July 2017

The Effect of Androstenone as a Mating Prime on Drinking and Approach Behavior

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by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
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Date of Approval:
September 06, 2016

Keywords: pheromones, alcohol, alcohol expectancies, evolutionary psychology

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ABSTRACT

Recent research has shown that sexual activity may be influenced by variables suggested by evolutionary theory, such as pheromonal cues. A recent study in our laboratory indicated that female pheromones influence men's drinking and approach behavior based on hidden pathways of behavioral influence caused by chemosensory signals. The current study sought to examine whether a link exists between male pheromones and women's drinking and approach behavior, through the use of a possible male sex pheromone called androstenone, and sought to examine this link within the context of a women's ovulation cycle. One hundred and three female participants were primed with either androstenone or a control scent and then completed measures assessing their beer consumption, approach behavior, and ovulatory phase. Results of the study indicated that females who were exposed to the androstenone prime drank significantly more than those exposed to the control prime, though results indicated no differences between groups in terms of approach behavior. No interaction effects existed between group condition and ovulatory phase on beer consumption or approach behavior; however, a limited amount of participants were ovulating when they completed the study, as indicated by a biological assay. The results from the current study implicate a specific pathway to alcohol use through biological signals within a sexual context. The findings from this study expand the existing literature on olfactory and pheromone signaling of sexual behavior in humans and shed light on newly uncovered biological pathways of influence on human behaviors.

INTRODUCTION

Alcohol use, abuse, and dependence have become a widespread public health concern, as alcohol is one the largest risk factors for morbidity, disability and mortality across the world. Over 3 million deaths per year worldwide can be attributed to alcohol use, and alcohol can be attributed as a causal component of more than 200 disease and injury conditions (e.g., liver conditions, neuropsychiatric conditions, cancers; Rehm et al., 2010; Shield, Parry, & Rehm, 2014; WHO, 1992). Beyond alcohol's effect on diseases, injuries, and mortality rates, alcohol also creates a significant social and economic burden. Alcohol abuse and dependence have been linked to dysfunction in the workplace, family life, and relationships, leading to a diminished quality of life and potential mental health concerns for individuals who suffer from alcohol use disorders. Given the significant global implications of alcohol consumption, research over the past few decades has focused on addressing factors related to the initiation and maintenance of alcohol use and has identified many different areas, including but not limited to: genetics, environmental/cultural influences, personality, development, neuropsychology, motivation, learning (see Goldman, Darkes, Reich, & Brandon, 2006; Sher, Gerkin, & Williams, 2005).

Alcohol Expectancy Theory

Research has turned to the psychological processes behind alcohol consumption and drinking behavior to decipher the linkages between contexts and outcomes of alcohol use. An area of research that has emerged while examining these psychological processes posits that alcohol-related behavior is influenced by expectations regarding the effects of alcohol. In

general, anticipation of the future "has a decided evolutionary advantage, and researchers have found many evolutionarily conserved mechanisms by which humans and animals learn to predict future events" (Brembs, 2003, p. 218). The human nervous system has evolved to process information regarding past experiences to predict future circumstances by deciding on the optimal adaptive response in an upcoming moment. Research has shown that brain circuitry is differentially sensitive to aspects of rewards, and this mechanism serves to adjust current behavior toward the most beneficial outcomes. Research on anticipatory processes can be applied to the context of alcohol consumption and shows how alcohol-related cognition represents the connection between the opportunity for reward/reinforcement, the learned behavioral pattern for obtaining that reward, and the anticipated outcome. That is, alcohol expectancy theory explains how future drinking behavior can be influenced based upon past and current memories and experiences related to alcohol (Goldman, Brown, & Christiansen, 1987; Smith & Goldman, 1994). Alcohol expectancies refer to the anticipated cognitive, behavioral or affective effects that can result from the consumption of alcohol (Goldman, Darkes, Reich, & Brandon, 2006). These phenomena are important because of their association with abusive and non-abusive drinking patterns (Brown, Goldman, & Christiansen, 1985; Christiansen, Goldman, & Brown, 1985; Smith, Goldman, Greenbaum, & Christiansen, 1995), as well as their utility in predicting current drinking, future drinking, and decision making strategies regarding alcohol consumption (Brown, Christiansen, & Goldman, 1987; Christiansen, Smith, Roehling, & Goldman, 1989; Goldman, Darkes, Reich, & Brandon, 2006). Furthermore, research has indicated that these expectancies mediate the relationship between genetic and environmental risk factors and drinking behavior (Darkes, Greenbaum, & Goldman, 2004; Goldman, Brown, &

Christiansen, 1987; Goldman, Darkes, & Del Boca, 1999; McCarthy, Wall, Brown & Carr, 2000).

Alcohol and Sexual Behavior

One of the more prominent alcohol expectancies is that humans anticipate that alcohol use encourages and facilitates sexual activity. This strong belief about sexual expectancies can be attributed to cognitive and psychological factors, such as a person's expectations about alcohol's effect on sexual behavior (i.e., sexual enhancement alcohol expectancies). The close association between sexual activity and alcohol use has long been recognized and was even described in the Old Testament. Studies have suggested that alcohol consumption leads to decreased sexual inhibitions and enhanced sexual enjoyment (Athanasiou, Saver, & Tavris, 1970; Wilsnack, Wilsnack, & Klassen, 1984). Other studies have reported that alcohol consumption was positively correlated with the likelihood of sexual intercourse occurring on a first date using a sample of adolescents and college students (Cooper & Orcutt, 1997; Dermen & Cooper, 1994). Furthermore, a link between drinking and sexual aggression has also been found, as sexual assault has been found to be associated with alcohol consumption by either one or both parties involved (Abbey, 1991; Koss, Gidycz, & Wisniewski, 1987; Muehlenhard & Linton, 1987).

Although alcohol typically reduces physiological sexual arousal above a certain dosage level, sufficient evidence has accrued to establish that both women and men expect drinking to have positive effects on sexual experiences (Goldman & Roehrich, 1991; Lang, 1985; Wilsnack, 1984). A recent study revealed that consuming more alcoholic drinks on a given day was associated with increased sexual behavior, and individuals with more positive sexual enhancement alcohol expectancies were more likely to engage in sexual behavior after drinking (Patrick & Maggs, 2009). Furthermore, contextual factors are inextricably connected to

anticipated outcomes from alcohol use and can activate specific types of alcohol expectancies to influence drinking behaviors. For example, women who read a hypothetical vignette describing a sexual situation experienced stronger social and sexual enhancement alcohol expectancies (MacLathy-Gaudet & Stewart, 2001).

Research on sexual experience and drinking in women indicates that the majority of female drinkers experience increased sexual excitement when drinking, with heavier drinkers being more likely to report positive effects (Klassen & Wilsnack, 1986; Filmore, Bacon, & Hyman, 1979). In a one-year prospective study of recent female high school graduates, positive sexual enhancement alcohol expectancies were related to an increased likelihood of engaging in sexual intercourse after drinking (Messman-Moore; Ward, & DeNardi, 2013; White, Fleming, Catalano, & Bailey, 2009). Positive sexual enhancement expectancies are also associated with increased risky sexual behavior in women, such as indiscriminate sexual activity (Messman-Moore et al., 2013; Zamboanga, 2005). Moreover, among women who were involved in a sexual assault, those who had consumed alcohol were more likely to report high levels of consensual sexual activity prior to the assault than women who were sober at the time of the assault (Harrington & Leitenberg, 1994; Testa & Livingston, 2000).

Evolutionary Theory

Research over the past few decades about human sexual behavior has been informed by evolutionary considerations that may offer suggestions about how sexual behaviors are guided; that is, men and women's sexual decisions may be influenced by factors suggested by evolutionary theory, such as genetic fitness and reproductive success (see Thornhill & Gangestad, 1996). For example, studies guided by evolutionary theory indicate that men tend to be less discriminatory in mating choices than women, who value resources and hierarchy status

more than physical attractiveness and youth in potential mates. From an evolutionary perspective, men aim to increase their chances of genetic survival while for women, genetic survival increases with a dependable mate (Jensen-Campbell, Graziano, & West, 1995). The latest research in evolutionary theory related to human sexuality suggests that one motivational pathway for sexual behavior may be based on previously unknown biological signaling systems, such as pheromonal cues. For example, one study showed that female lap dancers who were ovulating received significantly more tips than those who were not ovulating, a result indicating that men were more sexually attracted to ovulating women, presumably due to the fact that men favored these fertile women due to increased chances of reproductive success (Miller, Tybur, & Jordan, 2007). Furthermore, this study also demonstrated that women who were not using hormonal contraception earned significantly more tips than those who were using hormonal contraception; as hormonal contraception eliminates fertility effects on the female body and behavior by putting the body in a state of hormonal pseudopregnancy (e.g., Gangestad, Simpson, Cousins, Garver-Apgar, & Christensen, 2004; Gangestad et al., 2005; Macrae, Alnwick, Milne, & Schloerscheidt, 2002), this lends further support to evolutionary considerations guiding behaviors related to human sexuality.

And, in a recent study in our laboratory, the effect of female pheromones on male mating behaviors was shown to influence drinking behavior and opposite sex approach behavior, consistent with theories about evolutionary determinants (Tan & Goldman, 2015). This study was based on the theory that female ovulatory cues prime men to behave in ways to maximize reproductive success during this brief window of peak fertility. Females wore t-shirts for three nights in a row while they were fertile or while they were not fertile, and male participants were subsequently primed with the fertility scent or the control scent. The results revealed that, when

compared to males exposed to a control prime male participants exposed to female fertility pheromones consumed more of what they believed to be alcohol and exhibited greater approach behavior towards females. These findings suggested that scents related to fertility pheromones in human females may have activated an expectancy pathway associated with the utility of alcohol as a facilitator of sexual/mating experiences, which, subsequently manifested in increased drinking behavior, as well as increased approach behavior towards females. A natural next step would be to examine whether this pathway exists in females when exposed to scents related to male pheromones.

Androstenone and Behavioral Effects

Research on human biological signaling systems is part of a much broader domain that examines olfactory communication between humans. Not only can humans perceive chemosensory signals produced by other humans, but they also respond both physiologically and behaviorally to these chemosensory signals (see Lundstrom & Olsson, 2010; Pause, 2012). Examples of types of information that can be communicated through these chemosensory signals include gender (Doty, Orndorff, Leyden, & Kligman, 1978; Lübke, Hoenen, & Pause, 2012) and temporally experienced affect (Mujica-Parodi et al., 2009; Prehn-Kristensen et al., 2009; Zhou & Chen, 2009). Many studies examining olfactory communication between humans have utilized either human axillary secretions or synthetic copies of compounds present in body odor. Androstenone and related 16-androstenes, which are single molecules that are comprised within male human axillary secretions, have been extensively investigated for communicative properties (Pause, 2004). Androstenone is a sex pheromone in boars that is produced in the testes and is related to levels of testosterone (Andresen, 1976; Bonneau, 1982; Zamaratskaia, Babol, Andersson, & Lundstrom, 2004). Furthermore, androstenone facilitates the expression of

attraction to male boars and induces the mating stance in female boars. Evidence indicates that androstenone may exhibit similar pheromonal properties in humans. Axillary androstenone is detected in larger quantities in men than in women (Gower, Bird, Sharma & House, 1985), and the source of androstenone is mainly located in the testis (Kwan, Kraevskaya, Makin, Trafford, & Gower, 1997); thus, it is likely that a similar relationship between androstenone and testosterone exists in humans that is found in animals.

Previous studies have examined the physiological and behavioral effects of androstenone among humans. Kirk-Smith and Booth (1980) sprayed varying levels of androstenone on chairs in a dentist's waiting room and found that women selected seats with higher concentrations of androstenone, while men avoided sitting in odorized chairs, indicating that androstenone may attract females in an environmental setting in high concentrations. Another study used four female subjects with specific anosmia to androstenone, and after sensitizing them to androstenone, obtained chemosensory event-related potentials while perceiving their own body odor and a male's body odor during an olfactory oddball paradigm (Pause, Rogalski, Sojka, & Ferstl, 1999). Results indicated that sensitivity to androstenone was associated with a stronger brain response to the male body odor and anosmic females judged the male body odors as slightly more positive after they were sensitized to androstenone, indicating that androstenone may act as a sexual attractant.

Despite this supportive evidence, scientists have by no means reached consensus about the existence of human pheromones. Karlson and Luscher (1959) first introduced the concept of pheromones and described them as "substances which are secreted to the outside by an individual and received by a second individual of the same species, in which they release a specific reaction, for example, a definite behavior or a developmental process." Broadly,

pheromones can be classified as primers, signalers, modulators, and releasers. While evidence exists to support the presence of the former three in humans, little solid evidence for effects of releasers in human adults can be found within the current biomedical literature (Wysocki & Preti, 2004). Nevertheless, evidence has been offered for several specific pheromonal effects in human despite some uncertainty regarding the actual mechanisms of pheromone reception. Thus, we are encouraged to pursue this line of research based upon several well-controlled studies that strongly support, via observed changes in behavior, the inference that pheromones can be received by an individual.

For example, several studies have shown that female ratings of androstenone odor vary throughout the menstrual cycle, with perceptions being more positive around the time of ovulation than during other phases of the menstrual cycle (Grammer, 1993; Hummel, Gollisch, Wildt, & Kobal, 1991). Strikingly, this effect was not observed for females who were taking hormonal contraceptives at the time, suggesting that females need to possess active hormonal systems to receive sexual signals to detect male pheromones. That is, since androstenone is a steroid derived from male sex hormones, the positive change in the perception of androstenone during ovulation serves to facilitate reproductive behaviors. This finding is also consistent with evolutionary theory, which posits that humans behave in ways to maximize reproductive success during ovulation. Similarly, a more recent study showed that men with higher testosterone levels exhibited lower olfactory sensitivity to androstenone and reported less pleasure when exposed to androstenone, while women with higher estradiol levels tended to rate androstenone as less pleasant (Lubke & Pause, 2014). The authors posited that the results they found in men were due to androstenone indicating the readiness for competition in men, and they suggested that the results they found in women were due to androstenone indicating reduced willingness for social

cooperation and increased likelihood to engage in extramarital sex. Another study showed that among women who were able to perceive androstenone, those who had reported engaging in sexual intercourse with at least one partner rated the scent as more pleasant than women who had reported never experiencing sexual intercourse (Knaapila et al., 2012). The women with sexual intercourse experience may have encountered the scent of androstenone during their sexual encounters and may have paired the odor with the presumably positive value of the sexual experience.

In addition to examining participant ratings of androstenone odor, previous studies have also examined how androstenone odor has affected female participants' perceptions of males. Studies have found that androstenone had no effect on females' evaluation of males (Filsinger, Braun, & Monte, 1990; McCullough et al., 1981), while other studies reported that androstenone negatively influenced females' self-perception and evaluation of males (Filsinger et al., 1985; Maiworm & Langthaler, 1992). One other study examined the effect of male axillary secretions on female ratings of the sexual attractiveness of male stimuli and found that those exposed to male axillary pheromones rated male stimuli as significantly more attractive than those exposed to a control scent (no pheromone; Thorne, Neave, Scholey, Moss, & Fink, 2003). Additionally, they found that neither contraceptive pill use nor menstrual cycle phase had any significant effect on the ratings beyond pheromone exposure. Though some of the findings regarding the specific effects of androstenone have been inconsistent, sufficient evidence seems to exist that androstenone and related 16-androstenes have physiological and behavioral effects in humans (see Havlicek, Murray, Saxton, & Roberts, 2010). These inconsistent findings may be due to different methodologies employed by researchers, such as differences in sample size, varying concentrations of androstenes, study characteristics, and whether phase of the menstrual cycle or

hormonal contraceptive status were taken into account (see Preti, Spielman, & Wysocki, 1997). Existing evidence, however, suggests that when careful methodological precautions are taken, androstenone can affect women's sexual behaviors.

Current Study

The purpose of the current study was to explore whether variations in alcohol use and related cognitions may be attributed to biological inductions. This study aims to examine a novel domain of biological influences on drinking pathways by evaluating whether androstenone, a male pheromone, provides a sufficient sexual context to induce drinking in females and subsequent approach behavior towards males. As women often drink to facilitate sexual experiences, and androstenone represents a male sex pheromone and sexual attractant, this study was designed to examine whether sexual behaviors (i.e., increased drinking and approach behavior) could be elicited from females when exposed to androstenone, based on hidden pathways of behavioral influence caused by chemosensory signals.

The specific aims of the current study were to examine the effect of androstenone on female mating behaviors; that is, drinking behavior and approach behavior towards males. It was hypothesized that females exposed to the scent of androstenone would exhibit increased drinking behavior (presumably because they would view alcohol as a device to facilitate sexual behavior) and approach behavior towards males when compared to females exposed to a control scent. The study also aimed to examine whether drinking behavior and approach behavior change across different stages of the menstrual cycle, as previous research has shown varying preferences of androstenone across the menstrual cycle. It was hypothesized that a significant interaction between ovulation status/conception risk and prime condition would emerge, whereby females

who are ovulating or have a higher conception risk would exhibit increased drinking and approach behavior when primed with androstenone.

Exploratory aims of the study were to examine whether significant differences existed in sexual enhancement or social facilitation expectancies between groups after being exposed to the prime. Other exploratory aims of the study included investigating whether sexual enhancement expectancies or social facilitation expectancies moderated the effects on beer consumption. Another exploratory aim was to examine the correlational relationships between risky sexual behavior, sexual experiences under the influence of alcohol, sexual enhancement expectancies, and social facilitation expectancies, and the dependent variables (i.e., "beer" consumption and approach behavior). A final exploratory aim was to examine the differences in the participants' perceptions of the prime scent.

METHOD

Participants

Female participants were recruited from an online participant pool of undergraduates from psychology classes that participated for extra credit in their psychology courses. To be eligible, participants had to be at least 21 years of age, not pregnant, beer drinkers, not allergic to beer, not pregnant or trying to become pregnant, and not current smokers (studies have shown that smoking leads to smell impairment; Vennemann, Hummel, & Berger, 2008). Because the study was focused on pheromone signaling of sexual behavior, another requirement was that participants had to have engaged in sexual intercourse with a male at least once in their lifetime to ensure that they have had prior exposure to male pheromones in a sexual context in the past. A total of 131 participants completed the study; of those participants, 18 were later found to be ineligible due to abstaining from drinking beer, two were ineligible due to being under 21 years of age (those who were under 21 years old were not allowed to complete the taste-rating task portion of the study), and six other participants opted not to complete the taste-rating task. In addition, as the study's main interest was to examine the effect of male attraction to females, two participants were excluded from the analyses of the study due to identifying themselves as homosexual with no sexual interest in males. The final sample was 103 undergraduate females between the ages of 21 and 31 years old (M = 22.37, SD = 2.02) who identified themselves as either White/Caucasian (48.5%), Hispanic/Latino (26.2%), mixed race (8.7%), Black/African

American (7.8%), Asian/Pacific Islander (4.9%), or other (2.9%). Ethnicity data was missing for one participant (1.0%).

Materials

Olfactory prime. Each participant was randomly assigned to either the androstenone prime group or the control prime group. Pilot testing was conducted to determine the androstenone prime solution and control prime solution. To ensure that any effects found were not merely due to differences in scent, we wanted to select an androstenone prime and control prime that participants were unable discern. Thus, 30 pilot subjects were utilized to determine whether they could discern the difference between two different androstenone concentrations and water. Results indicated that there were significant differences in participants' ability to discern between androstenone at a concentration of 1 mg/ml and water and between androstenone at a concentration of 1 mg/ml and 78.13 μg/ml. There were no significant differences in participants' ability to discern between androstenone at a concentration of 78.13 μg/ml and water, so the current study utilized androstenone at a concentration of 78.13 μg/ml as the androstenone prime and water as the control prime.

The androstenone concentration for this study followed the formulation indicated in a previous study conducted by Lubke and Pause (2004). For the androstenone prime, androstenone (5-α-androst-16-en-3-one; ≥98%) was dissolved in 1,2-propanediol (ReagentPlus®, 99%) to form a concentration of 78.13 μg/ml. The chemicals were obtained from Sigma Aldrich, a trustworthy multinational chemical, life science and biotechnology company that has also supplied the materials for the majority of other studies conducted using androstenone. Participants were told that they would be participating in a study on consumer ratings and that part of the study would involve smelling and rating a men's cologne product. The "cologne" was

presented to participants on a fragrance test strip and instructions were given to each participant to put her nose very close to the test strip and to take three large inhalations. After the participant smelled the "cologne", they filled out a product rating form, rating the "cologne" on a 8-point Likert scale on the pleasantness and strength of its smell and how likely they would be to recommend and buy the product.

Attractiveness ratings of males. To provide a sexual context for the olfactory prime and to couple the pheromone stimulus with a male cue, females were asked to rate pictures of male faces on attractiveness. Participants were told that as part of the consumer rating study, they would be rating various images on aesthetic value and were later told that they would be rating pictures of male faces on attractiveness. The pictures were presented to participants on the computer and each picture was presented for the same amount of time (i.e., 5 seconds), so exposure to the male contextual cues was constant across participants and conditions. Pictures of male faces were shown to participants to minimize sexual provocativeness rather than showing full male bodies set in sexually provocative circumstances (e.g., shirtless males). Because in the real world, females are rarely exposed to pheromones in the absence of a man, the intent was to carefully balance the need to couple a male cue with the olfactory prime against the concern that the male cue might be sexually provocative and contribute independent influence on subsequent tasks. Participants were instructed by the experimenter and the computer to rate the attractiveness of each male picture on a Likert scale from 1 ("highly unattractive") to 7 ("highly attractive"). Participants were allowed to practice with 2 sample slides and then rated 12 pictures of men on attractiveness.

Taste-rating task. To unobtrusively measure levels of "alcohol" consumption, a modified version of the procedure developed by Marlatt, Demming, and Reid (1973) was used

for taste-rating. Non-alcoholic beers were used to avoid the possible pharmacological influence of actual alcohol on subsequent measures (approach task and expectancy assessment) and to minimize the risks to participants, particularly those that may have been unknowingly pregnant. Non-alcoholic beers have been employed effectively before for these purposes and have been proved to be a valid measure of alcohol consumption (e.g., Carter, McNair, Corbin, & Black, 1998), including in our laboratory (e.g., Roehrich & Goldman, 1995; Tan & Goldman, 2015). Participants were asked to taste and rate non-alcoholic beers to unobtrusively measure levels of "alcohol" consumption. During a 10-minute drinking period, participants were presented with 12 ounces each of two different types of nonalcoholic beers, and then were asked to taste and rate the beverages on several variables, such as taste, color and smell.

Approach task. Women's approach behavior to male stimuli was assessed using a behavioral task that has been utilized in prior studies (Holland, Roeder, van Baaren, Brandt, & Hannover, 2004; Macrae, Bodenhausen, Milne, & Jetten, 1994; Smith & Bargh, 2008). Participants were led into a room by the experimenter. In the room, five chairs were lined up in a row, with a man's jacket and hat hanging on one of the chairs at the end, and a man's belongings on and next to the chair. The four potential chairs available to the subjects were coded from 1 to 4, with seat 1 being the chair located next to the chair with the male items or the "phantom male". Lower numbered chairs are thought to reflect more approach behavior.

Ovulation status. As prior research indicated that ovulatory status changes a woman's psychology and behavior (e.g., Bullivant et al., 2004; Gangestad, Thornhill, & Carver, 2002; Gangestad & Thornhill, 2008; Regan, 1996) and that ovulatory status influences women's perception of androstenone (Grammer, 1993 Hummel et al., 1991), ovulation status was measured for each participant. Participants were asked about the typical length of their menstrual

cycle, their use of hormonal contraceptives, whether their menstrual cycle is typically regular, and the date of the first day of their most recent menstrual cycle. Using this information, the conception risk was calculated for each participant who was not using hormonal contraceptives at the time of the experiment using actual data from Wilcox et al. (2001). Each participant was assigned a value from 0 to 0.1, with higher values denoting greater conception risk. Methods similar to those of Haselton and Gangestad (2006) were also used to conservatively estimate cycle phase. Thus, cycle phase was divided into three phases: menstrual (Days 1-5 of the cycle), fertile (Days 9-15 of the cycle) and luteal (Days 18-28 of the cycle). Days 6-8 were dropped because participants could have been fertile and were likely not menstruating, Days 16-17 were dropped because participants could have been fertile, and Days 19 and greater were also dropped. Additionally, conception risk and menstrual cycle phase were be supplemented with a biological assay of ovulation status using a Wondfo One Step Ovulation (LH) Test Strip.

Chemical Sensitivity Scale (CSS). As the critical outcome measure in this study was dependent on detection of the androstenone odor, we wanted to ascertain whether baseline differences in smell sensitivity between group conditions existed. The Chemical Sensitivity Scale is a measure containing 21 items that assess for individual differences in smell sensitivity (Nordin, Millqvist, Lowhagen, & Bende, 2003). Participants utilize a 6-point Likert scale to rate agreement to various statements regarding their sense of smell (e.g., "I am easily alerted by odorous/pungent substances). A high score on this measure indicates a greater sensitivity to odor cues in the individual's environment. Information on smell sensitivity was collected to detect any baseline differences between prime conditions.

Alcohol Expectancy Questionnaire (AEQ; Brown, Christiansen, & Goldman, 1987). The AEQ is a 68-item scale using a 2-point forced choice format ("agree" or "disagree") that

measures the effects that respondents anticipate experiencing from consuming alcohol. The participant was asked to respond about what he personally believed as true as a result of drinking alcohol (e.g., "I often feel sexier after I have had a couple of drinks"). The AEQ has good internal consistency (α = .84), an 8-week test-reliability coefficient of 0.64, and contains six subscales ranging in length from 7 to 24 items (α = .72-.92; Brown, Christiansen, & Goldman, 1987); of particular interest to the current study are the Sexual Enhancement (7 items) and Social Assertiveness (10 items) subscales. Each item is scored either 0 ("disagree") or 1 ("agree), and subscale and total scale scores are computed by averaging the appropriate items. The AEQ was administered online before participation in the study as a baseline measure of expectancy and was then administered again towards the end of the study, following the approach task, but was modified so that the participant was instructed to answer how alcohol would make them feel in the moment.

Quantity Frequency Variability Index (QFVI). The Quantity Frequency Variability Index is a 13-item questionnaire that asks participants about the amount of alcohol consumed per sitting, frequency of alcohol use, and the variability of alcohol consumption, including the modal amount of alcohol consumption and the highest amount of alcohol consumption (Cahalan, Cisin, & Crossley, 1969). QFVI ratings yield five types of drinker classifications: heavy drinker, moderate drinker, light drinker, infrequent drinker, and abstainer. Drinker information was collected to examine whether baseline differences in drinker type between prime conditions existed.

Sexual experience. As differences in prior sexual experiences may be related to how participants respond after exposure to the olfactory prime, information about previous sexual experience was obtained. Questions adapted from the Sexual Behavior Inventory (SBI; see

Samek 2013; Huibregtse 2011) were used. The SBI assesses the age of onset and frequency of oral sex and sexual intercourse with romantic and casual partners, as well as recent sexual risk behavior. The SBI typically asks about how alcohol or drugs has influenced a participant's sexual experiences over the past year. For purposes of the current study, these questions were modified to ask only about alcohol's influence on a participant's sexual experiences over the past year. A score representing the participant's degree to which alcohol has influenced their sexual experiences over the past 12 months was calculated from 4 items. Another score representing the participant's sexual risk behavior was calculated using three indicators, including frequency of oral and penetrative sex with casual partners in the past 12 months and the frequency of engaging in risky sexual behavior under the influence of alcohol in the past 12 months.

Procedure

Figure 1 shows an outline of the experimental procedure. Participants completed the AEQ online before the day of the experiment, ranging from 2 days prior to the experiment to 3 months prior to the experiment. However, the AEQ is intended to measure individuals' trait-like alcohol expectancies, so the time differential in when alcohol expectancies were measured should not present a problem for this study. The AEQ was embedded within a larger questionnaire so that they were unaware which questions were related to the current experiment. Participants also completed questions related to the amount of beer they typically consume, whether they were allergic to beer, their smoking habits, whether they were pregnant or trying to become pregnant, and demographics to assess their eligibility for the study.

When participants arrived on the day of the experiment, they completed the informed consent for the study. An experimenter told the participants that the purpose of the study was to examine consumer ratings. The participants first filled out a questionnaire on their demographic

information (age, gender, ethnicity, year in college), sexual orientation, relationship status, and number of children, and then were asked to fill out the CSS. Each participant was assigned to either the androstenone prime condition or the control prime condition. Participants were told that they would be smelling and rating a men's cologne product. The "cologne" was presented to participants on a fragrance test strip, and instructions were given to each participant to put her nose very close to the test strip and to take three large inhalations. Participants and experimenters were blind to the experimental condition of each participant. After the participant smelled the "cologne," they filled out a product rating form, rating the "cologne" on a 8-point Likert scale on the pleasantness and strength of its smell and how likely they would be to recommend and buy the product.

Next, the participants rated pictures of male faces on attractiveness on a computer. They were first shown how to use the computer to rate the pictures using two test pictures. Twelve pictures were used for the actual task, which were shown in the same order and shown for five seconds each. The same pictures were used for all participants.

After participants rated the pictures of males, they completed the taste-rating task. The experimenter told the participants that they would be tasting beverages that were sparkling water, soda, or beer. The experimenter informed the participants that the type of beverages they would be rating would be new, low-calorie beers. Although participants were told that they might sample any of the beverages, all participants actually received the "beer" condition. Nonalcoholic beers were used, though participants did not indicate that they thought the beers were alcoholic. The participants were then asked to provide proof of being 21 years or older so that they were led to believe that they would be consuming actual alcohol. It was also made clear that participation was completely voluntary. Participants were poured two glasses of

nonalcoholic beer, 12 ounces each. All beers were chilled, and all identifying labels and contents were hidden. Participants were also left with a glass of water so that they were able to rinse their mouths in between tastings. Participants were given verbal instructions by the experimenter who told them to take their time and to sample as much of each beverage as needed to arrive at a decision. The experimenter gave the participants rating sheets for each beer and then left the room to reduce social constraints on drinking. The taste-rating task had a 10-minute time limit, of which participants were not aware. Halfway through the 10-minute period, the experimenter returned to check on the participant's progress, and at the end of the 10 minutes, the experimenter returned again and told the participant that they would be moving on to the next task.

After the taste-rating task, participants completed the approach task. They were led into a separate room where they were told they would be finishing the experiment by filling out some questionnaires. The room had five chairs lined up in a row, and one of the chairs at the end had a man's jacket and hat hanging on the back of the chair, a man's backpack in front of the chair with a sports magazine and car magazine in the backpack, and a clipboard on top of the chair. Participants were asked to take a seat and was then given the AEQ, QFVI, and SBI to complete. Upon completion of these questionnaires, participants were told that research has shown that women's preferences change depending on the phase of their menstrual cycle, and they were given a final questionnaire asking about the typical length of their menstrual cycle, their use of hormonal contraceptives, whether their menstrual cycle was typically regular, and the date of the first day of their most recent menstrual cycle. Finally, participants were given an ovulation test where they were asked to follow the instructions for the ovulation test in the bathroom and to report on the results to the experimenter. After they completed the ovulation test, participants

were asked several questions, such as how much alcohol they thought were in the beers that they consumed, to determine whether they were aware of the true nature of the study. Participants were then de-briefed about the experiment and permitted to leave.

Timing. The informed consent process, demographics questionnaire and CSS questionnaire typically took participants 5-10 minutes to complete. The experimental prime, or smelling of the "cologne", and then completing the fake product rating form usually took participants about one minute. Next, the instructions and demonstration for the attractiveness ratings and completing the actual task normally lasted between 5 and 10 minutes. Instructions to complete the taste-rating task were typically given in under one minute, and participants were given exactly 10 minute for the taste-rating task. Finally, participants usually completed the approach task, the QFVI, the AEQ, and the SBI in 10-20 minutes. It is unknown exactly how long it takes after a person is exposed to a scent before the smell begins to affect behavior, and it is unknown exactly how long the smell continues to affect behavior after a person is exposed, but the timing of the olfactory prime in the current study is similar to the timing of other olfactory pheromonal primes in previous studies.

Sequencing effects. It is evident that the sequencing of stimuli may result in differential responses on the outcome measures; for example, whether the male contextual cue comes before or after the olfactory prime may make a difference on a participant's response to the scent. This question ultimately should be investigated; however, in this initial study designed to establish the phenomenon between androstenone and drinking behavior, we chose a specific sequence rather than counterbalancing for all possible sequences. Based on the timing of many of the previous studies examining olfactory primes (e.g., Miller & Maner, 2010; Tan & Goldman, 2015), we chose to sequence the olfactory prime prior to presenting the male contextual cue. With regards

to the sequence of the dependent measures, we recognize that differential drinking behaviors could influence approach behavior and vice versa. As the main variable for the study was drinking behavior, we chose to measure drinking behavior before approach behavior so that differences in drinking will not be influenced by variations in approach behavior. Future studies could examine differences in results if the male contextual cue was presented prior to the olfactory prime or if approach behavior was measured prior to measuring drinking behavior.

RESULTS

Baseline Differences

Table 1 contains demographic information and baseline characteristics of the sample according to group condition. Baseline differences were examined to determine whether any systematic differences between groups emerged initially to which results may have been attributed other than the experimental prime. To explore any baseline differences in demographics, sensitivity of smell, drinker type, alcohol expectancies, and sexual experience between the ovulation and control groups, t-tests for continuous variables and Chi-square tests for categorical variables were utilized.

Results suggested no significant baseline differences between groups in age [$t(101) = -0.35$, $p = 0.72$), ethnicity [$\chi^2(5) = 4.22$, $p = 0.52$], sexual orientation, relationship status [$\chi^2(2) = 0.56$, $p = 0.76$], CSS total score [$t(101) = -0.21$, $p = 0.83$], overall drinker type [$\chi^2(3) = 2.13$, $p = 0.55$], total baseline alcohol expectancies [$t(97) = -0.83$, $p = 0.41$], baseline sexual enhancement expectancies [$t(95) = -0.75$, $p = 0.45$], baseline social assertiveness expectancies [$t(98) = -0.56$, $p = 0.58$], risky sexual behavior subscale scale [$t(100) = 1.34$, $p = 0.22$], influence of alcohol on sexual experiences subscale score [$t(100) = 1.05$, $p = 0.30$], conception risk [$t(97) = -0.98$, $p = 0.33$], menstrual cycle phase [$\chi^2(3) = 3.53$, $p = 0.32$], or hormonal birth control status [$t(101) = 0.15$, $p = 0.75$]. A lack of significant baseline differences between the control prime group and the androstenone prime group indicated that random assignment worked appropriately, and these

variables likely did not contribute to differences observed between groups after the independent variable was administered.

Perception of Alcohol Content in Beers

In follow-up questioning (debriefing), the majority of participants indicated that they were unaware that the beers they had been provided for the taste-rating task were nonalcoholic beers. Four participants reported that they thought that one of the two beers they had been provided with were nonalcoholic and no participants reported thinking that both beers were nonalcoholic. Of the four participants who indicated that they thought one of the beers might be nonalcoholic, two participants were in the androstenone prime condition and two participants were in the control prime condition. Furthermore, there were no significant differences between groups in how much alcohol they thought were in the first beer, $t(99) = 0.13$, $p = 0.36$, or the second beer, $t(98) = 0.98$, $p = 0.34$. It is, therefore, unlikely that any differences in results were due to differences between groups in the perception of whether the beers were nonalcoholic or alcoholic.

Attractiveness Ratings

Photographs of men were presented to participants primarily to enhance the sexual context of the study, though participant's ratings of attractiveness of each picture were also measured. Previous research showed no differences between female pheromone exposure and attractiveness ratings (Tan & Goldman, 2015). As the attractiveness ratings task was presented before the other dependent variables, any differences between groups in attraction may have presented a potential confound on subsequent tasks. Thus, differences in attractiveness ratings as a function of the androstenone scent exposure were examined so that subsequent analyses could be appropriately adjusted. T-tests produced no significant differences between groups on ratings

of attractiveness, $t(100) = 0.53$, $p = 0.60$ (see Table 2), indicating that the androstenone prime had no effect on participants' perceptions of attractiveness of the set of photographs of men shown to the participants in this study towards the photographs of men. Since no significant differences were found between groups, it could be concluded that differences in attraction levels between groups were unlikely to have been responsible for differences observed on tasks following the attractiveness ratings.

Beer Consumption

It was hypothesized that women who were in the androstenone prime condition would drink more beer during the taste-rating task due to being exposed to androstenone and then being exposed to a sexual context and thus having their sexual and social expectancies activated. To address this hypothesis, we first examined the descriptive statistics for beer consumption in our sample. The skewness and kurtosis values were 1.64 and 3.51, respectively. As the skewness and kurtosis values for beer consumption indicate a positive skew and a non-normal distribution (as is most often the case with alcohol consumption parameters), a square root transformation was utilized. After the square root transformation, the skewness and kurtosis values were 0.35 and 0.05. However, one outlier was identified after the square root transformation. To further improve distributional characteristics, this data point was Winsorized by setting its value to the upper limit of the interquartile range. Analyses for beer consumption were conducted using the square root transformation, along with the corrected outlier.

As can be seen in Figure 2, on average, participants in the androstenone prime group consumed more beer than participants in the control prime group. Analysis using a t-test confirmed this finding as statistically significant, $t(101) = 2.15$, $p = 0.03$ (see Table 2), in support of the main hypothesis of the study. This result is consistent with the prediction that

androstenone would cue females to the presence of a sexual context, which would, in turn, activate associational linkages between sex and alcohol use, thereby inducing increased drinking.

Approach Behavior

Differences in approach behavior between the ovulation group and the control group were examined to determine whether exposure to androstenone also would result in more approach behavior as a function of viewing the approach task as a potential sexual opportunity. Figure 3 displays the average chair number that participants sat in during the approach task. and show that, on average, differences did not exist between group in how far away participants sat from the "phantom male". Results of a t-test confirmed no statistically significant differences existed between prime conditions on approach behavior, $t(101) = -0.32$, $p = 0.75$ (see Table 2), indicating that the females in this study (unlike the males in Tan and Goldman [2015]) were not induced to approach males in the presence of the pheromonal sexual cue.

Ovulation Status

The study aimed to examine whether drinking behavior and approach behavior changed across different stages of the menstrual cycle, as previous research has shown varying preferences of androstenone across the menstrual cycle. It was hypothesized that an interaction between ovulation status/conception risk and prime condition would be found whereby females who are ovulating or have a higher conception risk and primed with androstenone would exhibit increased drinking and approach behavior when compared to other groups. The ovulation test strip results indicated only two participants were fertile; insufficient power was available, therefore, to carry out an interaction analysis using the results from the ovulation test strips. Instead, interactions were examined using conception risk, menstrual cycle phase, and hormonal contraception status.

The skewness and kurtosis values for conception risk were 2.07 and 3.54, respectively, indicating a positively skewed distribution; a square root transformation was employed, therefore, for the conception risk variable. After the square root transformation, the skewness and kurtosis values of the transformed variable were 1.15 and 0.13. In keeping with the advantages of using the transformed variable, analyses using conception risk were conducted using the square root transformation.

Drinking behavior. A hierarchical linear regression with group condition, conception risk, and the interaction effect between group condition and conception risk predicting the transformed beer consumption variable revealed a significant main effect for group condition on beer consumption, $\beta = 0.22$, $t(95) = 2.19$, $p = 0.03$, but no significant main effect for conception risk, $\beta = 0.12$, $t(95) = 0.99$, $p = 0.33$. The interaction between group condition and conception risk was also nonsignificant, $\beta = 0.08$, $t(95) = 0.62$, $p = 0.54$ (see Table 3). Additionally, the change in R^2 was not significant when the interaction effect was added to the regression model. We hypothesized that a high conception risk along with exposure to the androstenone prime would create a synergistic effect on drinking behavior; however, this finding indicated no interaction effect between conception risk and group condition on beer consumption, suggesting that the relationship between drinking behavior and conception risk did not differ significantly between the two prime conditions.

A two-way analysis of variance (ANOVA) was conducted to compare the main effects of the menstrual cycle phase and group condition and the interaction effect between menstrual cycle phase and group condition on the amount of beer consumed. Menstrual cycle phase included four levels (menstrual, fertile, luteal, birth control) and group condition consisted of two levels (androstenone, control). The main effect for group condition yielded an F ratio of $F(1, 76) =$

0.36, $p = 0.55$, and the main effect for menstrual cycle phase yielded an F ratio of $F(3, 76) = 0.56$, $p = 0.69$. These results indicate that the main effects for group condition and menstrual cycle were nonsignificant, and the interaction effect was also not significant, $F(3, 76) = 0.41$, $p = 0.75$. We hypothesized that those in the fertile condition and also exposed to the androstenone prime would have greatly increased drinking behavior compared to the other conditions; however the lack of significant interaction indicates that the relationship between drinking behavior and menstrual cycle phase did not differ significantly between the two prime conditions.

A two-way ANOVA was conducted to compare the main effects of hormonal contraception and group condition and the interaction effect between hormonal contraception and group condition on the amount of beer consumed. Hormonal contraception included two levels (hormonal contraception, no hormonal contraception) and group condition also consisted of two levels (androstenone, control). The main effect for group condition yielded an F ratio of $F(1, 99) = 4.49$, $p = 0.04$, indicating a significant difference between group conditions. The main effect for hormonal contraception was nonsignificant, $F(1, 99) = 1.12$, $p = 0.29$, and the interaction effect was also nonsignificant, $F(1, 99) = 0.01$, $p = 0.92$. We hypothesized that those who were not on hormonal contraception would exhibit increased drinking behavior and that the relationship between hormonal contraception and drinking behavior would differ between prime conditions; however, our findings did not support our hypotheses.

Approach behavior. A hierarchical linear regression with group condition, conception risk, and the interaction effect between group condition and conception risk predicting approach behavior revealed nonsignificant main effects for group condition $\beta = -0.01$, $t(95) = -0.13$, $p = 0.90$ and for conception risk, $\beta = 0.01$, $t(95) = 0.11$, $p = 0.91$, on approach behavior. The

interaction between group condition and conception risk was also nonsignificant, $\beta = -0.01$, $t(95) = -0.11$, $p = 0.91$ (see Table 4). Additionally, the change in R^2 was not significant when the interaction effect was added to the regression model. This finding indicated that no significant interaction effect between conception risk and group condition on approach behavior existed. We hypothesized that increased conception risk paired with the androstenone prime would lead to a synergistic effect on approach behavior; however, the results indicated that the relationship between conception risk and approach behavior did not differ between prime conditions.

A two-way ANOVA was conducted to compare the main effects of the menstrual cycle phase and group condition and the interaction effect between menstrual cycle phase and group condition on approach behavior to determine whether the relationship between menstrual cycle and approach behavior differed between prime conditions. Menstrual cycle phase included four levels (menstrual, fertile, luteal, birth control) and group condition consisted of two levels (androstenone, control). The main effect for group condition yielded an F ratio of $F(1, 76) = 0.03$, $p = 0.87$, and the main effect for menstrual cycle phase yielded an F ratio of $F(3, 76) = 1.14$, $p = 0.34$. Thus, the main effects for group condition and menstrual cycle were nonsignificant, and the interaction effect was also not significant, $F(3, 76) = 0.29$, $p = 0.84$. The results did not confirm our hypothesis, which was that the relationship between phases of the menstrual cycle would be more strongly related to approach behavior depending on the prime condition.

A two-way ANOVA was conducted to compare the main effects of hormonal contraception and group condition and the interaction effect between hormonal contraception and group condition on approach behavior. Hormonal contraception included two levels (hormonal contraception, no hormonal contraception) and group condition also consisted of two

levels (androstenone, control). The main effect for group condition yielded an F ratio of $F(1, 99) = 0.10$, $p = 0.75$, and the main effect for hormonal contraception yielded an F ratio of $F(1, 99) = 1.21$, $p = 0.28$, indicating that the main effects for group condition and hormonal contraception were nonsignificant. The interaction effect was also not significant, $F(1, 99) = 0.26$, $p = 0.61$, indicating that hormonal contraception status did not produce differential effects on approach behavior between group conditions.

Sexual Enhancement and Social Assertiveness Expectancies

A secondary interest of the study was to examine whether the androstenone prime would provide a sexual and/or social context for participants, thereby activating sexual and/or social expectancies for alcohol. However, expectancies were measured after the taste-rating task, so it was possible that the taste-rating task might have influenced responses on the AEQ. Our aims in examining expectancies, therefore, were exploratory in nature.

Changes in sexual enhancement and social assertiveness expectancies. Changes in sexual enhancement and social facilitation expectancies were calculated for each participant from baseline (pre-experiment) to after the experiment to examine whether women exposed to the androstenone prime would have greater increases in sexual enhancement and social assertiveness expectancies as compared to women exposed to the control prime. As can be seen in Table 2, the mean change in sexual enhancement expectancies for the androstenone prime group was 0.04 ($SE = 0.04$) and 0.08 ($SE = 0.04$) for the control prime group. The mean change in social assertiveness expectancies for the androstenone prime group was 0.06 ($SE = 0.04$) and 0.05 ($SE = 0.04$) for the control prime group. T-tests were conducted to determine whether significant differences emerged in the changes in sexual enhancement and social assertiveness expectancies between groups. Results found no significant differences between groups for sexual

enhancement expectancies, $t(94) = -0.74$, $p = 0.46$, or social assertiveness expectancies, $t(97) = 0.23$, $p = 0.82$ (see Table 2), indicating no differences in the changes in these expectancies from pre- to post-experiment between groups.

Interaction between expectancies and group condition. A hierarchical linear regression with group condition, sexual enhancement expectancies, and the interaction effect between group condition and sexual enhancement expectancies predicting alcohol consumption revealed a significant main effect for group condition on alcohol consumption $\beta = 0.23$, $t(98) = -2.36$, $p = 0.02$, but no significant main effect for sexual enhancement expectancies on alcohol consumption, $\beta = 0.15$, $t(98) = 1.16$, $p = 0.25$. The interaction between group condition and sexual enhancement expectancies was also nonsignificant, $\beta = 0.08$, $t(98) = 0.64$, $p = 0.52$ (see Table 5). Additionally, the change in R^2 was not significant when the interaction effect was added to the regression model. This finding indicates that no significant interaction effect exists between sexual enhancement expectancies and group condition on beer consumption, indicating that our hypothesis that the relationship between sexual enhancement expectancies and drinking behavior would be stronger within the androstenone prime condition was not supported.

A hierarchical linear regression with group condition, social assertiveness expectancies, and the interaction effect between group condition and social assertiveness expectancies predicting alcohol consumption revealed a significant main effect for group condition on alcohol consumption, $\beta = 0.22$, $t(98) = 2.36$, $p = 0.02$, but no significant main effect for social assertiveness expectancies on alcohol consumption, $\beta = 0.18$, $t(98) = 1.44$, $p = 0.15$. The interaction between group condition and social assertiveness expectancies was also nonsignificant, $\beta = 0.11$, $t(98) = 0.86$, $p = 0.39$ (see Table 6). Additionally, the change in R^2 was not significant when the interaction effect was added to the regression model. This finding

indicates that the relationship between social assertiveness expectancies and drinking behavior did not differ between group conditions.

Correlational Analyses

Beer consumption. An exploratory aim was to examine the correlational relationships between beer consumption and risky sexual behavior, sexual experience under the influence of alcohol, sexual enhancement expectancies, and social facilitation expectancies. Correlational analyses (see Table 7) showed significant correlations between beer consumption and risky sexual behavior ($r = 0.23$, $p = 0.02$) and social assertiveness expectancies ($r = 0.24$, $p = 0.01$). Of note, the relationship between beer consumption and sexual experience under the influence of alcohol ($r = 0.19$, $p = 0.05$) and sexual enhancement expectancies ($r = 0.18$, $p = 0.07$) were trending towards significance.

Approach behavior. Another exploratory aim was to examine the correlational relationships between approach behavior and risky sexual behavior, sexual experience under the influence of alcohol, sexual enhancement expectancies, and social facilitation expectancies. Correlational analyses (see Table 7) showed no significant correlations between approach behavior and the variables of interest; however, the relationship between approach behavior and sexual experience under the influence of alcohol ($r = -0.19$, $p = 0.06$) was trending towards significance.

Product Rating Form

The final exploratory aim was to examine the differences in responses on the product rating form between group conditions. As the product rating form is not a validated measure, results are simply exploratory in nature. Significant differences were found between groups on their ratings of the "cologne" on the pleasantness of the scent, $t(101) = -2.85$, $p < 0.01$, and the

strength of the scent, $t(101) = 2.23$, $p < 0.05$ (see Table 8). The ratings of the scent of androstenone from participants who received the androstenone prime in the experimental group were, on average, lower on pleasantness of the scent but higher on strength of the scent than the ratings of the control prime from participants in the control group.

DISCUSSION

Our study is the second in our laboratory to indicate the presence of a never-before-discussed biological pathway, operating outside human awareness, which may influence drinking behavior. Consistent with evolutionary theory, our prior research showed that variations in alcohol use among *men* could be attributed to pheromonal inductions (Tan & Goldman, 2015). The present study examined the drinking behavior and other mating-related behavior of *women* when exposed to either an androstenone prime or a control prime. As with the previous findings in men, it was anticipated that women who were exposed to the androstenone prime would behave in ways that facilitate the formation of sexual connections, such as consuming more alcohol and demonstrating greater approach behavior towards males.

The primary hypothesis that females exposed to an androstenone prime would consume more beer compared to those who were exposed to a control prime was supported by the study results. This finding suggests that a male pheromonal cue does, in fact, influence drinking behavior in women. Male pheromones may present a sexual context for women that leads to increased drinking due to the belief that alcohol will facilitate the formation of sexual connections.

When examining other mating behavior, however, results revealed no significant differences in approach behavior between participants in the androstenone group and the control group. The approach task has worked with both female and male participants in past studies; however, the "phantom participant" utilized in some past studies was gender neutral and not

within a sexual context. That is, when the chair for the approach task was set up in previous studies, there was only a jacket and no cues to the gender of the "phantom participants", unlike in this study where we also utilized a man's hat and man's backpack. Prior studies utilizing a gender neutral cue examined differences between participants in an interdependent self-construal condition and independent self-construal condition and found that participants in the interdependent self-construal condition exhibited increased approach behavior (Holland, Roeder, van Baaren, Brandt, & Hannover, 2004). Another study with both male and female participants utilized a male "phantom participant" and found decreased approach behavior in a stereotype suppressor condition than a control condition. In Tan and Goldman (2015), the approach task was modified so that the "phantom participant" was set up utilizing female cues, such as a purse and a pink jacket. During this "phantom female" version of the approach task, males were found to exhibit increased approach behavior as a result of being exposed to female pheromones. It is possible that females in the current study did not respond in the same way to a male "phantom participant" as males did in our previous study to a female "phantom participant" when exposed to male pheromones due to cultural expectations. Traditionally in the United States dating cultures, males are expected to be the ones to approach females, which may explain why males exhibited increased approach behavior after being exposed to pheromonal cues within a sexual context but females did not. Another consideration is that approximately half of the sample were married or in a committed romantic relationship, so relationship status may have affected approach behavior.

In addition to examining approach behavior, women's attraction to photographs of male faces using a modified visual reaction task was also examined. The lack of significance in participants' ratings of facial attractiveness between groups indicates that differences in

attraction levels between groups were unlikely to have been responsible for differences observed on tasks following the attractiveness ratings, thereby helping to maintain the validity of results from the approach task.

It was hypothesized that an interaction effect would exist between fertility and prime condition whereby females who fertile or had a higher conception risk and primed with androstenone would exhibit increased drinking and approach behavior when compared to other groups. Unfortunately, ovulation test strip results indicated only two participants were fertile, and therefore, insufficient power was available to carry out an interaction analysis using the results from the ovulation test strips. Instead, conception risk, menstrual cycle phase, and hormonal contraception status were used as proxy variables for ovulation status. Results revealed that the interaction effects between group condition and the variables of conception risk, menstrual cycle phase and hormonal contraception were not significant. Similarly, the interaction effect on approach behavior between group condition and conception risk, group condition and menstrual cycle phase, and group condition and hormonal contraception were all not significant. The effect of androstenone on drinking behavior that was found in the current study did not seem dependent on fertility, suggesting that women in our culture may be equally ready to drink alcohol in sexually charged situations regardless of conception risk, perhaps due to recent societal norms. However, diminished power due to a lack of equal distribution of conception risk and menstrual cycle phase may have led to difficulty detecting significant interactions.

It was also hypothesized that sexual enhancement and social facilitation expectancies would be activated by the androstenone prime. No significant differences existed between changes in either sexual facilitation or social assertiveness expectancies from pre- to post-experiment between the androstenone prime group and the control prime group. The interaction

effect between group condition and sexual facilitation expectancies, as well as group condition and social assertiveness expectancies, were both not significant. The lack of findings related to expectancies may be due to the fact that expectancies were measured after the taste-rating task; it is possible that the taste-rating task itself may have influenced responses on the post-experiment AEQ measure.

One exploratory aim of the study was to examine the correlational relationships between risky sexual behavior, sexual experience under the influence of alcohol, sexual enhancement expectancies, and social facilitation expectancies, and the dependent variables (i.e., "beer" consumption and approach behavior). Beer consumption was significantly correlated with risky sexual behavior and social assertiveness expectancies. The correlations between approach behavior and sexual experience under the influence of alcohol, beer consumption and sexual experience under the influence of alcohol, and beer consumption and sexual enhancement expectancies were trending towards significance. Although caution must be used when considering trends in statistical analyses (see Pritschet, Powell, & Horne, 2016), the possibility exists that risky sexual behavior, sexual experience under the influence of alcohol, sexual enhancement expectancies, and social facilitation expectancies may play a role in the relationship between the androstenone prime and the main dependent variables and may be variables of interest to explore further in future studies.

Another exploratory aim of the study was to examine the differences in responses on the product rating form between group conditions. Consistent with previous studies, participants rated the control prime as more pleasant than the androstenone prime. Participants also rated the androstenone as stronger than the control scent. These exploratory results support the inferences of a biological pathway, as one might hypothesize that unpleasant odors would lead to

diminished drinking; however, in the current study, we found increased drinking despite participants being exposed to a scent they rated as more unpleasant than participants in the control condition rated the control scent. Increased drinking in spite of an unpleasant odor is consistent with the presence of a non-conscious pathway, in that this pattern seems inconsistent with participants' drinking behavior being dependent on conscious experience. On the other hand, it is also possible that being exposed to an unpleasant odor may have led participants to drink more due to another unknown pathway (perhaps to counteract the aversive aspect of the stimulus). Again, these possibilities must remain speculative in the present context; results for the product rating form were exploratory in nature, as the instrument has not been validated and participants were under the impression that they were rating a men's cologne.

As mentioned previously, definitive evidence is lacking to prove the existence of human pheromones, and studies still need to verify the effects of releasers in humans. However, multiple studies through various methodologies have found observed changes in behavior as a result of putative pheromones (e.g., androstenone) and as a result of being exposed to T-shirts worn by human females overnight (and therefore thought to be exposed to human chemical secretions). The results from this study add to the growing evidence base suggesting that humans are in fact able to receive and respond to pheromones.

Limitations

One limitation of the study was our inability to reach conclusions about the influence of ovulation status on the pheromone effect, due to the very small number of participants who were ovulating or fertile. A very small window of time exists when females are ovulating or fertile and almost half of the participants in the study were taking a hormonal contraception. Future studies

should aim to recruit enough participants to be able to detect differences related to ovulation status.

Another limitation to the study was that sequencing effects may have influenced the dependent variables; that is, participation in the taste rating task may have influenced participants' behavior during the approach task. Due to limited resources, counterbalancing of the tasks was not possible. Future studies should aim to replicate findings using a counterbalanced design or should have only one dependent variable per study.

An additional limitation to the study was that our sample was limited to an undergraduate psychology population at one institution in the southeastern United States. Future research should examine if the effects found in this study occur to the same extent in males of other age groups, in non-college populations and in different geographic areas.

An advantage to using nonalcoholic beer was that measures obtained after the taste rating task were not affected by a participant's intoxication level; however, even though participants reported that they thought that the beer contained alcohol, their drinking behavior may have been different than if alcoholic beer had been used. Furthermore, participants were asked to drink the beverages alone in a lab room, which is a very unnatural setting and much different than where drinking usually takes place. While studies on the taste-rating task have shown that the lab environment does not influence the quantity of drinking, it is still possible that this unnatural environment influenced participants' drinking behavior. It is most likely, though, that this effect would likely influence both prime conditions and would be biased toward less drinking, if at all.

Another limitation of the study was that the expectancy measure was given to participants after they had completed the taste-rating task and consumed the beer. Our theory posits that the reason why people drink more after being exposed to the androstenone prime is so because they

believe alcohol will help them achieve a desired sexual outcome. As the main purpose of the study was to determine the effect of the androstenone prime on beer consumption, we were unable to measure their alcohol expectancies before drinking because we did not want the expectancy measure to prime or alter drinking behavior. Future studies should look for a minimally reactive measure of alcohol expectancies to directly assess if expectancies can explain the relationship between group condition and beer consumption.

Future Directions

Future studies should aim to replicate the findings with different samples and also using alcoholic beer. To our knowledge, no study to date has parsed the effects of androstenone in relation to female sexual preference. Another avenue to explore further is examining effects of androstenone on homosexual females to see whether their evolutionary instincts influence their reactions to androstenone exposure or if a prerequisite to being affected by male pheromonal is sexual attraction to males. If male pheromonal cues do have an effect on homosexual females, it could signal that they still have an evolutionary drive to reproduce; conversely, if male pheromonal cues have no effect on homosexual females, it is possible that their sexual attraction towards other women overrides their evolutionary instincts.

Conclusions

A variety of factors influence human mating and attraction, many of which people are unaware. Consistent with previous studies, olfactory male pheromonal cues are detectable and can influence female drinking behavior. The current research helps to explain subconscious influences on behavior and sheds light on the hidden determinants of human mating and attraction. This research demonstrates the value of examining mating behaviors through using evolutionary theories of human behavior and uncovers an entire domain of biological influences

on drinking behavior that may have important implications for research on the etiology of alcohol use and on treatment for alcohol use disorders. Future research should continue integrating cognitive, psychosocial and biological approaches with evolutionary approaches to further understanding of driving forces behind human behavior and social processes.

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APPENDIX A:

TABLES

Table 1

Baseline Participant Characteristics and Attractiveness Ratings

	Total Sample (N = 103)		Androstenone (n = 45)		Control (n = 58)	
	M	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Age	22.37	(2.02)	22.29	(1.83)	22.43	(2.16)
% Caucasian	48.5%		52.3%		56.6%	
Sexual Orientation	1.38	(0.77)	1.53	(0.97)	1.26	(0.55)
% Married/In a Relationship	53.5%		51.2%		55.2%	
Baseline AEQ Total Score	0.49	(0.23)	0.47	(0.24)	0.51	(0.23)
Baseline AEQ SE Score	0.38	(0.33)	0.35	(0.034)	0.40	(0.32)
Baseline AEQ SA Score	0.66	(0.34)	0.64	(0.35)	0.67	(0.33)
CSS Total Score	2.67	(0.70)	2.68	(0.69)	2.66	(0.72)
SBI Risky Sex Subscale	4.59	(2.12)	4.91	(2.79)	4.34	(1.41)
SBI Alcohol Subscale	1.70	(0.67)	1.78	(0.77)	1.64	(0.59)
% Heavy/Moderate Drinkers	58.3%		60.0%		56.9%	
Conception Risk	1.38%	2.45%	1.10%	(1.88%)	1.59%	(2.81%)
% Birth Control	47.6%		46.7%		48.3%	

Note: AEQ = Alcohol Expectancy Questionnaire, CSS = Chemical Smell Sensitivity, SA = Social Assertiveness, SBI = Sexual Behavior Inventory, SE = Sexual Enhancement.

Table 2

T-test Results of Dependent Variables

	Androstenone (n = 45)		Control (n = 58)		t (df)	p
	M	(SD)	M	(SD)		
Attractiveness Ratings	4.45	(0.72)	4.36	(0.81)	0.53 (100)	0.60
Beer Consumption[a]	10.39	(4.11)	8.51	(4.63)	2.53 (101)	0.03*
Beer Consumption (mL)[b]	126.09	(99.09)	93.41	(91.59)		
Approach Task	2.13	(0.69)	2.17	(0.53)	-0.32 (101)	0.75
Δ AEQ SE	0.04	(0.26)	0.08	(0.28)	-0.74 (94)	0.46
Δ AEQ SA	0.06	(0.27)	0.05	(0.29)	0.23 (97)	0.82

Note: SE = Sexual Enhancement. SA = Social Assertiveness.
*p < .05 **p < .01 [a]transformed [b]unadjusted values

Table 3

Regression Table for Group Condition x Conception Risk Predicting Amount of Beer Consumption[a] (n = 98)

Predictor	*b*	*SE*	*β*	*t*	*p*	*F*	ΔR^2
Model 1						3.55*	0.07*
Group Condition	1.95	0.89	0.22	2.18	0.03*		
Conception Risk	7.86	4.75	0.16	1.66	0.10		
Model 2						2.48*	0.004
Group Condition	1.96	0.90	0.22	2.19	0.03*		
Conception Risk	5.76	5.85	0.12	0.99	0.33		
Condition x Conception Risk	6.22	10.08	0.08	0.62	0.54		

Note: **p* < .05 ***p* < .01 [a]transformed

Table 4

Regression Table for Group Condition x Conception Risk Predicting Approach Behavior (n = 98)

Predictor	*b*	*SE*	*β*	*t*	*p*	*F*	ΔR^2
Model 1						0.01	0.00
Group Condition	-0.02	0.12	-0.01	-0.12	0.90		
Conception Risk	0.04	0.66	0.01	0.06	0.96		
Model 2						0.01	0.00
Group Condition	-0.02	0.13	-0.01	-0.13	0.90		
Conception Risk	0.09	0.82	0.01	0.11	0.91		
Condition x Conception Risk	-0.16	1.41	-0.01	-0.11	0.91		

Note: $*p < .05$ $**p < .01$

Table 5

Regression Table for Group Condition x Sexual Enhancement Expectancies Predicting Amount of Beer Consumption[a] *(n = 101)*

Predictor	*b*	*SE*	*β*	*t*	*p*	*F*	ΔR^2
Model 1						4.53*	0.08*
Group Condition	2.05	0.87	0.23	2.35	0.02*		
AEQ SE	2.82	1.31	0.21	2.15	0.03*		
Model 2						3.14*	0.41
Group Condition	2.06	0.88	0.23	2.36	0.02*		
AEQ SE	2.06	1.77	0.15	1.16	0.24		
Condition x SE	1.70	2.65	0.08	0.64	0.52		

Note: AEQ = Alcohol Expectancy Questionnaire, SE = Sexual Enhancement. *$p < .05$ **$p < .01$

[a]transformed

Table 6

Regression Table for Group Condition x Social Assertiveness Expectancies Predicting Amount of Beer Consumption[a] (n = 101)

Predictor	*b*	*SE*	*β*	*t*	*p*	*F*	ΔR^2
Model 1						6.06**	0.11*
Group Condition	2.02	0.86	0.22	2.35	0.02*		
AEQ SA	3.86	1.44	0.26	2.68	0.01**		
Model 2						4.28**	.01
Group Condition	2.03	0.86	0.22	2.36	0.02*		
AEQ SA	2.76	1.92	0.18	1.44	0.15		
Condition x SA	2.51	2.90	0.11	0.86	0.39		

Note: AEQ = Alcohol Expectancy Questionnaire, SA = Social Assertiveness. *$p < .05$ **$p < .01$
[a]transformed

Table 7

Correlations Between Beer Consumption and Approach Behavior and Exploratory Variables

Variable	Beer Consumption	Approach Behavior
SBI Risky Sex	0.23*	-0.09
SBI Alcohol	0.19	-0.19
AEQ Sex	0.18	0.10
AEQ Soc	0.24*	-0.02
CSS Score	-0.13	-0.10

Note: AEQ = Alcohol Expectancy Questionnaire, SA = Social Assertiveness. *$p < .05$ **$p < .01$

Table 8

T-test Results of the Product Rating Form

	Androstenone (n = 45)		Control (n = 58)		t (df)	p
	M	(SD)	M	(SD)		
Pleasantness of scent	3.00	(1.60)	3.91	(1.60)	-2.85 (101)	0.01**
Strength of scent	1.20	(1.56)	0.64	(0.99)	2.23 (101)	0.03*
Likelihood of recommending	1.00	(1.46)	1.29	(1.76)	-0.90 (101)	0.37
Likelihood of buying	0.56	(1.04)	0.83	(1.50)	-1.04 (101)	0.30

Note: *$p < .05$ **$p < .01$.

APPENDIX B:

FIGURES

Pre-Experiment:
- AEQ
- Screening Questions

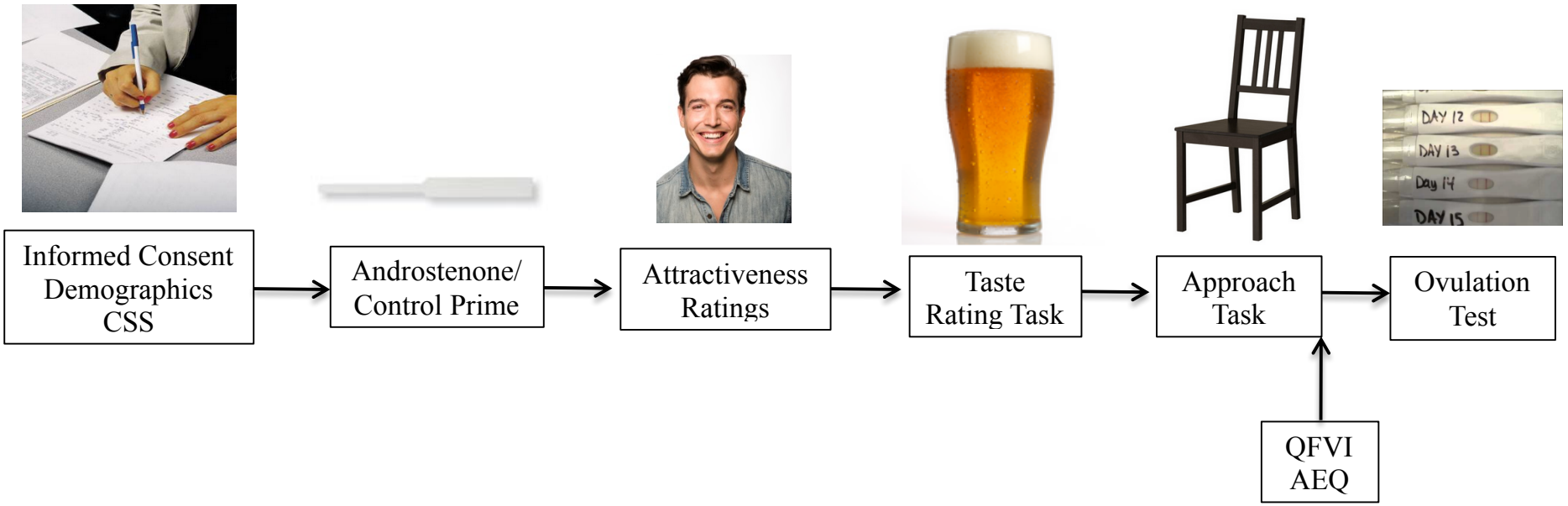

Figure 1. Outline of experimental procedure

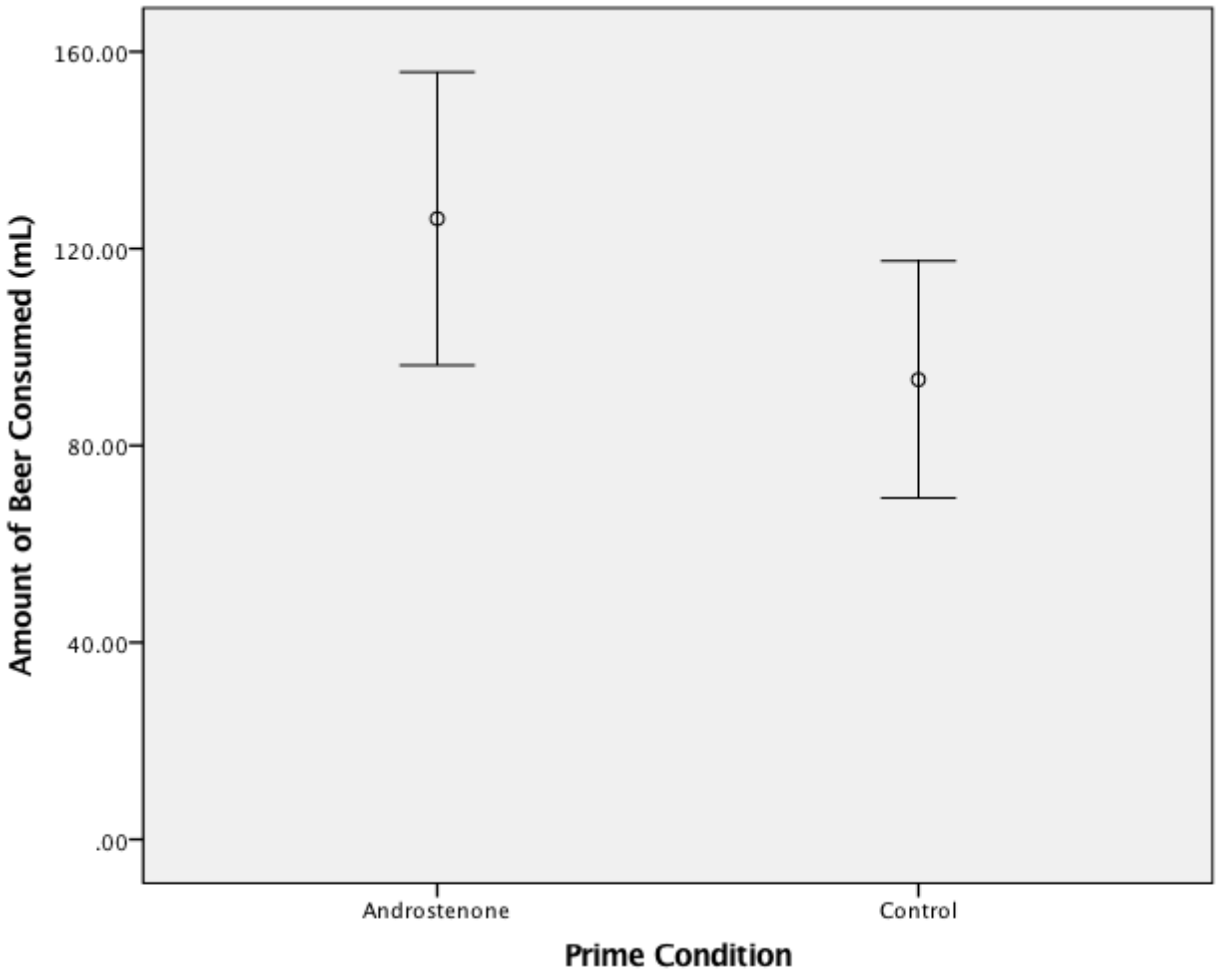

Figure 2. Graph of the 95% confidence interval of amount of beer consumed by group.

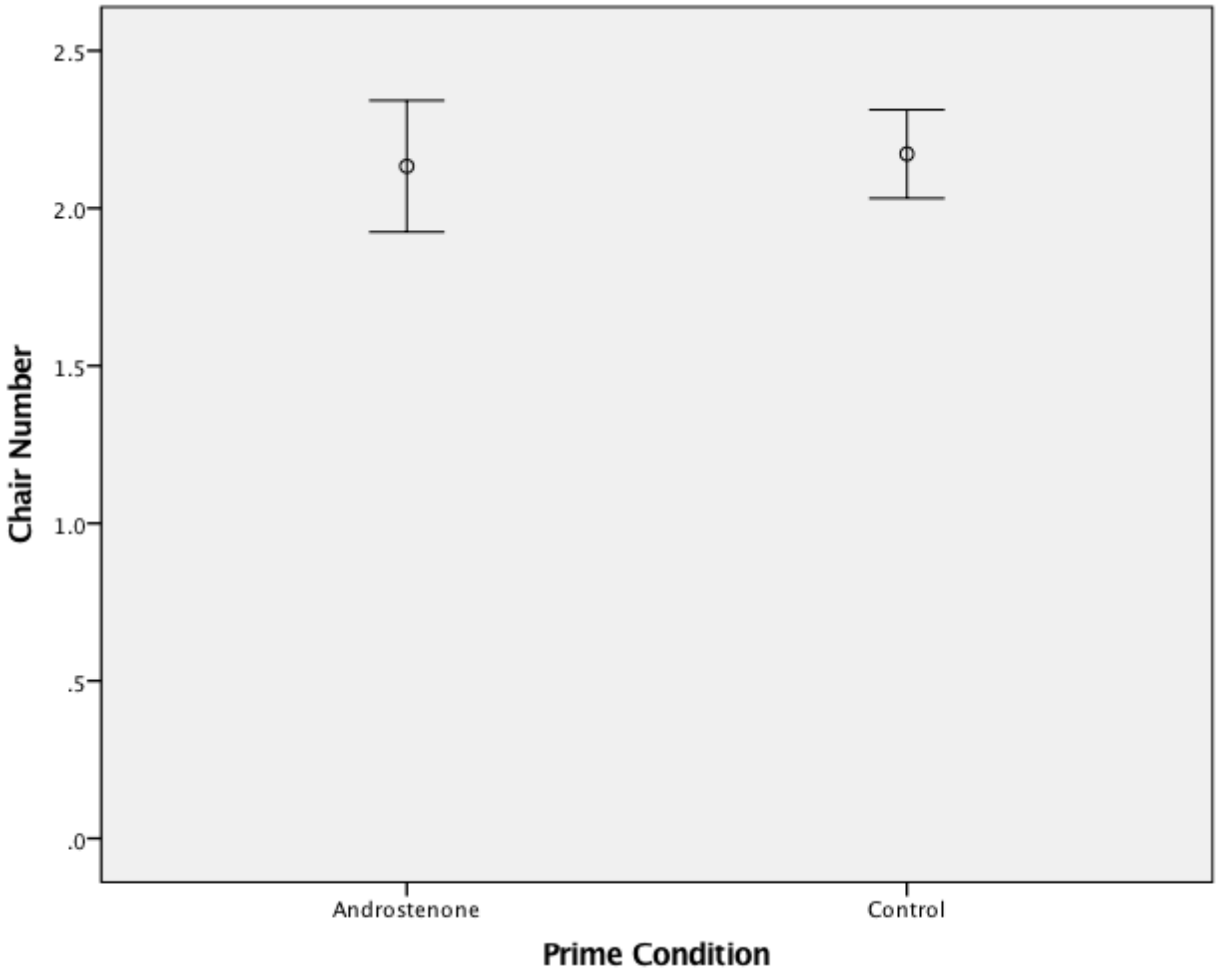

Figure 3. Graph of the 95% confidence interval of chair number by group.