obvious, well-known medications like birth control, many other medications contain or affect hormones. Around half of people, in the United States alone, report difficulty when it comes to using and reading and understanding health/medicinal information (Shrank & Avorn, 2007). Therefore, it could be that a large percentage of the non-hormonal medication group may be unaware of what is in the medicine they may be taking which could result in imperfect group assignment and potentially mask between-group differences. It may also be important for future research to investigate how different hormonal medications (i.e., there are dozens of variations of "the pill" alone) may impact these preferences.

Limitations & Future Directions

There are several potential explanations for the null results of this study. Firstly, the study is underpowered. The probability of finding a significant difference when one exists is directly related to the power of your test. The general level of power accepted to find the difference is .8 or greater, 80% (Cohen, 2016). The power for the three analyses ranged from .05 to .31, indicating the need for a much larger sample to find any difference that may exist.

Critically, there were almost five times as many people not taking hormonal medication (N = 231) than those currently using medications that alter their hormone levels (N = 49) in the present sample. It is possible that the hormonal medication group was simply too small to detect differences. With a longer sampling period or more targeted recruitment, it could be possible to increase the number of participants who use hormonal medication. It is especially important to have large samples in each group when doing this type of between-subjects work. Future research on this topic should endeavor to recruit large groups to more accurately test for between-group differences in odor preferences.

Checking for odor preferences through questionnaires can be difficult when participants are not asked to smell and rate specific odors. To get a more informative sample when conducting this type of research collecting data in person would be preferable, but COVID-19 prevented that. The use of questionnaires does lead to a larger and more diverse sample while in person research would have limited this study to the classic college sample.

Conclusion

In conclusion, the current study does not support the hypothesis that the use of hormonal medications impact odor preferences. However, this finding should be interpreted cautiously given the relatively small sample size. We tried to include the many different hormonal medications that are available, instead of just hormonal contraception. Unfortunately, almost 50% of the United States alone have bellow basic or basic literacy (DeBuono, 2006), suggesting a lack of knowledge about what one's medication contains. This would indicate that knowing what medications, if any, people are taking would be needed for accurate sampling. This study also sought to include non-binary individuals to more generalize the data. Unfortunately, we only received 5 non-binary participants which was in line with real world percentages, the total sample size was too small. Future research should endeavor to recruit a larger population while including non-binary individuals to better address these questions.

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