Oral Contraceptives and Emotional Memory

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Thesis submitted in partial fulfillment of the requirements for the MA Clinical Psychology program

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Abstract

Previous research has suggested that oral contraceptive (OC) use is associated with altered memory for an emotional story. The current study further examined the extent to which OCs influence emotional memory by examining the relative recall of positive and negative stimuli and whether memory would be altered for general information (gist) versus specific details of the emotional stimuli used. The study involved the assessment of memory for a visually presented narrated emotional story and an emotional visuospatial task in 135 participants (58 OC users, 40 nonusers, and 37 men). Short-term memory was examined and a surprise recall test was administered one week later to assess recall of positive and negative emotional information, as well as recall of gist versus detail for emotional and neutral information. Based on previous research, it was hypothesized that OC users and men would have enhanced memory for gist in all emotional memory conditions compared to neutral conditions and that nonusers would show the opposite effect, showing enhanced memory for detail in all emotional memory conditions compared to neutral conditions. There was no support for these hypotheses. However, overall, OC users remembered relatively more positive than negative items (or less negative than positive items) than nonusers and men in the emotional visuospatial task. OC users also recalled fewer negatively-valenced items than did nonusers. This finding held even after controlling for group differences in negative affect. The results suggest that OCs may affect the immediate recall of emotional stimuli. These findings may provide insight into the effects of OCs on emotional memory and the emotional and cognitive side effects of OCs.

Acknowledgments

I would like to express my sincere appreciation to my supervisor, Dr. Kirsten Oinonen. Her guidance, insight, advice, and support has meant a great deal to me and to this project. I would also like to thank my committee members, Dr. Michael Wesner and Dr. Gordon Hayman for their comments and suggestions. I would also like to thank my friends and family for their continued support and encouragement throughout my academic pursuits. Lastly, a great thanks to all the participants who took part in this study, for without them, this project would not be possible.

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Oral Contraceptives and Emotional Memory

Introduction

Research has indicated that hormones can affect cognition and mood, and that there are menstrual cycle phase effects on cognition and mood (see reviews in Erlanger, Kutner, & Jacobs, 1999; Romans, Clarkson, Einstein, Petrovic, & Stewart, 2012; Steiner, Dunn, & Born, 2003). Studies have also suggested that oral contraceptives (OCs) can influence mood (see reviews in Kurshan & Epperson, 2006; Oinonen & Mazmanian, 2002). While few studies have examined OC effects on cognition (see review in Gogos, Wu, Williams, & Byrne, 2014), surprisingly little is known about the effects of OCs on cognition despite their frequent use. According to Mosher and Jones (2010), 82% of women between the ages of 15 and 44 in the United States have taken OCs during their lifetime. This necessitates the need for more research on physical, emotional, and cognitive side effects of OCs. Moreover, 59% of women who discontinue OCs in favour of another contraceptive method do so because of side effects (Rosenberg & Waugh, 1998). Therefore, given that side effects are a major complaint, it is critical for women to be informed of potential side effects, both positive and negative that may be associated with their birth control method. Women should fully understand any potential effects of OCs on their health and well-being. As a bonus, research in this area also contributes to our understanding of hormonal mechanisms in cognition and affect.

A recent study by Nielsen, Ertman, Lakhani, and Cahill (2011) found that OC use was associated with altered memory for an emotional story. It was found that women using OCs exhibited enhanced memory of gist (central information), but not story details, in the emotional story condition compared with the neutral story condition. That is, in

contrast to their recall of non-emotional information, OC users seemed better able to recall generalities but not details when emotional information was involved. In contrast, free-cycling women (i.e. those not taking hormonal contraceptives) exhibited enhanced memory for story details, but not of gist, in the emotional compared with neutral story conditions. These findings suggest that the use of OCs may affect memory for emotional information. Some mechanisms for an effect of OCs on emotional memory may involve: (a) sex and stress hormone interactions involved in memory formation, (b) brain plasticity, and/or (c) hemispheric lateralization of the amygdala. Each of these possibilities is discussed below.

The amygdala functions in part to modulate the storage of emotional information. A relationship between the degree to which the amygdala is activated in response to emotional stimuli, and the degree to which those events are subsequently recalled has been found (e.g., Cahill et al., 1996). Furthermore, research suggests a sex-related hemispheric lateralization of the amygdala where activity on the right side during exposure to emotional stimuli correlates with emotional memory in men and activity on the left side correlates with emotional memory in women (Cahill, Uncapher, Kilpatrick, Alkire, & Turner, 2004; Cahill et al., 2001; Canli, Desmond, Zhao, & Gabrieli, 2002; Mackiewicz, Sarinopoulos, Cleven, & Nitschke, 2006; Schneider et al., 2011). Possibly related to this is evidence suggesting that the two cerebral hemispheres differentially process more global versus local aspects of a stimulus or scene. Research indicates that the right hemisphere is biased toward the processing of global aspects or the gist of a stimulus or scene, whereas the left hemisphere is biased toward more local or detail oriented processing of the same stimulus or scene (Beeman & Bowden, 2000; Fink,

Marshall, Halligan & Dolan, 1999; Fink et al., 1996). Given that on anatomical grounds, each amygdala modulates its own hemisphere (Cahill, 2009), it is plausible to hypothesize that men who show more activity in the right amygdala in response to emotional stimuli will remember more global aspects or the gist of emotional information while women who show more activity in the left amygdala in response to emotional stimuli will remember more local aspects or details of emotional information. With this in mind and the fact that OC users have shown unaltered amygdala reactivity and slower habituation to emotional stimuli (Gingnell et al., 2013) it is reasonable to hypothesize that OCs can influence emotional memory. If the above sex differences in the processing of information are related to hormones, OC users' memory performance may show a shift towards the male patterns given that OCs reduce absolute levels and the natural cyclicity of endogenous hormones (e.g., Fleischman, Navarrete, & Fessler, 2010). More specifically these previous findings suggest that OC users will show a bias toward the processing of global aspects or the gist of emotional information (more like men), and nonusers will show a bias toward the processing of more local aspects or details of the same information (more like women).

Hormones and Cognition

Research has shown that hormones can have profound effects on affect and cognition. A hormone is a chemical substance that is secreted by endocrine glands that can exert physiological control over other cells (Neave, 2008). It is through their actions on the central nervous system that hormones influence both sexual and social behavior, affect, and cognition. Sex hormones are known to directly influence the hypothalamus and hippocampus and these brain areas are implicated in the interpretation of sensory

information, emotional processing, and perception and memory (Hines, 2010). Researchers and clinicians have been increasingly studying the potential role of hormones in the etiology and possible treatment of cognitive problems associated with a range of conditions that affect the central nervous system (Erlanger et al., 1999). There is also evidence that hormones have a major influence in the organization, and perhaps maintenance, of human sex differences in cognition (see Feingold, 1996; Kimura, 2004). For an extensive and comprehensive review of the effects of hormones on cognition see Erlanger et al. (1999) and Luine (2008). A few brief examples on how hormones affect cognition or, more specifically memory, follow.

Estradiol belongs to a class of steroid hormones called estrogens. This hormone has been studied for its role in cell proliferation, especially in the non-proliferative cells of the reproductive tract (Gupta, Johar, Nagnal, & Vasavada, 2005). Estradiol has also been found to rapidly excite neurons in the cerebral cortex, cerebellum, and the CA1 pyramidal neurons of the hippocampus (McEwen & Alves, 1999). This hormone is capable of modulating dendritic spine formation, activating neurite growth, modulating calcium handling, and regulating early gene expression (McCarthy, 2008). Estrogens may also exert a measurable neuroprotective effect on the brain (Hagemann, Tarik, Ekkehard, Hans-Joachim, Clemens, Otto & Christian, 2011).

In regards to effects on memory, Solis-Ortiz and Corsi-Cabrera (2008) have found evidence that high levels of estrogen may increase visuospatial memory on a modified version of a Localization Test. According to Maki, Rich, and Rosenbaum (2002) estrogen may in fact have a favourable effect on tests of implicit memory in young women. More specifically they suggest that estrogen may facilitate the automatic

activation of verbal representations in memory. In addition, the synthesis of acetylcholine, known for its role in memory, is facilitated by estrogen-induced increases in choline acetyltransferase (McEwen & Parsons, 1982). This may be a possible mechanism by which estrogens, or more specifically estradiol, can improve memory function.

Androgens or male sex hormones (e.g., testosterone) have also been shown to have effects on learning and memory. Testosterone deprivation is associated with poor memory in men and replacement can enhance memory and spatial cognition, however, there are gaps in our knowledge regarding the degree to which testosterone affects cognitive performance in women (see review in Janowsky, 2006). In a study by Aleman, Bronk, Kessels, Koppeschaar, and van Honk (2002) it was found that a single administration of 0.5mg of testosterone improved visuospatial ability (a 3-D Mental Rotations Test) in young women. Postma et al. (2000) found a single administration of 0.5mg of testosterone to improve selective aspects of object-location memory in young women. These studies suggest that testosterone may be related to visuospatial ability in young women, more specifically, on tests that have been associated with male superiority. Although these studies involved exogenous testosterone, in a review by Herlitz and Lovén (2009) it was concluded that endogenous testosterone does not affect cognitive sex differences substantially.

Cortisol is another hormone that has been linked to memory, more specifically the emotional aspects of memory. There seems to be an interaction between stress hormones, like cortisol, with sex hormones, that together affect emotional memory performance. Cortisol administration has been found to enhance memory for details of a

neutral story but impair memory for details of an emotionally arousing version when memory was tested one week later (Rimmele, Domes, Mathiak, & Hautzinger, 2003). Similarly, Kuhlmann, Kirschbaum, and Wolf (2005) found that acute cortisol administration after learning but prior to retrieval, impaired 5-hour recall of only negative words from a list of negative and neutral words. Using the same method, Kuhlmann and Wolf (2005) confirmed their previous work and found cortisol to impair memory for emotional words whereas neutral words were found to show a non-significant trend towards being adversely affected by cortisol administration. The authors concluded that stress and cortisol treatment (four hours after learning but one hour prior to retrieval) impairs memory retrieval, and that prolonged cortisol treatment produced pronounced negative effects on declarative memory. In addition, Kulmann and Wolf (2005) found evidence suggesting that estrogens may modulate the cortisol effect on memory (reducing retrieval impairment), as progesterone was found to have no influence on the cortisol effects.

Overall, there is evidence that hormones can affect different forms of memory and furthermore that hormones may play a role in cognitive sex differences. Generally, it is likely that many hormones and hormonal interactions are involved in explaining individual differences in cognition and memory. Given evidence that hormones can affect cognition and that women experience cyclical changes in hormone levels across the menstrual cycle, it is not surprising that research has also examined menstrual cyclicity in cognition.

The Menstrual Cycle

An understanding of the human female menstrual cycle and the fluctuations in hormone levels throughout different phases is important in understanding how hormonal fluctuations affect women's cognitive functioning. During the menstrual cycle, physical and biochemical changes occur in the mature female body that makes it possible to conceive. The normal cycle lasts 25 to 35 days but most literature refers to a standard 28-day cycle. The menstrual cycle is divided into two main phases (follicular and luteal), which can be further divided up in a total of six distinct phases, each corresponding to certain physical and hormonal changes. However, the names of phases and the days within each do vary in the literature. The follicular phase typically consists of days 1 to 14, with day 1 being the first day of menses. The luteal phase consists of days 15 to 28, with day 28 being the day before next menses. In the 28-day cycle, days 1 to 5 are referred to as the early follicular phase, or the menstrual phase, days 6 to 10 are considered the middle follicular phase, days 11 to 14 comprise the late follicular phase, ovulatory phase or periovulatory phase, and days 15 to 28 are regarded as the luteal phase. Within the luteal phase, days 15-19 are regarded as the early luteal phase, 20 to 24 as the midluteal phase, and 25 to 28 as the late luteal phase (Hawkins & Matzuk, 2008).

In the first phase, early follicular or menstrual phase, the uterus sheds the uterine lining, a layer of blood-enriched tissue that enables pregnancy through successful implantation of a fertilized egg (Lessey, 2000). If the woman did not become pregnant in the previous cycle the lining is shed through the process of menstruation. All hormone levels (i.e. estradiol, progesterone, LH, FSH) are low during this phase of the menstrual cycle (Carlson, 1991; Hampson & Young, 2008).

In the second phase, called the middle follicular phase, estrogen and progesterone are still at their lowest during the beginning of the phase. Later on in the phase, estrogen levels rise, while progesterone levels remain low. The pituitary gland begins to increase production of follicle stimulating hormone (FSH), which causes ovarian follicles to begin maturing. The middle follicular phase is sometimes called the postmenstrual phase, and is characterized by low hormone levels, with FSH being slightly elevated (Carlson, 1991; Hampson & Young, 2008).

In the third phase, late follicular or ovulatory phase, ovulation occurs wherein the follicle wall ruptures, and the ovum is released (Schnatz, 1985). During the beginning of the phase, the maturing follicles begin to secrete estradiol due to a rise in luteinizing hormone (LH), which inhibits further secretion of FSH from the pituitary gland. The increase in estradiol and other estrogens signals the thickening of the uterine lining in preparation for possible conception. The decrease in FSH slows the growth of ovarian follicles until the eventual death of all but one follicle that secretes inhibin to further suppress FSH production. The surviving follicle continues to mature while secreting estradiol which then triggers the release of LH (Havez, 1979). The high levels of LH signal ovulation and the fact that conception is most likely to occur, providing that the time of intercourse coincides. However, it is worth noting that only about 30% of women have their fertile windows fall entirely within the days of the menstrual cycle as identified by clinical guidelines (i.e., between days 10 and 17; Wilcox, Dunson, & Baird, 2000). In addition to the high levels of LH, other hormones such as FSH and estrogen are at increased levels, with LH and estrogen being particularly high (Carlson, 1991; Hampson & Young, 2008). However, it is worth noting that FSH, LH, and estradiol all reach

cyclical peaks during this phase and that these hormone levels are not consistently high across the phase.

In the luteal phase (further divided into early, mid, and late luteal), the released follicle, now called the corpus luteum, secretes large amounts of progesterone and estrogens. Increased progesterone helps create an environment that is ready for the implantation of a fertilized egg. In the mid-luteal phase, estradiol levels rise to moderate levels, progesterone levels peak, and pituitary secretion of LH and FSH diminishes. If pregnancy does not occur, the corpus luteum perishes while progesterone and estradiol levels decline, causing menstrual flow and the reoccurrence of the menstrual cycle. As noted above, the luteal phase can be further divided into early, mid, and late luteal phases, as hormone levels are significantly different throughout. In the early luteal phase, also referred to as the postovulatory phase (days 15 to 19), estrogen, LH, and FSH all drop fairly rapidly following ovulation, while progesterone starts to rise. In the mid luteal phase (days 19 to 24), LH and FSH levels are low and slowly dropping, estrogen levels rise slightly to moderate levels, and progesterone levels rise and then level out at their peak. In the late luteal phase, sometimes referred to as the "premenstrual" phase (days 25 to 28), LH and FSH are very low and slowly drop, estrogen levels drop back down, and progesterone levels drop rapidly. Thus, the six menstrual cycle phases show some distinct hormonal differences.

The Menstrual Cycle and Cognition

Researchers have used the phases of the menstrual cycle to explore how cognitive performance changes with fluctuations in endogenous hormones. However, it is important to note the disparity that exists in how phases have been delineated in each

study. Some researches use different sub-phases within each phase such as the mid-luteal phase (e.g., Maki, Rich, & Rosenbaum, 2002) while others use the phase as a whole such as the luteal phase (e.g., Nielsen, Ahmed, & Cahill, 2013). Some researchers prospectively assign women to groups based on cycle days and phases (e.g., Jarva & Oinonen, 2007) while other researchers test women regardless of cycle day and retrospectively assign them to cycle phases (e.g., Lens, Driesmans, Pandelaere, & Janssens, 2012). Both of these designs define cycle phase according to day of cycle and rely either on the insight or accuracy of the participant and a calendar counting method (e.g., Anderson et al., 2010). The best designs use day of cycle calculations based on a participant's self-report but also include other measures like body temperature, hormonal assays, or ovulation kits to validate menstrual cycle day/phase (e.g., Andreano, Arjomandi, & Cahill, 2008; Solis-Ortiz and Corsi-Cabrera, 2008). One potential confound found in this type of research is the high incidence of anovulatory cycles in young women. As rates are as high as 26.9% (Lopez, Verdejo, Javier, Ordonana, & Gomaz-Amor, 2010), it is possible that not all women are ovulating, which can introduce error in findings that do not include an objective confirmation of ovulation. Finally, additional methodological challenges in menstrual cycle research often leave researchers with smaller data sets, and as a result, greater difficulty in detecting effects. This is especially the case when multiple test sessions are used to detect changes across the menstrual cycle, as there are often high dropout rates and participants frequently do not fall within the cycle phase that they were expected to (e.g., Mordecai, 2006).

Researchers tend to examine cognition in women during certain menstrual cycle phases. Typically women are studied in the early follicular phase when estrogen and

progesterone levels are at their lowest (days 2 to 5) and the midluteal phase (days 19 to 24) when estrogen and progesterone levels are considerably higher (Mordecai, 2008). Thus, researchers most interested in the effects of progesterone will likely compare the midluteal phase with any of the follicular phases (with recognition that estrogen differs amongst them). Researchers interested in the effects of estrogen will likely compare the late follicular with the early follicular phase or even the midluteal with the early follicular phase (with recognition that both estrogen and progesterone are high in the midluteal phase).

This next section will review some of the relevant literature regarding the menstrual cycle and cognition (see reviews in Sacher, Okon-Singer, & Villringer, 2013; Souza, Ramos, Hara, Stumpf, & Rocha, 2012), with a main focus on memory. Of particular interest is a study by Nielsen, Ahmed, and Cahill (2013) that examined the effect of menstrual cycle phase at time of encoding on the retention of gist and detail information for either an emotionally arousing or neutral story. Gist was defined as central information or the main elements of the story whereas detail pertained to specific peripheral elements of the story. A surprise free recall test for story details was administered one week following exposure to the story. The results indicated that women in the luteal (high hormone) phase exhibited enhanced memory for details, but not gist, in the emotional compared to neutral story condition. In contrast, women in the follicular (low hormone) phase did not show enhanced memory for gist or details in the emotional compared to neutral story condition. Women in both menstrual cycle phases performed similarly on measures of attention and arousal. The findings suggest that cycle phase at

encoding influence long-term memory for different types of emotional information (gist versus detail).

Visuospatial ability and memory are areas of cognitive functioning that have been studied across the menstrual cycle. A study by Maki, Rich, and Rosenbaum (2002) addressed both verbal and spatial implicit memory. They found a positive association between verbal priming and being in the mid luteal phase (high estrogen and progesterone) while visuospatial priming was negatively correlated with estrogen and progesterone. Therefore, the effects of visuospatial priming are evident while estrogen levels are low. Likewise, low levels of estradiol and progesterone during menses have been shown in multiple studies to be associated with greater visuospatial ability relative to the follicular and luteal phases of the menstrual cycle (Hausmann, Slabbekoorn, VanGoozen, Cohen-Kettenis, & Gunturkun, 2000; Maki et al., 2002; Silverman & Phillips, 1993). Thus, there could be a menstrual-phase advantage in visuospatial ability for women across the menstrual cycle.

Hampson, Finestone, and Levy (2005) found that performance on a conventional perceptual closure task was better in women during the menstrual phase than in women in the midluteal phase, consistent with a menstrual-phase advantage on visual-perceptual and spatial tests. It seems as though high levels of gonadal hormones, as seen in the luteal phase, may facilitate skills favoring females (verbal-articulation, fine motor) but be detrimental to skills favoring males (spatial ability, deductive reasoning) and that performance on these male-favored tasks improves during the menstrual phase when hormone levels are at a low (Hampson, 1990). These results suggest that performance on

tests of mental rotation and other spatial abilities is improved at phases of the menstrual cycle characterized by low estrogen and decreased at phases of high estrogen.

Kimura and Hampson (1994) specifically studied cognitive abilities that show reliable sex differences, and compared phases of the menstrual cycle in which circulating concentrations of estradiol, or estradiol and progesterone, are maximal or minimal. It was found that women performed better on tests of manual dexterity (known to favour females) and performed more poorly on a perceptual-spatial task (known to favour males) during the midluteal phase of the menstrual cycle. This suggests that high levels of ovarian hormones during certain phases of the menstrual cycle may facilitate certain skills that show a female advantage, while being detrimental to skills that show a male advantage. Kimura and Hampson (1994) further tested cognitive performance a day or two before ovulation, when estradiol levels are extremely high, but progesterone levels are still relatively low, to help understand the role that hormones play in the relationship. Again, women performed significantly better on tests of manual and articulatory speed, and accuracy at high estradiol levels, and poorer on tests of visuospatial ability. In a study by Silverman and Phillips (1993) this pattern was also shown with women in the menstrual phase of the cycle. In line with expectations, women showed significantly better spatial performance during the menstrual phase, compared to performance during the early luteal phase (high estrogen and progesterone levels).

In terms of other memory tasks, Phillips and Sherwin (1992) found lower delayed recall (story memory) during the menstrual phase compared to luteal phase and that the visual memory decrease was significantly correlated with progesterone in the luteal phase, suggesting that changes in memory test performance may be associated with sex

steroid levels across the menstrual cycle. However, Natta and Nagaya (2009) found no significant difference between the midluteal and menstrual phase for performance on the Wechsler Memory Scale's logical memory task (recall and recognition for a short story) and no correlation between hormone level and memory task performance for either phase. Protopopescu et al., (2008) assessed verbal declarative memory across the menstrual cycle using a computerized recognition task of 360 words (240 previously seen words and 120 distracter words) but compared the late follicular and late luteal phases of the menstrual cycle. The authors found that verbal declarative memory was increased in the late follicular phase (days 10-12 after onset of menses) in comparison to the late luteal phase (1-5 days before the onset of menses), suggesting that estrogen-dependent cyclical alterations might account for cognitive differences across the menstrual cycle.

Gasbarri, Pompili, D'Onofrio, Cifariello, and Tavares (2008) found that high levels of estradiol in the follicular phase (confirmed by immunoassay) could have a negative effect on a delayed matching-to-sample working memory task when using stimuli with emotional valence. The task involved the presentation of a sample stimulus (a pictured actor displaying 1 of 6 different facial expressions). After a delay, four comparison stimuli were presented, one being the same as the sample stimulus and the other three different. The percent errors were significantly higher for the emotional expressions of sadness and disgust during the middle to late follicular phase (days 4 to 13) when compared to the menstrual phase (days 1 to 2), suggesting that the high levels of estradiol might impair the performance of working memory. In another study, Phillips and Sherwin (1992) found delayed recall of visual stimuli to be significantly higher in the luteal phase compared with menses. Similarly, Andreano et al. (2008) found that cortisol

was positively correlated with story recall only for women in the mid-luteal phase. The authors suggest that if subjects had been tested in the follicular phase a stronger relationship may have been seen when progesterone levels do not mediate the effects of estradiol.

Another set of studies has suggested that progesterone plays a role in neural reactivity to emotional images. Andreano and Cahill (2010) had women view negative and neutral images selected from the International Affective Picture System (IAPS) in the early follicular phase (defined as 0 to 7 days since onset of menses) and mid-luteal phase (defined as 18 to 24 days since onset of menses) of the menstrual cycle. Results showed that women in the mid-luteal phase, where progesterone is high, had significantly enhanced activity in response to negative images in the hippocampus and amygdala when compared to those in the early follicular phase. This was in line with van Wingen, Ossewaarde, Backstrom, Hermans, and Fernandez (2008) who demonstrated that high levels of synthetic progesterone (400mg of micronized progesterone administered orally) significantly increased amygdala responses to emotional images (angry and fearful face stimuli) compared to neutral images (horizontally or vertically oriented ellipses). Furthermore, Goldstein et al. (2005) showed that women in the late follicular phase, where estrogen is high, showed significantly decreased responses in several limbic, frontal, and hypothalamic regions in response to visual images from the International Affective Picture System (IAPS). Therefore, it seems that estrogen and progesterone may play different roles in modulating the arousal centers of the brain and perhaps emotional memory processing across the menstrual cycle.

Attention is also another area of cognitive functioning related to memory that has been studied across the menstrual cycle. The maintenance of attention is key to successful information processing, thus, it is important to understand how attention may co-vary with cognitive function across the menstrual cycle. One study by Anderson and colleagues (2010), found that high fertility women (near ovulation) paid relatively more attention to attractive male targets in arrays of varying faces than low fertility women. It was found that high fertility increased visual attention to men, but that the increase in attention did not translate to better memory. Therefore, high fertility was associated with more attention to attractive men relative to low fertility. The authors hypothesized that the results mitigated against a cognitive processing explanation, but perhaps is a strategic inclination, where increased visual attention by highly fertile women serves as a nonverbal signal for romantic interest. Similarly, Lens, Driesmans, Pandelaere, and Janssens (2012) found that women pay more attention to status products (e.g., Porsche, exclusive mansion, ipod) as opposed to functional products (e.g., bucket, towel, bicycle) in a visual display around ovulation than in other phases of the menstrual cycle. Interestingly, OC use eliminated these cycle phase effects. These results suggest that biological processes, such as the flow of hormones, may affect attention. In a third study, sustained attention showed an increase in the early luteal phase (days 20 to 21), when progesterone levels are high (Solis-Ortiz & Corsi-Cabrera, 2008). Lastly, Hatta and Nagaya (2009) examined differences in an attention-related task (evaluated by the Stroop test) during the menstrual and midluteal phase. The results revealed a significant difference in Stroop test performance (required time for colour naming) with higher scores in the menstrual phase than in the midluteal phase but no correlation between

hormone level and attention task performance. These findings suggest that menstrual cycle phase may affect cognitive attention-related performance. Research regarding the effects of hormones on attention deserves further study. This area of research is of importance because of its impact on performance with other cognitive abilities such as memory.

In summary, it has been found that menstrual cycle phase at encoding can influence long-term memory for different types of emotional information (e.g., enhanced memory for detail in the luteal phase), can modulate the arousal centers of the brain and perhaps memory processing (e.g., enhanced activity in response to negative images in the hippocampus and amygdala during the luteal phase), and is related to performance on a working memory task using emotional stimuli (i.e., impaired during the follicular phase). There is also a menstrual cycle phase advantage in visuospatial ability (e.g., improved performance on tests such as mental rotation and other spatial abilities at phases of the menstrual cycle characterized by low estrogen), and high levels of ovarian hormones during some phases of the menstrual cycle may facilitate certain skills that show a female advantage (e.g., manual dexterity) and be detrimental to skills that show a male advantage (e.g., perceptual-spatial task). Finally, with respect to attention, there is evidence of an increase in sustained attention in the luteal phase, and greater attention to attractive male targets and status products during the periovulatory phase.

Overall, research on cognitive changes that may be associated with hormonal fluctuations across the menstrual cycle suggests subtle cyclical changes in a number of cognitive abilities. It might be expected that cognitive areas, which remain relatively stable over long periods of time, will not be easily affected by hormonal changes during

the menstrual cycle. However, evidence does exist for noticeable influences of hormone level or menstrual cycle phase on cognitive functions as seen in the above literature review. Given this evidence, it seems plausible that greater cognitive changes would be seen after a more prolonged period of hormonal change, such as that which occurs when women use OCs. Thus, cognitive differences between OC users and free-cycling women is an area worthy of study in order to determine all potential side effects of OCs and to better understand the role of hormones in cognition. A brief overview of the hormones and hormonal mechanisms involved in oral contraceptives is given below before discussing research on oral contraceptives, cognition, and memory.

Oral Contraceptives

Oral contraceptives (OCs) have a considerable impact on the natural processes of the menstrual cycle by disrupting normal hormone fluctuations. The majority of women taking OCs are prescribed pills containing synthetic forms of estrogen and progesterone while progestin-only pills are also available. The synthetic hormones suppress LH and FSH levels, impeding follicular development and ovulation to prevent pregnancy. Consequently, the expected natural surges in endogenous estrogens and progesterone during the follicular and luteal phases do not occur (Fleischman, et al., 2010). Circulating levels of these two hormones are estimated to be at least 50% less in OC users than those found in naturally cycling women (Fleischman, et al., 2010; Gordon & Lee, 1993). Production of testosterone is also diminished in users (Coenen, Thomas, Borm, Hollanders, & Rolland, 1996; Liening, Stanton, Saini, & Schultheiss, 2010; Zimmerman, Eijkemans, Bennink, Blankenstein, & Fauser, 2014). Therefore, with OC use, the natural production of hormones is inhibited by synthetic versions of estrogen

and/or progesterone, essentially eliminating any menstrual-cycle variability for monophasic users during days of pill use. In general, OCs have a stabilizing effect on hormone levels by reducing levels and endogenous fluctuations across the menstrual cycle.

There is a possibility that OCs may show effects on women's cognition and memory, which makes it imperative that we explore these side effects for the benefit of women's well-being and functioning. Various physiological effects such as induced nausea, weight gain, and increased risk for more serious health problems, such as stroke, have been identified as possible effects that OC use can have on women's bodies (e.g., Seibert et al., 2003). Behavioural or emotional side effects have also been reported, such as emotional lability and decreased sexual desire (Battaglia et al., 2012; Sanders, Graham, Bass, & Bancroft, 2001).

According to Mosher and Jones (2010), 82% of women between the ages of 15 and 44 in the United States have taken OCs during their lifetime. This necessitates further research on physical, emotional, and cognitive side effects. As noted above, Rosenberg and Waugh (1998) found that 59% of women who discontinue OCs in favour of another contraceptive method do so because of side effects. It is important for women to be informed of the possible side effects of OCs and the effect OC use might have on their health, especially considering the widespread use of OCs and the evidence that side effects are a major complaint for many women.

Since women taking OCs do not experience hormonal fluctuations like free-cycling women do, they can serve as a useful control group to assess whether physical or behavioural changes across the menstrual cycle are specifically related to specific

hormonal influences. Also, OCs may cause physical, emotional, or cognitive side effects due to the lack of hormonal fluctuation, reduced hormone levels, or the presence of exogenous hormones. Thus, researchers have examined such side effects of OC use. However, like studies assessing changes over the menstrual cycle, there are some difficulties surrounding this research. Because of the wide variety of OCs available to women it is sometimes difficult to compare results across studies since all OCs do not contain the same type of hormones, the same amount of hormones, or have the same pattern of administration (e.g. monophasic versus biphasic versus triphasic OCs). OCs can contain different types of progestogens (e.g., progesterone, norgestimate, norgestrel, medroxyprogesterone, levonorgestrel, and drospirenone) and a few different types of estrogens, but most commonly contain ethinyl estradiol. Pills can contain both estrogen and progestogens (combined pill) or they can contain only progestogen (progestogen-only pills). In addition, some progesterones can be more androgenic (e.g., levonorgestrel, methyltestosterone, norgestrel) while others can be more anti-androgenic (e.g., drospirenone, norethynodrel, norgestimate) (Sitruk-Ware & Nath, 2013). There is also the problem of whether women participating in studies are taking their pills every day at the same time as prescribed. Some women may forget to take a pill or take them at varying times (e.g., Potter, Oakley, de Leon-Wong, & Canamar, 1996; Rosenberg, Waugh, & Thomas, 1995), which can influence the effectiveness of the pill and as a result influence the outcome of studies. Regardless, research on OCs is vital to our understanding of hormonal influences and the effects that OCs can have on women's behaviours, emotions, and cognition.

Oral Contraceptives, Affect, and Mood

Although most research has focused on differences between OC users and nonusers in *level* of mood or affect, other studies tend to suggest that there is less mood *variability* or reactivity in OC users compared to nonusers (see review in Oinonen & Mazmanian, 2002). OC-related mood changes, including mood reactivity and mood variability, are possible side effects of OC use. However, more research is needed in order to examine possible specific differences between users and nonusers. The finding of reduced mood variability in OC users is plausible for two reasons. First, mood change during times of hormonal fluctuation in women is a well-documented phenomenon (for review see Steiner, Dunn, & Born, 2003). Second, OC use tends to have a stabilizing effect on hormonal fluctuation and thus should reduce variability in mood. It is possible that OCs affect mood variability as opposed to overall mood levels. Mood variability can be examined between menstrual cycle phases, day-to-day, or within-day. Studying the variability of mood in OC users can help in gaining a better understanding of whether OCs act on mood stability.

However, research results have been inconsistent in studies examining the possibility of OC-related mood level changes. That is, some studies have found no differences (e.g., Natale & Albertazzi, 2006) while some studies have found differences in mood level with OC use (e.g., Poromaa & Segebladh, 2012). According to Oinonen and Mazmanian (2002) this may be partly due to different research designs, changes in OC formulation, or the survivor effect. The survivor effect (Kutner & Brown, 1972) occurs when women who experience negative side effects while taking OCs discontinue their use, resulting in an unrepresentative study group of women, as there is a lower

likelihood that the group of OC users contains those women who experienced negative effects. Thus, the incidence rates of negative mood change associated with OC use could be underestimations since women who experience moderate to severe mood effects would likely have discontinued OC use.

In a review of the literature, Oinonen and Mazmanian (2002) noted some evidence for the possibility that OCs exert a stabilizing effect on mood. Of the studies they reviewed, four studies suggested that OC users demonstrated less variability in affect than nonusers (Graham & Sherwin, 1993; Paige, 1971; Sutker, Libet, Allain, & Randall, 1983; Walker & Bancroft, 1990). Only one study (McFarlane, Martin, & Williams, 1988) found no significant differences in affect variability between OC users and nonusers. Given study limitations (e.g., survivor effect) and changes in OC formulations, further research is needed in order to draw any conclusions regarding the day-to-day stabilizing effect of OCs on mood.

In an earlier study by Oinonen and Mazmanian (2001) the relationship between affect (positive and negative) and OC use was examined across menstrual cycle phases and day-to-day using the Positive and Negative Affect Schedule (PANAS). The results showed no differences in positive or negative affect level between groups or menstrual cycle phases. For day-to-day affect variability, a significant result was found between the menstrual cycle phases. Both OC users and nonusers experienced less positive affect variability during the menstrual phase than during the other cycle phases. Furthermore, it was found that first-time monophasic users experienced higher positive affect (PA) variability during menstruation than did long-time monophasic, first-time triphasic, or long-time triphasic users. These findings suggest a possible withdrawal effect of

monophasic OCs on PA stability during early use of OCs, as the menstrual phase is the time when OC users are likely taking the inert pills.

Although Oinonen and Mazmanian (2001) did not find any differences in level of positive or negative affect between OC users and nonusers, it is still possible that OCs may influence affect level. With regards to the differential effects OCs may have on negative affect (NA), the majority of studies have found no group differences between users and nonusers across the entire menstrual cycle (Almagor & Ben-Porath, 1991; Marriott & Faragher, 1986; Paige, 1971; Wilcoxon, Schrader, & Sherif, 1976). However, group differences have been found at specific cycle phases. More specifically, consistent group differences in NA have been seen during the menstrual phase. For example, one study found higher levels of NA for monophasic OC users, but not for triphasic users (Walker & Bancroft, 1990), whereas four studies found that OC users experienced less NA than nonusers during the menstrual phase (Boyle & Grant, 1992; Paige, 1971; Sutker et al., 1983; Wilcoxon et al., 1976). Additionally, four studies found no group differences in NA during the menstrual phase (Alexander, Sherwin, Bancroft, & Davidson, 1990; Almagor & Ben-Porath, 1991; Graham & Sherwin, 1993; Natale & Albertazzi, 2006). Lastly, no relationship was found between negative mood and changes in plasma androgen levels induced by OC use in a study by Graham, Bancroft, Doll, Greco, and Tanner (2007). This study did not look at mood changes across the menstrual cycle like the previously mentioned studies but instead examined whether OC induced reduction in free testosterone adversely affects mood.

With regard to the differential effects OCs may have on positive affect (PA), few conclusions have been made due to there being only a small number of studies on PA

across the menstrual cycle. However, no consistent group differences in PA have been found at any of the menstrual cycle phases (Almagor & Ben-Porath, 1991; Boyle & Grant, 1992; McFarlane et al., 1988; Walker & Bancroft, 1990). Randomized controlled trials or studies minimizing the survivor effect are needed in order to draw firm conclusions surrounding the effects that OCs may have on PA across or during certain menstrual cycle phases.

Mood reactivity is another area of study that examines mood responses to events by measuring the difference in mood before and after exposure to an event or stimulus. However, there have been very few studies looking at differences between OC users and nonusers in terms of mood reactivity. Interestingly, one study by Jarva and Oinonen (2007) found that OCs may reduce the degree of positive affect change that women experience in response to environmental events. These results indicate that OCs may have a stabilizing effect on PA. The suggestion that OCs are associated with reduced mood fluctuations in OC users seems plausible given the reduced hormonal fluctuations in OC users across the menstrual cycle when compared to naturally cycling women. A blunted cortisol response in OC users (Cornelisse, van Stegeren, & Joels, 2011) or decreased receptor sensitivity to cortisol changes in OC users (Kuhlmann & Wolf, 2005) may be one possible explanation for this effect, resulting in fewer fluctuations in positive affect.

Despite the evidence reviewed above that OCs may provide some affect stabilization when women are examined as a group, there has always been a subgroup of women who report distinct increases in negative affect (e.g., depression, irritability) with OC use (e.g., Kulkarni, 2007). Given the hypothesis that some women may be more

sensitive to mood side effects of OCs than other women, recent research has moved towards examining women who have a history of such hormonal sensitivity. For example, in a recent study by Gingnell et al. (2013), using a randomized, double-blinded, placebo-controlled trial, women on OCs with a history of negative OC mood side effects had significantly increased scores of depressed mood, mood swings, and fatigue, whereas a similar group of women on placebos had virtually unchanged mood scores. In addition, women in the OC group had significantly higher scores of self-rated depression during the last week of OC exposure compared to their pretreatment ratings. The major findings from Gingnell et al. (2013) were that women with subjective reports of previous OC-induced mood deterioration exhibited depressive mood and mood swings when re-exposed to OCs. Furthermore, the intensity of these symptoms was significantly enhanced compared to the women randomized to placebo. The methodological strengths of this study provide strong evidence that OCs may induce mood deterioration in a sub-group of hormonally sensitive women.

Overall most of the research in this area has looked at the broad relationship between OC use and mood and the evidence has been inconclusive. The above review primarily focused more narrowly on the relationship between OC use and affect. While most of the studies are confounded by the survivor effect, the findings seem to suggest that OC use may have a stabilizing effect on PA whereas no evidence has been found for consistent differences between users and nonusers in NA.

Oral Contraceptives and Cognition

The effects of OCs on cognition have been explored to a lesser extent than cognitive changes across the menstrual cycle. However, there have been a number of

studies comparing women using OCs to free-cycling women (nonusers). While the focus of these studies was usually on examining the effects of free-cycling hormone levels on cognition, the results are relevant to also understanding possible cognitive effects of OC use. It is also of interest to mention that there is a body of literature which suggests that hormone replacement therapy after menopause can reduce Alzheimer's disease rates and increase cognitive ability in women (see reviews in Henderson 1997; Ryan, Scali, Carriere, Ritchie, & Ancelin, 2008). This provides evidence that exogenous hormones such as estrogens have the potential to affect cognition. A brief overview of the studies examining OC use in relation to cognitive performance follows.

One trend in the literature is that OCs appear to have a "masculinizing" effect on some aspects of women's behaviour (i.e., better performance on "male-favored" tasks). For example, women using OCs perform significantly better on tasks of mental rotation (a "male-favored" task) compared with free-cycling women (Silverman & Phillips, 1993; Wharton et al., 2008). A recent study by Pletzer, Kronbichler, Nuerk, and Kerschbaum (2014) suggests that OCs masculinize brain activation patterns in the absence of behavioural changes on two numerical tasks (number comparison and number bisection). That is, despite no difference between naturally cycling women and OC users in behavioral performance on the cognitive tasks, women taking OCs had brain activation patterns that were more similar to men than naturally cycling women. Behavioral performance and brain activation patterns (BOLD-response) were used to identify whether and how OCs altered women's number processing by examining OC users, naturally cycling women (nonusers), and men. The results revealed that OC users showed male-like brain activation patterns during both tasks, but resembled the

behavioural performance of naturally cycling women in the follicular phase (low hormone levels). These results suggest that the actions of OCs on brain activation and behaviour are not solely attributable to either androgenic or progestogenic effects of the synthetic steroids or the reduction of endogenous steroids, but rather a combination of these effects. In another study by Pletzer et al. (2010) on brain changes associated with OC use it was found that OC use led to enlarged grey matter volumes in brain regions with a sexual dimorphism favoring women (i.e., prefrontal cortex, the pre- and postcentral gyri and the supramarginal gyrus). Regions with a sexual dimorphism favoring men were much less affected by the use of OCs, except that the right hippocampus and parahippocampus showed a weak enlarging effect with OC use. While this study suggests more of a "feminizing" effect of OCs on the brain, the finding that OC use led to enlarged grey matter volumes in the right hippocampus and parahippocampus lends some support to the suggestion that OC use may have a masculinizing effect on some brain areas and behaviours, suggesting the possibility that behaviours subserved by the right hippocampus and parahippocampus may become more "masculine" with OC use.

In a recent study by Egan and Gleason (2012), chronic OC use was found to predict better cognitive outcomes later in life. A variety of 17 neuropsychological tests (e.g., the Wechsler Abbreviated Scale of Intelligence (WASI), Wide Range Achievement Test-3rd ed. (WRAT-3), and Wechsler Adult Intelligence Scale (WAIS-3)) were administered to 261 cognitively normal women aged 40 to 65, enrolled in the Wisconsin Registry for Alzheimer's Prevention. These tests assessed the domains of Verbal Ability, Visuospatial Ability, Working Memory, Verbal Learning and Memory, and Speed and

Flexibility. It was found that previous OC users preformed significantly better than women who had never used OCs (never users) in the domains of Visuospatial Ability and Speed and Flexibility, with duration-dependent increases in performance, especially in OC users with more than 15 years of use. While a limitation of this study is the self-selection for OC use and the possibility of premorbid group differences, the results provide preliminary evidence that OC use may have a long-term influence on some cognitive processes in midlife.

The progesterones in OCs differ in their androgenicity or anti-androgenicity, primarily related to their relative interactions with the progesterone receptor and the androgen receptor (Sitruk-Ware & Nath, 2013). A study by Wharton et al. (2008) investigated whether the androgenic activity of OCs mediates performance on sexually dimorphic cognitive tasks. Androgenicity refers to the property of producing physiological reactions similar to those produced by androgens (*Merriam-Webster's*, 2003). It was found that OC androgenicity influenced performance on a mental rotation task. More specifically, mental rotation performance was best in women using second generation OCs which are most androgenic (i.e., contain more androgenic progestins) compared to third generation users, Yasmin™ users, and nonusers. Furthermore, women using Yasmin™, which contains an antiandrogenic progestin, demonstrated poorer performance on the mental rotation task in comparison to second and other third generation users, as well as nonusers. Therefore, it seems as though it is the androgenic activity in some OCs that is responsible for enhanced performance on the mental rotation task. These results are consistent with the idea that some OCs, particularly ones with

androgenic effects (i.e., not Yasmin), could have a masculinizing effect on cognition that may enhance performance on male-favored tasks.

Overall, while only a few studies exist, the literature suggests that a relationship between OC use and cognitive changes, relative to nonusers, may exist. Theses changes include improved performance on visuospatial, speed, and flexibility tasks, as well as differences in mental rotation tasks. As will be discussed next, another cognitive change associated with the use of OCs may be an alteration in memory.

Oral Contraceptives and Memory

Only six published studies have examined the effects of OCs on memory (Egan & Gleason, 2012; Cornelisse, van Stegeren, & Joels, 2011; Kuhlmann & Wolf, 2005; Mordecai, Rubin, & Maki, 2008; Wharton et al., 2008; Wutke et al., 1975). Findings in this area often involve an interaction between OCs and stress hormones, such as cortisol, on memory. Cortisol is known to impair memory for emotionally charged stimuli (Mordecai et al., 2008). However, Kuhlmann and Wolf (2005) found no significant impairment in memory for word lists and number digit span with cortisol injection in OC users relative to naturally cycling women. The fact that free-cyclers experienced greater memory impairment with cortisol than OC users suggests that OC use may be associated with reduced sensitivity of the brain to acute exogenous cortisol elevations. Furthermore, Cornelisse, van Stegeren, and Joels (2011) found that women who used OCs had blunted cortisol responses when exposed to stress compared to males and also showed lower cortisol responses than naturally cycling women. They also suggested that the lack of cortisol response may have accounted for the lack of stress effects on memory in women, perhaps because OC use leads to blunted HPA axis responses. Again, this is in line with

studies showing that cortisol affects memory retrieval in naturally cycling women but not women who are using OCs (Kuhlmann & Wolf, 2005).

As mentioned above, Egan and Gleason (2012) looked at the relationship between OC use and cognition later in life and found that OC use may have a protective cognitive effect in some areas, especially with longer duration of use. However, no significant findings were found for OCs in the domains of Working Memory and Verbal Learning and Memory when assessed by the Wechsler Adult Intelligence Scale (WAIS-3) Working Memory index and Auditory Verbal Learning Test. Thus, the proposed protective cognitive effect of OC use may not pertain to these domains of memory in older adult users. Similarly, findings from Wutke et al. (1975) found no significant effects of OC use on memory with respect to performance tests when comparing OC users and nonusers. Furthermore, Wharton et al. (2008) found no significant differences on a verbal recognition memory task between OC users and nonusers. This task involved participants recognizing a list of 100 medium-to-high frequency words after a five-minute retention interval. Thus, these studies suggest no significant effects of OC use on the specific memory tasks used within each study (i.e., primarily verbal semantic memory tasks) when compared to the performance of nonusers.

Even fewer studies, a total of four, have examined the effects of OCs on emotional memory (Merz et al., 2012; Nielsen, Ahmed, & Cahill, 2014; Neilsen, Ertman, Lakhani & Cahill, 2011; Nielsen, Segal, Worden, Yim & Cahill, 2013). Given that research suggests that OCs can affect both emotion and cognition, it follows that OCs may have maximal effects on cognitive tasks that involve emotional stimuli. The four studies that examined the effect of OCs on emotional memory will be reviewed here.

One study by Neilsen, Ertman, Lakhani and Cahill (2011), examined the effects of OCs on memory for an emotional story. The authors specifically looked at memory for central story information (gist) versus peripheral details for both an emotionally arousing and closely matched neutral story. This was based on previous work that had shown a significant sex-related influence on memory for the gist versus detail of these stories (Cahill & van Stegeren, 2003; Cahill, Gorski, Belcher, & Huynh, 2004). In these previous studies, "gist" was defined by a 75% consensus rating from four independent judges as "any story element that could not be changed or altered without changing the fundamental story line" whereas "detail" was defined as all other recalled elements of the story. Nielsen et al. (2011) found that, similar to men in past studies, OC users had enhanced memory for gist but not detail in the emotional story condition compared with neutral story condition. The opposite was true for free-cycling women, as they showed enhanced memory for detail but not gist in the emotional compared with neutral story conditions. This is the pattern typically seen for women versus men on this emotional memory task. That is, men have shown enhanced memory for detail but not gist of the emotionally arousing story as opposed to the closely matched neutral story (Cahill, Gorski, Belcher, & Huynh, 2004; Nielsen, Ahmed, & Cahill, 2013). The authors postulated that it is plausible that OC usage alters emotional memory by disrupting normal sex/stress hormone interactions involved in memory formation. One weakness of this study design is that a between-subjects design was used to determine emotional and neutral scores within the two groups of OC users and nonusers (i.e., different women were tested on their recall of the neutral and the emotional stories). It seems important to

replicate these findings in a study where all four of the following scores are calculated for *each* participant: emotional gist, emotional detail, neutral gist, and neutral detail scores.

Nielsen, Segal, Worden, Yim and Cahill (2013) recently found further evidence that OC use alters stress responses and emotional memory. They found that women taking OCs displayed a significantly blunted endogenous cortisol response to the Cold Pressure Stress test when compared to naturally cycling women. OC women also showed significantly blunted overall noradrenergic response to emotional images from the IAPS database when compared to naturally cycling women. OC women who experienced noradrenergic activation at encoding and no cortisol activation while viewing the stimuli showed enhanced recall of emotionally negative information. The opposite was found for enhanced recall of positive images in OC women (i.e., only when cortisol was released post training in the absence of noradrenergic activation at encoding). No emotional memory enhancement for negative or positive images was seen for naturally cycling women, regardless of noradrenergic response and cortisol release. These results suggest that in OC users, norepinephrine at encoding and cortisol release post-training do not interact to enhance emotional memory. Instead, it seems that for women using OCs, stress hormones seem to act independently to enhance memory for emotional material depending on the valence of the stimulus.

A third study by Nielsen, Ahmed, and Cahill (2014) explored how a postlearning stressor might modulate the influence of OC status on memory for gist and detail in an emotional versus neutral story condition. Similar to Nielsen et al. (2011) OC users and nonusers viewed a brief narrated story containing either emotionally-arousing or neutral elements. However, immediately after exposure, a cold pressor stress (CPS) or a control

procedure was administered. One week later, a surprise free recall test was administered to participants. It was found that nonusers exhibited greater cortisol increases to the CPS procedure compared to OC users. Nonusers who viewed the emotional version of the story and were administered the CPS procedure recalled the most details overall and more gist from the emotional compared to neutral story version. However, in OC users, the CPS procedure did not affect memory for gist or detail from the emotional or neutral story in any way. Similar to Nielsen et al. (2011), OC users and nonusers did not significantly differ on measures of attention and arousal. The findings suggest that postlearning stress differentially affects memory for gist and detail from an emotional story depending on OC status. Again this study demonstrates that retention of emotional information differs in OC users and nonusers and perhaps OC status interacts with postlearning stress to modulate memory for emotional information.

Merz et al. (2012) found that OC use significantly modified cortisol effects on emotional learning in women. Although not the main brain area where emotional learning would be taking place, OC usage particularly modified cortisol effects in memory-related medial temporal lobe regions. Brain images were acquired using a 1.5 T whole-body tomography with a standard head coil. Fear learning was measured using a custom-made impulse-generator that provided transcutaneous electrical stimulation along with three geometric figures serving as conditioned stimuli, unconditioned stimuli, and a distractor stimulus. It was found that cortisol influenced neuronal correlates of fear conditioning depending on current sex hormone availability. More specifically, cortisol reduced fear learning in the anterior parahippocampal gyrus and hippocampus in men, and in free-cycling women in both the follicular (3rd to 8th day after the onset of their last

menstruation; cycle days 4 to 9) and luteal phase (3rd to 9th day before the onset of their next menstruation; cycle days 20 to 26 of a 28-day cycle), whereas it enhanced fear learning and neuronal differentiation in OC women. This shows the influence that sex hormones and OC use have on the basic modulation of emotional learning processes and their modulation by cortisol. This may be due to the exogenous hormones in OCs and not due to low endogeneous sex hormone levels since women in the follicular phase have low levels of sex hormones comparable to OC women. Therefore, women in the follicular phase should have displayed the same response pattern as OC women if the low endogenous sex hormones were indeed responsible. The results also emphasize the importance of activational effects of sex hormones on the encoding of emotionally relevant material since the women should have displayed the same response pattern if only organizational effects were related to the modulation by cortisol. Putatively, the findings suggest that OC women are more susceptible to remembering or learning information carrying negative connotations in stressful situations versus normal conditions. While such an effect may be adaptive in some situations, having too much fear can also be maladaptive in terms of moving forward in life. The authors hypothesized that the reason why men and normal cycling women are less susceptible may be because of an evolutionary-based survival mechanism that is disrupted by OC use. It is possible that the mechanism that is disrupted is the same mechanism postulated to be behind the mood repair hypothesis. The mood repair hypothesis assumes that persons in a negative mood are motivated to repair their mood to a more pleasant state, as it predicts that all else being equal, people would prefer good moods over bad ones (Erber

& Erber, 2009). Thus, OCs may increase women's likelihood of remembering/learning negative information in stressful situations by inhibiting mood repair processes.

Although little is known about the relationship between premenopausal hormone use and cognition, the research reviewed above suggests that OC use can have an effect on cognition and more specifically, memory. OCs have been found to interact with stress hormones, such as cortisol, to alter stress responses and memory. A recent focus has been on emotional memory where studies indicate that OCs may alter memory for an emotional story, stress hormones may act independently of OCs to enhance memory for emotional material depending on the valence of the stimulus, and OCs may modify cortisol effects on emotional learning. These findings need to be replicated before they can be accepted. Below is a review of some possible underlying mechanisms involved in OC-related memory changes.

Possible Mechanisms of Oral Contraceptive-Related Changes in Memory

Neuroplasticity. Neural plasticity concerns a response to changes in behaviour, environment, and neuronal processes, involving lasting alterations in both the structure and function of the brain (e.g., Schwartz, Manquet, & Frith, 2002). Plasticity in cortical function is not only seen in early development of the human brain but also in learning and memory within the adult brain (e.g., Harms & Dunaevsky, 2007). Only recently has the potential for plastic changes in the adult brain been investigated thoroughly and extensively throughout the central nervous system. For example, Burke and Barnes (2006) have reported that changes occurring during the normal aging process such as cell loss and deterioration of dendritic branching are more subtle and selective than once believed, suggesting that the general pattern of most age-related cognitive impairments

seem to result from region specific changes in dendritic morphology, cellular connectivity, or other factors that affect plasticity.

Excitatory synapses in the Central Nervous System (CNS) mostly form on dendritic spines, tiny projections from the excitatory neuron, and as such, spines are one of the more likely cytological loci associated with synaptic plasticity (Harms & Dunaevsky, 2007). According to Malenka (1994), excitatory afferents in the form of adequate postsynaptic depolarizations may result in long-term potentiation (LTP) in the hippocampus, where there is a sustained increase in synaptic strength. LTP reveals specificity, occurring only at those synapses stimulated by afferent signals, most likely enhancing the storage capacity contained in a neural circuit. With repeated activation, enough Ca++ enters the postsynaptic dendritic spine to trigger the mechanisms involved in LTP. All in all, neuronal plasticity plays a vital role in forming synaptic connections during development, learning, and memory formation through the strengthening of associations between neurons (Lynch, 2004). In addition, LTP may be one mechanism in which the strengthening of these synaptic connections is achieved.

Research has also shown estradiol to increase spine density in the cornu ammonis region of the hippocampus (CA1), where dendritic spines have been implicated in spatial memory function (Gould, Woolley, Frankfurt, & McEwen, 1990; Luine, Attalla, Costa, & Frankfurt, 2006; MacLusky, Luine, Hajszan, Prange-Kiel, & Leranth, 2005; Woolley, 1998). Engert and Bonhoeffer (1999) further showed a correlation between CA1 pyramidal neurons in hippocampal slices with the emersion of new spines in the corresponding stimulated regions. Woolley and McEwen (1994) found that higher levels of estrogen are associated with higher densities of dendritic spines and synapses on

hippocampal CA1 pyramidal cells and that the addition of estradiol to estradiol-depleted ovariectomized rats caused a significant increase in spine density and memory in rats. Furthermore, Murphy and Segal (1996) sought to confirm these findings using cultured rat hippocampal neurons, to further investigate the relation between dendritic spines, plasticity, and hormones within the hippocampus. Their results showed that hippocampal neurons grown in culture for 2 to 3 weeks showed a twofold increase in dendritic spine density after being exposed to 17-β-estradiol. Taken together, these findings suggest that estrogens may be playing a major role in neuronal plasticity. Therefore, it is feasible that estrogens may be regulating neuronal plasticity in the adult human brain as well. It is possible that individual differences in memory could be influenced by neuronal plasticity and circulating levels of estradiol and that OC use may interact with or influence estradiol levels.

Laterality in brain plasticity or activation. Stimulus-induced emotional processing is hypothesized to involve an emotion processing network, that involves the activation of the amygdala, anterior cingulated cortex (ACC) and insula (Davidson, Putnam, & Larson, 2000). This emotion processing network is also influenced by ovarian hormones (van Wingen et al., 2011; Gingnell, Morell, Bannbers, Wikstrom, & Sundstrom Poromaa, 2012). Fischer, Furmark, Wik, and Fredrikson (2000) suggested that the right amygdala habituates to emotional stimuli more so than the left amygdala. Previous studies have suggested that this is especially the case when dealing with facial displays (Breiter et al., 1996; Fischer et al., 2003). Furthermore, Gingnell et al. (2012) have shown that menstrual phase affects amygdala habituation, especially if the first exposure is during the follicular phase (i.e., days 1 to 10 after the onset of menses) when

estrogen and progesterone levels are low. They found that women with premenstrual dysphoric disorder (PMDD) had enhanced bilateral amygdala reactivity to an emotional face-matching task during the follicular phase in comparison with healthy controls, but there was no difference between groups during the luteal phase in response to exposure to emotional faces. Schneider et al. (2011) suggest a sex-dependent development of human emotion processing and observed sex-dependent lateralization of amygdala activation related to emotional memory. It has been shown that memory for images judged as emotionally arousing in men correlates more strongly to the activity of the right amygdala compared to women, whereas a significantly stronger relationship between activity of the left amygdala and memory for emotionally arousing images is seen in women (Cahill et al., 2004; Cahill et al., 2001; Canli et al., 2002; Mackiewicz et al., 2006; Schneider et al., 2011). Thus, these results suggest a sex-dependent lateralization of amygdala activation that is present in the basic processes of emotional perception and memory.

Research has indicated some differences in brain laterality between OC users and nonusers. It has been found that OC users with previous negative mood side effects show reduced left insula reactivity in BOLD responses to an emotion processing task when compared to placebo users (Gingnell et al., 2013). The left insula plays an important role in processing the anticipation and subjective experience of aversive stimuli (Paulus & Stein, 2010) but is also activated by positive emotional feelings (Bartels & Zeki, 2004; Johnstone, van Reekum, Oakes, & Davidson, 2006; Takahashi et al., 2008). Pletzer et al. (2010) found that women using OCs had significantly larger prefrontal cortices, pre- and postcentral gyri, parahippocampal and fusiform gyri and temporal regions, compared to

women not using OCs. In addition, Gingnell et al. (2013) found that women with a previous history of OC-induced adverse mood side effects showed the following changes when re-exposed to OC use: lower reactivity to emotional faces in the left insula, left middle frontal gyrus, and bilateral inferior frontal gyri compared to women with a previous history of OC-induced adverse mood exposed to placebo. It was also found that the OC group had decreased reactivity bilaterally in the inferior frontal gyri while the placebo group had decreased reactivity in the right amygdala between the pretreatment (baseline) and OC treatment cycles. This decrease in reactivity in the right amygdala was absent in OC users. Given that OC users had unaltered amygdala reactivity between baseline and treatment cycles, it is possible that placebo users developed a habituation between trials or that OC users experienced a slower habituation to emotional stimuli. According to the study's authors, the slower habituation among OC users could suggest that the administration of exogenous ovarian steroid hormones such as OCs reduce habituation of the amygdala, leading to a higher level of vigilance to emotional stimuli in OC users, which could also be related to their mood deterioration.

Menstrual cyclicity in brain structure size has also been noted. Hageman et al. (2011) found a significant grey matter peak and cerebrospinal fluid (CSF) loss at the time of ovulation in free-cycling females. These changes did not correlate with estradiol or progesterone hormone levels. No significant brain volume alterations were found in men over a similar time frame. The data from the Hageman et al. (2011) study gives evidence of short-term hormone-dependent structural brain changes during the menstrual cycle. It has also been reported that during the early follicular phase, larger volumes in the right fusiform/parahippocampal gyrus have been found compared to the mid-luteal cycle phase

(Pletzer et al., 2010). Compared to men, women show larger grey matter volumes in the lateral prefrontal regions, especially in the left hemisphere, pre-and postcentral gyri and inferior parietal lobes, and the findings suggest that these sex-dependent effects were modulated by menstrual cycle, as well as OC use as mentioned above. Furthermore, menstrual cycle effects on hippocampal volumes have been related to performance variations in hippocampus dependent memory (Protopopescu et al., 2008). Therefore, brain alterations in brain structure over the female menstrual cycle have been noted in some studies and these changes may be modulated by menstrual cycle phase such as grey matter peaks during ovulation and larger volumes in the right fusiform/parahippocampal gyrus during the early follicular phase compared to mid-luteal.

Overall, these findings suggest that OCs may alter memory for emotional information by altering: (a) sex and stress hormone interactions involved in memory formation (discussed in previous section), (b) brain plasticity, or (c) hemispheric lateralization of the amygdala. An interaction between these mechanisms may also be at play whereby emotional memory is altered in OC users.

Additional links between Hormones, Emotions, and Memory

As reviewed above, there is evidence that hormones, the menstrual cycle, and OCs can influence emotional behaviours. Hormonal fluctuations affect brain processes in regions involved in emotion regulation (Ossewaarde, Hermans, van Wingen, Kooijman, Johansson, et al., 2010). As an example, the changes in brain processes with hormonal fluctuations across the menstrual cycle are thought to play a part in premenstrual mood symptoms (Backstrom et al., 2003). The amygdala is a subcortical network involved in emotional processing. It is important for the identification of the emotional significance

of stimuli, generation of affective responses, and emotion regulation (Phillips, Drevets, Rauch, & Lane, 2003). Thus, research indicating that OCs and the menstrual cycle affect amygdala reactivity or habituation (reviewed above) further suggests a role of the amygdala in any OC-related affect or mood effects.

Research has indicated that the menstrual cycle and accompanying hormonal fluctuations can affect emotional behavior (see review in Sakaki & Mather, 2012). One area of study involves facial emotion recognition. A study by Derntl et al. (2008) explored the association of amygdala activation and ovarian hormone levels during an explicit emotion recognition task consisting of facial expressions portraying an equal number of the 5 basic emotions of anger, disgust, fear, happiness, and sadness, as well as neutral expressions. The results indicated significantly stronger amygdala activation using an echo-planar-imaging (EIP) protocol and enhanced emotional recognition during the follicular phase when progesterone levels are low. Interestingly, negative correlations between progesterone levels and amygdala response to fearful, sad, and neutral faces were also observed, suggesting stronger amygdala activation in women with lower progesterone levels during emotion processing. Another study by van Wingen et al. (2008) investigated whether a single administration of 400mg of progesterone to healthy women during the follicular phase would increase amygdala reactivity to angry and fearful face stimuli using functional magnetic resonance imaging (fMRI). The progesterone administration increased plasma concentrations of progesterone to levels that are comparable to those reached during the luteal phase. However, results showed that a single administration of progesterone to women during their follicular phase selectively increased amygdala reactivity in response to the facial stimuli in a within

subjects design comparison. Although both of the above-discussed studies found increased amygdala activity during the follicular phase in response to emotional faces, it seems as though the findings regarding the relationship between progesterone and amygdala response to emotional faces are conflicting as one study found low endogenous progesterone associated with higher responses and the other found high exogenous progesterone associated with higher response. The difference may perhaps be due to differences in methodology, such as the dosage of progesterone used or the focus on endogenous versus exogenous progesterone. Since van Wingen et al. (2008) raised progesterone concentrations to the level reached during the luteal phase, their findings are in line with Andreano and Cahill (2010) who demonstrated that women in the mid-luteal phase, where progesterone is high, had significantly enhanced activity in the hippocampus and amygdala in response to emotional images when compared to those in the early follicular phase as previously discussed.

Ertman, Andreano, and Cahill (2011) demonstrated that memory for emotional materials changes significantly in accordance with hormonal fluctuations across the menstrual cycle. Here, women rated 120 images on arousal and valence and one week later completed free recall and recognition memory tests. It was found that memory for the emotional items only, was significantly better when women were in the luteal phase (high hormones) at the time of encoding compared with the follicular phase (low hormones) on the free recall test. On both the free recall and recognition tests, emotional memory correlated positively with progesterone collected at the time of encoding. In contrast, there was no relationship between salivary 17β-estradiol levels and emotional memory. These findings suggest that ovarian hormones, such as progesterone, influence

the modulation of emotional memories across the menstrual cycle. However, given that there is greater rationale to suspect a role of estradiol in memory (as discussed above) it is surprising that estradiol was not correlated with any memory scores. The possibility that progesterone's effects depend in part on estrogenic activity should not be ruled out.

In some cases stress has been found to enhance memory consolidation, especially for emotionally arousing information (Cahill, Gorski, & Le, 2003; Andreano & Cahill, 2006; Payne et al., 2007). However, cortisol (related to stress) has been found to impair memory as discussed above and delayed retrieval of previously learned emotional material has been found to be impaired by stress (Smeets et al., 2008; Tollenaar, Elzinga, Spinhoven, & Everaerd 2008). In a study by Cornelisse et al. (2011), it was found that men showed a higher cortisol response to the Trier Social Stress Test (TSST) than natural cycling women and women using OCs, and that naturally cycling women showed higher responses when compared to OC users. Women rated emotional, but not neutral pictures higher on arousal compared to men. Both men and women remembered emotionally arousing information better than neutral information one week later. Stress enhanced recognition memory for emotional versus neutral pictures only in male subjects. Interestingly, in women there was no effect of stress on recognition memory. A substantial part of the female sample used OCs and perhaps this contributed to the lack of stress effects on memory by way of blunted HPA axis responses, which ties into the earlier research discussed regarding OC use and cognition. Therefore, there is evidence that stress can either impair or enhance memory for emotional material depending on the level of stress. Furthermore, there is some research suggesting that the effects of stress on memory may be blunted in women who use OCs.

The Present Study

As stated above, research suggests that hormones and hormonal change, including changes across the menstrual cycle influence different types of cognitive abilities, such as memory. Thus, it seems likely that OC use could influence memory as well. In particular, an effect of OCs on memory for emotional material seems plausible, particularly given the findings of Nielsen et al. (2011). The present study specifically looked at how OCs influence emotional memory by comparing the performance of OC users, free-cycling women (nonusers), and men on two memory tasks. The two memory tasks included an Emotional Visuospatial task and Nielsen et al.'s (2011) Emotional Story task. The Emotional Visuospatial task was created for the present study. Each task included measures of both gist and detail for emotional and non-emotional/neutral stimuli. The relative recall of positive and negative stimuli and memory for general central information (gist) versus the specific recall of specific details of the emotional stimuli used were examined and three main hypotheses were tested.

The first hypothesis was that, relative to nonusers, OC users and men would show enhanced memory for gist in emotional memory conditions when compared to memory for gist from non-emotional or neutral memory conditions (i.e., a larger emotional gist: neutral gist ratio) (**Hypothesis 1**). Secondly, we hypothesized that, relative to OC users and men, nonuser females would have enhanced memory for emotional detail when compared to neutral detail in all emotional memory conditions (e.g., a larger emotional detail: neutral detail ratio in nonusers) (**Hypothesis 2**). These two hypotheses were examined using both the Emotional Visuospatial task and the Emotional Story task. As the Emotional Visuospatial task involved positive, negative, and neutral to-be-

remembered stimuli, we examined whether the three groups showed any differences in relative memory for positive or negative emotional information. Part of the rationale for this research question comes from Jarva and Oinonen's (2007) finding of differences in positive, but not negative, affect reactivity/variability between OC users and nonusers and the possibility that OCs may differentially affect positive and negative emotions as well as women's response to stimuli that evoke these two different emotions. The present study examined whether there were any group differences in relative memory for positively- and negatively-valenced stimuli between OC users, nonusers, and men (**Hypothesis 3**). This hypothesis was nondirectional in nature as there was not enough consistent previous research to justify a directional hypothesis.

Hypotheses 1 and 2 of the current study represent an attempt to replicate and extend Nielsen et al.'s (2011) findings that OC use is associated with altered memory for an emotional story. As mentioned previously, they found that OC users showed enhanced memory for gist but not detail of an emotional story when compared to a neutral story while free-cycling women showed enhanced memory for detail but not gist of the emotional story when compared to neutral story condition. However, the present study is unique in that it is the first to examine whether the effect of OCs on emotional memory extends to memory for visuospatial material. Thus, the present study represents a comprehensive test of the "gist versus detail OC effect". Second, the present study included a more sensitive within-subjects design than the Nielsen et al (2011) study as we were able to calculate emotional gist, emotional detail, neutral gist, and neutral detail scores for each participant as opposed to only calculating emotional scores or neutral scores for each person. Furthermore, while Nielsen et al. (2011) examined the effects of

OCs on memory for sad or traumatic material, this is the first study that examined how OCs affect memory for stimuli that elicit both positive and negative affect through the use of the Emotional Visuospatial task. Additional strengths of the present study include controls for menstrual cycle phase and examination of possible menstrual cycle effects in nonusers. This is an improvement over the study by Nielsen and colleagues as it is possible that nonusers memory performance could vary systematically according to the menstrual cycle phase a women is in during exposure to the tasks, during memory testing, or both. Men were also asked to participate in the present study to explore any possible sex differences in emotional memory and the recall and recognition of gist versus detail. Furthermore, the study explored differences in emotional memory for both positively and negatively valenced to be-remembered stimuli across all groups. The current study may provide insight or have clinical implications in regards to disorders related to learning and emotional memory, such as depression and PTSD, and how sex hormones may influence these disorders and cognitive complaints in women. In addition, the current study adds to knowledge of factors affecting women's health and well-being, and the possible emotional and cognitive side effects of OC use.

Method

Participants

The final sample of participants consisted of 135 participants who were Lakehead University students and community volunteers aged 16 to 35 (58 women currently using OCs, 40 nonusers, and 37 men). The mean age of participants was 20.16 (*SD* = 3.82) and mean year of education was 13.88 (*SD* = 1.44) corresponding to the first year of post-secondary education. In terms of ethnicity, 87.3% of the sample was of European decent.

All community participants were 18 years of age or older with the exception of Lakehead University students, who were 16 years and older. Participants were recruited from Introductory Psychology classes and upper year psychology classes at Lakehead University through classroom visits, email invitations, and communication bulletins for a study on "Cognition and Hormones". Community recruitment also took place at local health expos and community fairs within Thunder Bay. We also used posters and online advertisements (e.g., on social networking sites, local classified advertisement sites, and group forums) to recruit from both the community and Lakehead University population. Eligible participants in Psychology courses received course credit for participation in the study (up to 3.5 bonus points). The Psychology Research Ethics Committee as well as the Lakehead University Research Ethics Committee approved the study.

A total of 471 participants completed the screening questionnaire, and 282 of these participants met the inclusion criteria for the study. The three main inclusion criteria (and the number of participants who were excluded for failing to meet one or more of the criteria), were: (a) age 16 to 35 (n = 9), (b) no history of brain injury or a diagnosed memory problem (n = 13), and (c) no use of mood altering medications, other than OCs (e.g. antidepressants, lithium, benzodiazepines) (n = 37). In addition, the women who met the above criteria, were excluded if they failed to meet one or more of the following additional inclusion criteria (d) no current pregnancy, lactation, or breast feeding (n = 5), (e) no hysterectomy or menopausal status (n = 5), (f) must have menstruated in the past two months (n = 9), (g) must have a regular menstrual cycle or provide enough menstrual cycle information to determine cycle day (n = 18), and (h) if taking OCs, duration of use must have been at least the past two months and if a previous

user of OCs, time since discontinuation must have been more than two months (n = 8). Additional post-hoc inclusion criteria included: (i) self-classification as male or female (n = 1), (j) no evidence of current high alcohol intake (i.e., consumption of five or more alcoholic drinks in the 24 hrs prior to laboratory sessions one or two) (n = 4), (k) no change in OC status between the time of screening to participation in laboratory session one (n = 1), and no hormonal contraceptive use (i.e., NuvaRing) (n = 7). When recruiting the 58 women currently using OCs we attempted to recruit primarily monophasic users, such as those on Alesse™, Ortho-TriCyclen™, Yasmin™, or Yaz™. The majority of the women in the OC user group (17%) were currently using Alesse™ birth control. A break down of the type or "brand" of OC use among the OC user group can be seen in Table 1. An additional reason why a number of participants were not eligible for inclusion in the lab sessions was due to geographic location (n = 50). Thus, those participants who filled out the screening questionnaire who were not living in Thunder Bay could not participate (i.e. those attending the Orillia Lakehead University Campus or taking summer courses long distance). Finally, those who did not complete the screening questionnaire in its entirety and thus had incomplete data to screen for eligibility for the laboratory sessions were excluded (n = 28).

Of the 282 participants who met the inclusion criteria, 150 participated in the first laboratory session, and 147 of those participants returned for the second laboratory session. Those participants who participated in the first testing session but did not return for the second session gave a variation of the following reasons for their choice: they were too busy with school and/or work to give up an hour of their free time to complete laboratory session two or were going out of town unexpectedly.

Table 1

Type or "Brand" of Oral Contraceptive Use and Hormonal Dosage Among OC users: Raw Frequencies and Percentages.

Type/Brand (Hormonal Dosage)	Raw Frequency (Percentage)
Alesse (0.10mg levonorgestrel – 0.02mg ethinyl estradiol)	23 (17.0)
Alysena (0.10mg levonorgestrel – 0.02mg ethinyl estradiol)	3 (2.2)
Apri (0.15mg desogestrel – 0.03 mg ethinyl estradiol)	1 (0.7)
Diane 35 (2.00mg cyproterone – 0.03mg ethinyl estradiol)	2 (1.5)
Marvelon (0.15mg desogestrel – 0.03mg ethinyl estradiol)	4 (3.0)
MinEstrin 1/20 (1.00mg norethindrone acetate – 0.02mg ethinyl estradiol)	1 (0.7)
Min-Ovral (0.15mg levonorgestrel – 0.03mg ethinyl estradiol)	4 (3.0)
Mirvala (0.15mg desogestrel – 0.03mg ethinyl estradiol)	2 (1.5)
Ortho 7/7/7 (0.50 to 1.00 mg norethindrone – 0.03mg ethinyl estradiol)	1 (0.7)
Ortho Micronor (0.35mg norethindrone)	1 (0.7)
Seasonale (0.15mg levonorgestrel – 0.03mg ethinyl estradiol)	1 (0.7)
Tri-Cyclen (0.18 to 0.25mg norgestimate – 0.02mg ethinyl estradiol)	12 (8.9)
Yasmin (3.00mg drospirenone – 0.03mg ethinyl estradiol)	1 (0.7)
Zarah (3.00mg drospirenone – 0.03mg ethinyl estradiol)	1 (0.7)

Note: $N = 58$.

Stimulus Development and Pilot Testing

Fifteen participants were recruited for "A Pilot Study on Hormones and Cognition" through email announcements and personal invitations (See Appendix A). Participants were adults between the ages of 18 and 35 years of age from Lakehead University and the Thunder Bay area. There were no other initial inclusion criteria. A total of 15 participants completed the pilot study testing. The pilot study was used to determine whether items being considered for inclusion in the Emotional Visuospatial task (described below) were positive, negative, or neutral in emotional valence in order to determine the final items in the Emotional Visuospatial task.

Interested participants were presented with a cover letter and consent form (See Appendix B) where more information about the study was provided. Participation took place in the Health, Hormones and Behaviour Laboratory or a quiet location of convenience for the participant (e.g. another classroom). Participants were logged onto an online survey (through SurveyMonkey.com) where they were presented with pictures of possible items/stimuli for the Emotional Visuospatial task. They were asked to carefully look at each item and think about what kind of emotion that item elicits. Participants recorded the extent to which they considered each item to be negative, neutral, or positive using a rating scale provided beneath each photo. Response options ranged from 1 (*very negative*) to 5 (*very positive*). Following completion of the pilot study, participants were debriefed (See Appendix C) and thanked for their participation.

Emotional visuospatial task development. This test of visuospatial memory was designed for the present study to assess memory for (a) gist versus detail of visuospatial material with emotional valence and (b) memory for stimuli with positive

and negative emotional valence. The final test included a tray that was divided into 30 small equal sections. One item/stimulus was found in each section, and the same item always occupied the same spot on the tray. The test included 30 stimulus items in total with three types of emotional valence: 10 with positive emotional valence, 10 with negative emotional valence, and 10 emotionally neutral items. The final 30 stimuli were chosen based on the current pilot study, which included 60 items as potential stimuli. The goal of the pilot study was to verify the perceived emotional valence of each of these items. For the pilot study, the two researchers included 20 positive, 20 negative, and 20 to be emotionally neutral items based on a two-person consensus judgment of emotional valence. Based on results from the pilot study, the top 10 items in each category were chosen i.e. the 10 items with the highest positive ratings, the 10 items with the highest negative ratings, and the 10 items with the most neutral ratings. Emotional valence ratings of very positive and slightly positive were summed to make an overall positive rating and the emotional valence ratings of very negative and slightly negative were summed to make an overall negative rating. The neutral ratings were deduced by only one response option of neutral. Through this process, the emotional valance of the final 30 items was verified through the pilot testing. The final stimulus items and their rated emotional valence within the pilot testing are presented in the first three columns of Table 2.

Measures and Tasks

Screening questionnaire. This questionnaire contained questions pertaining to all of the above-noted inclusion and exclusion criteria (see Appendix D). It included questions about demographics (e.g., age, sex, ethnicity), memory, mental health history,

Table 2

The Final 30 Stimulus Items and Corresponding Emotional Valence Ratings for the Emotional Visuospatial Task as Determined by Pilot Testing.

Stimulus Item	% Participants Indicating a Positive, Negative or Neutral Rating	Mean Score Pilot Study	Mean Score Main Study
Negative:			
Skull	93.34% negative	1.47	2.15
Spider	93.33% negative	1.47	1.99
Bat	86.67% negative	1.80	2.37
Rat	86.67% negative	1.67	2.25
Payment Due Notice	86.67% negative	1.73	1.61
Gun	80.00% negative	1.53	2.04
Handcuffs	80.00% negative	1.73	2.32
Pin/Needle	80.00% negative	1.93	2.46
Tombstone	80.00% negative	1.53	1.89
Knife	73.34% negative	1.67	1.95
Neutral:			
Button	80.00% neutral	3.13	3.16
Paper Clip	80.00% neutral	3.07	3.14
Pen Cap	80.00% neutral	2.80	2.93
Rubber Elastic	80.00% neutral	2.93	3.02
Twist Tie	80.00% neutral	2.93	2.98

Bobby Pin	73.33% neutral	3.33	3.32
Key	73.33% neutral	3.33	3.24
Thread	73.33% neutral	3.07	3.20
Toothpick	73.33% neutral	2.87	2.85
Clothes Peg	60.00% neutral	3.00	3.03
Positive:			
Heart	100% positive	4.80	3.99
Present	100% positive	4.80	4.25
Rainbow	100% positive	4.80	4.28
Winking Face	100% positive	4.53	4.28
Bow	93.34% positive	4.40	4.34
Cake Slice	93.34% positive	4.40	4.20
Happy Face	93.34% positive	4.60	4.31
Peace Sign	93.34% positive	4.40	4.03
Birthday Candle	93.33% positive	4.47	4.23
Flower	93.33% positive	4.53	4.48

Note: $N = 15$ for column 2 and 3 (Pilot Study); $N = 135$ for column 4 (Main Study).

Mean score = weighted average of response options ranging from 1 (*very negative*) to 5 (*very positive*) with the middle point of 3 representing *neutral*.

and a variety of factors that were hypothesized to have potential effects on memory like stress, sleep, alcohol and caffeine consumption, medications, medical and psychological conditions, exercise, and diet. The screening questionnaire was also used to obtain information regarding menstrual cycle phase and OC use for female participants in order to determine if they met the inclusion criteria. Many of the questions used in the screening questionnaire were developed within the Health, Hormones, and Behaviour Laboratory and have been used in numerous previous studies. Additional measures of mood and memory (described below) were included for use as possible covariates or to provide additional information about participant mood or memory.

The Toronto Alexithymia Scale (TAS-20) (Bagby, Parker, & Taylor, 1994) was included within the Screening Questionnaire to measure each participant's ability to express and identify with emotional events. This 20-item instrument is commonly used to measure alexithymia, the extent to which people: (a) have trouble identifying and describing emotions, (b) minimize emotional experiences, and (c) focus attention externally. It is comprised of three subscales: Difficulty Describing Feelings, Difficulty Identifying Feelings, and Externally-Oriented Thinking. The TAS-20 is a self-report measure and items are rated on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Reliability data indicates good internal consistency (Cronbach's alpha = .81) and test-retest reliability (r = .77). In addition, the TAS-20 demonstrates adequate levels of construct, criterion, and concurrent validity and these have been well established in diverse samples of adults (Bagby, Parker, & Taylor, 1994; Bagby, Taylor, & Parker, 1994; Parker, Taylor, & Bagby, 2003; Taylor, Bagby, & Parker, 2003).

Emotional visuospatial task. This test of visuospatial memory was designed for the present study to assess (a) memory for gist versus detail of visuospatial material with emotional valence, and (b) memory for stimuli with positive, negative, and neutral emotional valence. Participants were initially presented with a tray containing 30 items or stimuli. The tray was divided into 30 small equal sections, one item was found in each section, and the same item always occupied the same spot on the tray. The stimuli included 10 emotionally positive, 10 emotionally negative, and 10 emotionally neutral items as determined through a pilot study to verify the emotional valence of each item (see above section on stimulus development and pilot testing). In Laboratory Session I participants were instructed to look at each item on the tray for a total of 60 seconds and think about how each of the items made them feel. This instruction was given in order to both enhance the emotional value of the stimuli and to provide the participants with a common activity that maximized the likelihood that the items were attended to. After 60 seconds a towel was placed over the tray and the tray was removed from the participant's view. An immediate free recall test followed, where participants were asked to list as many items as they could remember on a sheet of paper. In order to assess gist versus detail, a second memory test was then given where participants were presented with an empty tray and asked to indicate where each item they remembered was located on the tray. Whether the participants remembered the exact section (detail) or general location (gist) was recorded. Gist or the correct recall of the general location of an item was defined as any section on the tray that was in direct contact with the exact section (not including the correct section itself).

In Laboratory Session II (one week later) participants were asked to complete three tasks. First they were asked to recall all the items that they saw on the tray during the previous session (free recall) and indicate the location of each item they remembered on the tray. Second, they were then presented with a slideshow of all 30 items plus 30 items not previously seen (i.e., foils) to test recognition. Participants were asked whether each item was one of the items presented on the tray in the previous session by indicating 'yes' or 'no' on a response form. Third, they were presented with a slideshow of all 30 of the original items and asked to indicate the extent to which each item elicits positive, negative, or neutral feelings in them (emotional rating). Response options ranged from 1 (*very negative*) to 5 (*very positive*).

For the Emotional Visuospatial task, short-term memory (STM) was measured during the first laboratory session and long-term memory (LTM) was measured one week later during the second laboratory session. The Emotional Visuospatial task was scored by calculating the total number of correctly recalled items (item STM, item LTM), the total number of correctly recalled positive items (positive item STM, positive item LTM), the total number of correctly recalled negative items (negative item STM, negative item LTM), and finally the total number of correctly recalled neutral items (neutral item STM, neutral item LTM). Recalling an exact item and its location was scored as detail (item detail STM, item detail LTM) while recalling only a general description of the item (e.g., "something red") or a location adjacent to the actual location was scored as gist (item gist STM, item gist LTM).

Emotional story task. The stimuli used were based on the Nielsen et al. (2011) study. The stimuli consisted of 11 narrated picture slides. Participants watched both a

brief emotionally neutral story followed by a closely matched, but more emotionally arousing story. Both stories consisted of the same 11 picture slides. The two stories were identical in narration for slides 1 to 4 or "phase 1" and similar for slides 8 to 11 or "phase 3". The stories only differed substantially in the narration of slides 5 to 8 or "phase 2" as there were negative emotionally arousing elements contained in the emotional version that were not contained in the neutral version of the story. In previous research (e.g., Nielsen et al., 2011; Nielsen et al., 2013; Nielsen et al., 2014), each participant was typically exposed to one version of the story (i.e., the emotional version or the neutral version) whereas participants in the current study were exposed to both.

In Laboratory Session I participants viewed both the emotionally neutral and emotionally arousing version of the story. No specific instructions were given to participants to remember the stories; they were simply instructed to watch. In Laboratory Session II (one week later) a surprise recall and recognition test was administered and participants were reminded that they previously watched two stories. For the recall test they were asked to write a brief phrase identifying each slide they could remember as well as any elements of the story they could recall associated with each remembered slide for both story conditions. The recognition task consisted of 67 multiple-choice questions that pertain to the stories. Of the 67 questions, 11 questions were relevant to both stories, 28 questions pertained only to the neutral story, and 28 questions pertained only to the emotional story. Since scoring mainly looked at differences in memory (recall) for slides 5 to 8 or phase 2 of the emotional versus neutral version of the story, questions relevant to both stories for slides 1 to 4 and 9 to 11 were reduced to one question per slide in order to reduce testing time and maintain participant attention. Participants were told which

questions pertained to both stories (the similar story elements), the neutral story, or the emotional story. Previous use with these stories (e.g. Nielsen et al., 2011) has shown 91% inter-rater agreement between judges when scoring the recalled story elements as either 'gist' or 'detail' for correctly remembered slides.

For both stories, correct recall of a slide would be credited if the phrase used by the participant to identify the slide could unambiguously be attributed to a specific slide in the recall test. The scoring template used by Nielsen et al. (2011) was employed (available from authors). It was created based on previous work with these stories (Cahill & van Stegeren, 2003; Cahill et al., 2004) in order to score recalled story elements as pertaining to either "gist" or "detail" of the story. In these previous studies, "gist" was defined by a 75% consensus between four independent judges as "any story element that could not be changed or altered without changing the fundamental story line" whereas "detail" was defined as all other recalled elements (Cahill & van Stegeren, 2003). For each slide, the number of elements that can be recalled varied for both gist and detail. Examples of gist for the emotional version would include "mother," "son," and "boy hit by a runaway car" while examples of detail elements from the emotional version include "hospital – light brown," "parked car in background," and "boy post-surgery." Scoring mainly looked at differences in memory (recall) for slides 5 to 8 or phase 2 of the emotional versus neutral version of the story. Thus, the calculations in the previous paragraph were also computed for phase 2 of the emotional and neutral story, that is, only taking into account story recall of slides 5 to 8. In the present study, two trained judges independently scored each participant's recall responses in terms of gist and detail. Agreement between the two judges was 89%. A third independent judge decided the few

cases of disagreement. The LTM recognition scores were calculated using the multiple-choice questions pertaining to both stories. The scoring template used by Nielsen et al. (2011) was also employed (available from authors).

California computerized assessment package (CalCap). The CalCap (Miller, 1990) is a measure of attention that assesses reaction time, speed of information processing, rapid visual scanning, form discrimination, brief memory and divided attention. The abbreviated version was used here. This version uses only those measures from the Standard test battery that are most sensitive to cognitive decline, and takes only 10 minutes to administer. The test battery consisted of four tasks: Simple Reaction Time, Choice Reaction Time for Single Digits, Serial Pattern Matching 1, and Serial Pattern Matching 2. The Simple Reaction Time task instructs participants to press a key as soon as they see anything at all on the screen and allows a basal measure of reaction time. The Choice Reaction Time for Single Digits instructs participants to press a key as soon as they see a specific number on the screen, adding a simple element of working memory and selective attention to the task. The Serial Pattern Matching 1 task instructs participants to press a key only when they see two of the same number in sequence (e.g., '3' followed by '3'), adding a more complex element of attention and working memory since the participant must keep in mind the last number that was seen. The Serial Pattern Matching 2 task instructs participants to press a key only when they see two numbers in sequence involving increasing order such as the number '3' followed by the number '4'. This task has a greater working memory demand than the Serial Pattern Matching 1 task because the participant must both remember the previous number and recognize if the new number is one higher. Overall, the Reaction Time measures have very high internal

consistency reliability (r = .77 to .96), indicating that the constructs show uniform assessment across the trials of each task. In regards to test-retest reliability, the six-month test-retest reliability for the Choice Reaction Time measures (r = .43 to .68) is comparable to other conventional neuropsychological procedures. The internal consistency reliability for the Choice Reaction Time measures are quite high (r = .81 to .96). The Simple Reaction Time measures have very low test-retest reliability (r = .20 to .29) but very high internal consistency reliability (r = .77 to .95), suggesting that these measures might vary considerably depending on state variables such as attention, mood, and fatigue.

The CalCap was used in this study to assess whether there were any differences between the three groups in terms of attention. In particular, d prime scores or the discriminability index from the Calcap Choice Reaction Time test was used to examine group differences in attention. This measure examines accuracy and takes into account both hits and false alarms on the attention test. However, it is worth noting that the two previous studies in the area by Nielsen and colleagues (2011; 2014) found that differences in retention or memory observed between OC users and nonusers could not be explained by attention or any potential effects of OCs on attentional focus to the emotional story.

Laboratory questionnaire I. This questionnaire (see Appendix E) contained questions pertaining to a variety of factors that were potentially theoretically relevant and hypothesized to have potential effects on memory and performance like sleep, alcohol and caffeine consumption, tobacco, medications, hunger, fatigue, boredom, and interest. For female participants, the questionnaire was also used to obtain additional information

regarding oral contraceptive use (to confirm user or nonuser status) and menstrual cycle phase (to confirm phase at time of encoding).

Laboratory questionnaire II. This questionnaire (see Appendix F) contained all of the same questions in the first laboratory questionnaire. In addition, the questionnaire included questions that asked participants about their experience with the study, such as how emotional or emotionally involved they felt. There were also questions asking whether participants did anything to intentionally remember any of the items or stories, and whether they talked to any other participants about the study.

Positive and negative affect schedule (PANAS). The PANAS consists of 20 adjectives that describe affective states with 10 items for negative affect and 10 items for positive affect (Watson, Clark, & Tellegen, 1988). Participants rated the degree to which they experienced each emotion at the time of testing. They were instructed to indicate to what extent they currently felt that way. Response options ranged from 1 (*very slightly or not at all*) to 5 (*extremely*). In regards to internal consistency, Watson and colleagues reported that the coefficient alphas for the positive affect (PA) and the negative (NA) subscales are .89 and .87, respectively. The PANAS was used to assess affect level throughout the study and affective reactivity in response to the emotional stimuli. It was included within Laboratory Questionnaires I and II.

Procedure

Recruitment and screening. Potential participants were invited to take part in a study on "Cognition and Hormones", which involved the completion of several brief questionnaires and lab tasks over one week. Participants were recruited primarily from Introductory Psychology classes and upper year psychology classes at Lakehead

University through classroom visits, email (see Appendix G), and communication bulletin boards (see Appendix H) at Lakehead University. Participants were also recruited from the general university community and from the community of Thunder Bay. Recruitment included the use of posters (see Appendix I), online advertisements (see Appendix J), email (see Appendix K) and booths at local community fairs. Interested participants were directed to an online screening questionnaire where they were presented with a cover letter (see Appendix L) and Consent Form A (see Appendix M). Each participant was required to read and agree to the information in Consent Form A to continue with the study. At this time, participants were then screened for inclusion in the laboratory sessions by completing the initial Screening Questionnaire. Participants provided a first name and contact email or phone number in order to be contacted to schedule a laboratory session. Each participant was assigned a participant number that was associated with their name until data collection was complete and their data was entered into a Statistical Package for Social Sciences (SPSS) data set. At that point the participant codes were destroyed so that all data would be anonymous and confidential. After completion of the Screening Questionnaire, participants were provided with Debriefing Form A (see Appendix N) that explained the lab portion of the study. Participants in Psychology courses allowing bonus points were also given 0.5 bonus points for completing the Screening Questionnaire.

Scheduling laboratory sessions. Based on the information in the screening questionnaire, participants were selected for lab sessions. The two groups of women were selected based on the criteria noted above in the participant section. If selected to continue, participants were contacted by email or phone to schedule two laboratory

sessions separated by one week (i.e., 7 days). For women, sessions were booked according to the participant's menstrual cycle phase. Three menstrual cycle phases were chosen: the menstrual phase (also known as early follicular), the periovulatory phase (also known as the late follicular), and the mid luteal phase. These phases were chosen in order to capture the wide variations in the levels of progesterone and estrogen across the cycle. Typically estrogen and progesterone levels are at their lowest in the early follicular or menstrual phase (days 1 to 5) while estrogen and progesterone levels are considerably higher in the mid luteal phase (days 20 to 24) which offers a comparison between the lowest and the highest levels of progesterone and estrogen (Mordecai, 2008). Estrogen levels are typically high in the late follicular phase (days 11 to 14) and comparisons to this group can help researchers differentiate the effects of estrogen and progesterone when examining free-cyclers.

An attempt was made to book an equal number of women in each group for session 1 during the menstrual phase (days 1 to 5 with day 2 being ideal), periovulatory phase (days 11 to 14 with day 12 as ideal), and the mid luteal phase (days 20 to 24 with day 22 as ideal). On each day that a woman was booked, an attempt was made to also book a man, in order to yoke the men's testing days with women's menstrual cycle phases and to minimize sex differences in testing days.

Day counts were based on a 28-day cycle. Cycle day was calculated using the forward counting method for the menstrual phase (days 1 to 5) and the backwards-counting method for the periovulatory (-15 to-19) and midluteal (-5 to -9) phases. The backwards counting method was used to identify the latter two phases given evidence that the length of the luteal phase is much less variable across women than the length of

the follicular phase (Treloar, Boynton, Behn, & Brown, 1967). Thus, counting backwards from the next menses better determines cycle phase or cycle day than counting forwards. The backwards counting method is commonly used in menstrual cycle research (e.g., Anderson et al., 2010). Women's testing order was counterbalanced according to menstrual cycle phase. That is, not all women started the study in the same menstrual phase. Cycle day and phase was calculated based on information collected in all three questionnaires (screening, lab session I, and lab session II). Also, women were asked to email the researcher following the study to provide the first day of their next period. Permission was also requested to contact participants via email after the study to request this information. This maximized the validity of the final data on cycle days and phases.

Across the OC users and nonuser groups a relatively equal number of women were brought in for the first laboratory session during each menstrual cycle phase: (a) the menstrual phase (n = 23) (b) the periovulatory phase (n = 17); and (c) the luteal phase (n = 22) phase. These menstrual cycle phases were verified via email by obtaining women's first day of next menstruation. Only those that were verified were included in the numbers reported above (n = 62). Based on the menstrual cycle information obtained in the screening questionnaire and laboratory questionnaires, menstrual cycle phases were calculated for the remaining women in order to determine testing days/phases for all women. Such a process is comparable to most studies in the area that tend to verify cycle day/phase by following up to obtain the next menstruation date (e.g., Hatta & Nagaya, 2009; Protopopescu et al., 2008). The proportion of women in the three different menstrual cycle phases (see Table 3) did not differ significantly between the OC user and

Table 3

Percentages of Women in Each Menstrual Cycle Phase for both the OC user and Nonuser Groups.

Group	Menstrual Cycle Phase		
	Menses	Periovulatory	Mid Luteal
Verified Cycle Phases:			
Non users ($N = 23$)	11 (47.8%)	5 (21.7%)	7 (30.4%)
OC users ($N = 39$)	12 (30.8%)	12 (30.8%)	15 (38.5%)
Cycle Phases for all Women:			
Nonusers ($N = 40$)	16 (40.0%)	11 (27.5%)	13 (32.5%)
OC users ($N = 58$)	16 (27.6%)	21 (36.2%)	21 (36.2%)

Note: Cell entries reflect number of individuals and the percentages within each group that fell into that phase is in brackets. The likelihood of being in each of the three cycle phases did not differ as a function of group, X^2 (2, $N = 62$) = 1.828, $p = .401$ for verified menstrual cycle phases. The likelihood of being in each of the menstrual cycle phases also did not differ as a function of group, X^2 (2, $N = 98$) = 1.761, $p = .415$, when all women were included.

nonuser groups with verified menstrual cycle phase, X^2 (2, N = 62) = 1.828, p = .401, nor did the groups differ when all women were included, X^2 (2, N = 98) = 1.761, p = .415. Please refer to Table 4 for mean cycle days of each menstrual cycle phase, for both women with verified cycle days and all women.

Laboratory session I. All experimental sessions were conducted in the Health, Hormones, and Behaviour Lab at Lakehead University between the hours of 12:00 and 18:00. This time frame was used in order to best replicate Nielsen et al.'s (2011) methodology. They chose this time frame in an effort to control for the effects of circadian rhythm on alpha-amylase levels as previous work suggested that analysis of salivary alpha-amylase (an indicator of noradrenergic activation) might be useful in detecting noradrenergic activation in response to viewing emotional stimuli. However, it should be noted that no significant effects of alpha-amylase levels were detected in their study. During the first experimental session participants were asked to fill out Consent Form B (see Appendix O) and Laboratory Questionnaire I, including the PANAS. Following completion, participants were presented with the Emotional Visuospatial task where they were shown a tray of 30 items containing positive, negative, and neutral items for approximately 60 seconds. After removal of the tray, participants were asked to immediately recall as many items and their locations as possible. Participants then completed the CalCap and the exposure portion of the Emotional Story task, which involved viewing an emotional and neutral story with narrated words. Participants then filled out the PANAS a second time. At the end of the session, the second laboratory session date and time was confirmed for seven days later. Participants taking relevant psychology courses were also provided with 1.5 bonus points for participation.

Table 4

Menstrual Cycle Day Counts on Day of Testing (Laboratory Session One) Across the OC user and Nonuser Groups: Means and Standard Deviations.

Day of Cycle (Menstrual Cycle Phase)	Means (Standard Deviations)
Women with Verified Cycle Days:	
Days 1 to 5 (Menses)	2.52 (1.38)
Days -19 to -15 (Periovulatory)	-17.12 (1.58)
Days -9 to -5 (Mid Luteal)	-6.77 (1.07)
All Women:	
Days 1 to 5 (Menses)	2.41 (1.62)
Days -19 to -15 (Periovulatory)	-16.44 (2.65)
Days -9 to -5 (Mid Luteal)	-6.91 (2.11)

Note: $N = 62$ for verified cycle days and $N = 98$ for all women.

Laboratory session II. One week later participants returned to the lab where they completed the last phase of the study. First, the long-term recall portion of the Story task was administered and completed for both the neutral and emotional story conditions (see Appendix P). As noted above, they were asked to write a brief phrase identifying each slide they remembered as well as any elements of the story they could recall associated with each remembered slide. Next, they were given the recognition portion of the Emotional Story task for both the neutral and emotionally arousing conditions in the form of a multiple choice test. Next, the long-term recall test for the Emotional Visuospatial task was administered, followed by the relevant recognition and emotional rating tests associated with this task. These recall and recognition tests were administered to further explore long term memory for visuospatial material. After completion of the tests, participants were asked to fill out Laboratory Questionnaire II. Once the questionnaire was completed, participants were debriefed (see Appendix Q) and individuals in the Psychology pool were given another 1.5 bonus points (in total a maximum of 3.5 bonus points towards their course: 0.5 Screening Questionnaire, 1.5 Laboratory Session I, 1.5 Laboratory Session II) as compensation for their participation.

Data reduction and analyses. For the Emotional Visuospatial task we predicted that OC users (and men) would recall relatively more emotional gist items and/or locations relative to neutral gist items (i.e., higher emotional gist: neutral gist ratios) and that nonusers would recall relatively more emotionally detailed or exact items and/or locations relative to neutral detail items (i.e., higher emotional detail: neutral detail ratios). The Emotional Visuospatial task was scored by calculating the total number of correctly recalled items (item STM, item LTM), the total number of correctly recalled

positive items (positive item STM, positive item LTM), the total number of correctly recalled negative items (negative item STM, negative item LTM), and finally the total number of correctly recalled neutral items (neutral item STM, neutral item LTM). Scores were also calculated for gist versus detail (item detail STM, item detail LTM, item gist STM, item gist LTM). These item detail and gist scores were further broken down into eight emotional and neutral scores (emotional item detail STM, emotional item detail LTM, neutral item detail STM, neutral item detail LTM, emotional item gist STM, emotional item gist LTM, neutral item gist STM, and neutral item gist LTM). Overall performance on these scores and performance as a function of group (OC users, nonusers, and men) can be seen in Table 5. Finally, ratios were computed between the following scores: emotional item detail LTM: neutral item detail LTM, emotional item gist LTM: neutral item gist LTM, positive item STM: negative item STM, and positive item LTM: negative item LTM.

On the Emotional Visuospatial task, participants recalled an average of 13 items out of a possible 30 in laboratory session one (range of 5 to 26). As for emotional valence of the recalled items, participants recalled on average 4 positive items, 5 negative items and 3 neutral items in laboratory session one (10 is maximum possible for each). During laboratory session two, participants recalled an average of 8 (range of 1 to 17). As for emotional valence of the recalled items, participants recalled on average 2 positive items, 3 negative items and 2 neutral items when long-term memory was tested in laboratory session two. Please refer to Table 5 for the means and standard deviations of overall and group performance on the Emotional Visuospatial task.

Table 5

Performance Results on the Emotional Visuospatial Task and Emotional Story Task for OC users, Nonusers, Men, and Overall: Means and Standard Deviations.

Task Score	Nonusers *n* = 40	OC users *n* = 58	Men *n* = 37	Overall *n* = 135
	Means (Standard Deviations)			
Emotional Visuospatial Task				
STM Recall	13.92 (3.98)	12.93 (3.25)	12.76 (3.08)	13.18 (3.45)
Positive	4.32 (1.72)	4.48 (1.43)	3.97 (1.59)	4.30 (1.56)
Negative	6.00 (1.60)	5.17 (1.84)	5.73 (1.39)	5.57 (1.68)
Neutral	3.60 (1.81)	3.28 (1.42)	3.05 (1.53)	3.31 (1.58)
Gist	5.05 (2.09)	4.43 (2.36)	4.24 (1.99)	4.56 (2.19)
Emotional	3.40 (1.55)	2.97 (1.66)	3.03 (1.40)	3.11 (1.56)
Neutral	1.65 (1.12)	1.47 (1.10)	1.22 (0.98)	1.45 (1.08)
Detail	7.43 (3.41)	7.16 (2.98)	6.97 (3.18)	7.19 (3.15)
Emotional	5.93 (2.77)	5.74 (2.45)	5.57 (2.57)	5.75 (2.56)
Neutral	1.50 (1.15)	1.40 (1.18)	1.41 (1.26)	1.42 (1.19)
LTM Recall	9.25 (3.51)	8.70 (2.81)	8.42 (2.47)	8.79 (2.95)
Positive	2.98 (1.51)	3.00 (1.36)	2.58 (1.40)	2.88 (1.42)
Negative	4.08 (1.58)	3.68 (1.49)	4.14 (1.55)	3.92 (1.54)
Neutral	2.17 (1.45)	2.07(1.13)	1.69 (1.12)	2.00 (1.24)
Gist	3.33 (1.61)	3.40 (2.04)	2.86 (1.85)	3.23 (1.87)
Emotional	2.45 (1.36)	2.51 (1.54)	2.22 (1.29)	2.41 (1.41)
Neutral	0.88 (0.85)	0.89 (0.96)	0.64 (0.87)	0.82 (0.90)
Detail	3.58 (2.43)	2.88 (1.73)	3.06 (2.10)	3.14 (2.07)

Emotional	2.88 (1.95)	2.40 (1.58)	2.69 (1.94)	2.62 (1.79)
Neutral	0.70 (097)	0.47 (0.71)	0.36 (0.54)	0.51 (0.76)
Emotional Story Task				
Recall				
Gist				
Emotional	8.95 (2.77)	7.89 (3.22)	7.69 (2.65)	8.16 (2.97)
Neutral	8.25 (2.69)	7.86 (3.08)	7.60 (2.97)	7.90 (2.93)
Detail				
Emotional	3.38 (2.98)	2.89 (2.11)	3.26 (2.34)	3.14 (2.45)
Neutral	3.10 (2.91)	2.61 (2.45)	2.66 (2.17)	2.77 (2.52)
Phase 2 Recall				
Gist				
Emotional	2.63 (0.93)	2.82 (1.07)	2.94 (1.16)	2.80 (1.05)
Neutral	1.88 (1.16)	1.80 (1.49)	2.29 (1.41)	1.95 (1.38)
Detail				
Emotional	1.57 (1.63)	1.56 (1.25)	1.60 (0.91)	1.58 (1.30)
Neutral	1.05 (1.24)	0.98 (1.30)	0.97 (0.82)	1.00 (1.16)

For the Emotional Story task we predicted that OC users (and men) would recall relatively more emotional gist information (story elements) relative to neutral gist information (i.e., higher emotional gist: neutral gist ratios) and that nonusers would recall relatively more emotional detail information relative to neutral detail information (higher emotional detail: neutral detail ratios). For the emotional and neutral stories, a LTM recall score for both stories (emotional story LTM recall, neutral story LTM recall) was calculated. The LTM recall scores were further broken down into an emotional gist LTM recall score, a neutral gist LTM recall score, an emotional detail LTM recall score, and a neutral detail LTM recall score. Overall performance on these scores and performance as a function of group (OC users, nonusers, and men) can be seen in Table 5. Finally, ratios were computed between the following scores: emotional gist LTM recall score: neutral gist LTM recall score, and emotional detail LTM recall score: neutral detail LTM recall score.

On average, participants scored a total of 8 gist points and 3 detail points on long-term recall for the neutral story in laboratory session two. On average, participants scored a total of 8 gist points and 3 detail points on long-term recall for the emotional version of the story in laboratory session two. On average, participants scored a total of 2 gist points and 1 detail point on long-term recall for phase 2 of the neutral story in laboratory session two. On average, participants scored a total of 3 gist points and 2 detail points on long-term recall for phase 2 of the emotional version of the story in laboratory session two. Please refer to Table 5 for the means and standard deviations of overall and group performance on the Emotional Story task.

Three main sets of analyses were carried out. The first two tested directional hypotheses and the third was nondirectional and more exploratory in nature. First, a multivariate analysis of variance (MANCOVA) was used to examine group differences (OC users, nonusers, men) in the ratio of the scores for emotional gist to neutral gist. The three groups were compared on emotional gist to neutral gist scores for two dependent variables: (a) the recall portion of the LTM Emotional Visuospatial task and (b) the recall portion of the LTM Emotional Story task. More specifically, the ratio of emotional item gist LTM to neutral item gist LTM from the Emotional Visuospatial task and the ratio of emotional gist LTM recall to neutral gist LTM recall from the Emotional Story task were used. The purpose was to determine if any differences exist between OC users and nonusers in their memory for emotional versus neutral gist information (Hypothesis 1). It was hypothesized that OC users and men would have enhanced memory for emotional gist versus neutral gist across memory conditions (e.g., a larger emotional gist to neutral gist ratio)

A second MANCOVA was conducted to examine group differences (OC users, nonusers, men) in ratio scores for memory for emotional detail: neutral detail. Again the three groups were compared on the emotional detail: neutral detail scores for two dependent variables: (a) the recall portion of the LTM Emotional Visuospatial task and (b) the recall portion of the LTM Emotional Story task. More specifically, the ratio of emotional item detail LTM to neutral item detail LTM from the Emotional Visuospatial task and the ratio of emotional detail LTM recall to neutral detail LTM recall from the Emotional Story task were used. The purpose of this second MANCOVA was to determine if any differences exist between OC users and nonusers in their memory for

emotional versus neutral detail information (Hypothesis 2). It was hypothesized that nonusers would have enhanced memory for emotional detail versus neutral details across memory conditions (e.g., larger emotional detail to neutral detail ratios).

A third MANCOVA was conducted to test whether there were any group differences (OC users, nonusers, men) in relative recall of positive and negative stimuli. The groups were compared on two dependent measures: positive to negative item STM recall and positive to negative item LTM recall (both from the Emotional Visuospatial task). The purpose of this MANCOVA was to test Hypothesis 3.

Covariates and their rationale for inclusion in the analyses are described below. For the above three MANCOVAs, follow-up ANCOVAs were conducted where justified in order to examine group differences on the individual memory tasks.

Results

Data Screening/ Statistical Considerations

The data was assessed for accuracy of data entry and any errors were corrected. For all analyses, a significance level of $\alpha \leq .05$ was chosen. Pillai's trace criterion was used to evaluate multivariate significance. The Bonferroni adjustment was used for follow-up pairwise comparisons. All means reported are untransformed unadjusted means, unless otherwise indicated (i.e., figures represent adjusted means and their standard errors).

Assessing univariate assumptions. Data were assessed to ensure that univariate assumptions were met. Skewness, kurtosis, and outliers were assessed in order to check the normality of the distributions of scores. Skewness and kurtosis were examined using the following formulas: skewness divided by the standard error of skewness <3; kurtosis

divided by the standard error of kurtosis <3 (Tabachnik & Fidell, 2001). As confirmation of normality, visual inspections of histograms were also utilized. All values were not within the acceptable range. However, upon visual inspection, all distributions looked reasonably normally distributed.

Outliers were identified as any z score exceeding an absolute value of 3.29 (Tabachnik & Fidell, 2001). Several outliers were found in each group (OC users, non-users, and men) on the dependent measures (see Appendix R). Given that the outliers appeared to represent real and accurate data that should not be deleted, the decision was made to run each analysis twice, once with outliers included, and once with outliers removed. This was done to satisfy any concerns about statistical assumptions as well as maximizing available data.

Normality assumptions were re-examined without outliers which improved the distributions but there were still some minor problems with skewness and kurtosis (not all values were <3). Although Kline (1998) reviewed studies that indicate that nonnormality is not problematic unless skewness is >3 and kurtosis >10, as an additional control for possible violations of statistical assumptions, significant parametric analyses (i.e., MANCOVAs and ANCOVAs) were followed up with nonparametric tests (i.e., Kruskal-Wallis analysis of ranks and Mann-Whitney *U* tests), which require that fewer normality assumptions be met.

Examination of Group Equivalency

The three groups (OC users, nonusers, men) were examined for equivalency in the following variables from within the screening questionnaire: age, education, diagnosis of an attention problem (e.g., Attention deficit and hyperactivity disorder, ADHD), tobacco

use, typical drug use, typical caffeine use, typical alcohol use score (frequency of alcohol use x typical number of drinks per occasion) and alexithymia scores. Univariate ANOVAs and chi-squares were used to examine group equivalency and results can be seen in Table 6 and 7, respectively. It was found that diagnosis of an attention problem, X^2 (2, N = 135) = 8.127, p = .017, and typical alcohol use significantly differed between groups, F(2, 130) = 4.807, p = .010. Diagnosis of an attention problem reflected the general sex differences in population prevalence of ADHD (American Psychiatric Association, 2013) with men endorsing a yes response more than the two female groups of OC users (p = .026) and nonusers (p = .046), while there was no difference between groups of women (p = .100). Given that the pattern reflected general population sex differences in ADHD and that there was no evidence of a difference in attention scores during the lab session (see below), it was decided that diagnosis of an attention problem would not be used as a covariate in the main analyses. Typical alcohol use was lower in nonusers than both OC users (p = .046) and men (p = .013). Given that typical alcohol use could have a possible effect on an individual's memory and/or cognition and influence performance on laboratory tasks and results, typical alcohol consumption was used as a covariate in the main analyses.

Group equivalency for participants in the first and second laboratory sessions was also tested using the following dependent variables: alcohol consumption in the past 24 hours, number of alcoholic drinks in past 24 hours as well as number of alcoholic drinks in the past week, caffeine consumption in the past 24 hours, number of caffeine servings in the past 24 hours, medication use in the past 2 hours, drug use in the past 24 hours, sleep, fatigue, interest, and boredom. Results from the univariate ANOVAs and chi-

Table 6

Examination of Group Equivalency for Relevant Variables in the Screening Questionnaire, Lab Session I and Lab Session II between Nonusers, OC users, and Men: Means and Standard Deviations.

Variable	Nonusers $n = 40$	OC users $n = 58$	Men $n = 37$
	Means (Standard Deviations)		
Age (years)	20.95 (5.42)	19.60 (2.70)	20.22 (3.24)
Education (years)	13.43 (0.98)	13.97 (1.54)	14.27 (1.59)
Typical drug use	1.41 (0.90)	1.31 (0.66)	1.19 (0.46)
Typical caffeine use	3.90 (1.15)	3.74 (1.22)	3.57 (1.19)
Typical alcohol use *	7.54 (5.99)[x]	11.74 (8.77)	13.11 (9.48)
Alexithymia (TAS-20)	45.74 (10.05)	46.75 (11.50)	46.18 (10.33)
Sess. 1 No. of drinks [a]	0.28 (0.86)	0.10 (0.48)	0.22 (0.75)
Sess. 1 No. of caffeine servings [a]	0.73 (1.63)	0.22 (0.56)	0.43 (0.83)
Sess. 2 No. of drinks [a]	0.13 (0.46)	0.12 (0.50)	0.29 (0.80)
Sess. 2 No. of drinks* [b]	2.28 (2.14)[y]	4.14 (3.93)	5.90 (8.68)[y]
Sess. 2 No. of caffeine servings [b]	0.78 (1.72)	0.25 (0.51)	0.42 (0.97)
Sess. 2 Sleep (hours) [a]	8.20 (1.40)	8.14 (1.60)	8.42 (2.01)
Sess. 2 Fatigue	1.65 (0.98)	1.49 (0.80)	1.25 (0.77)
Sess. 2 Interest	2.15 (0.77)	2.02 (0.77)	2.09 (0.70)

Sess. 2 Boredom	0.60 (0.59)	0.46 (0.57)	0.50 (0.56)
Attention (CalCap)	0.99 (0.01)	0.99 (0.02)	1.00 (0.10)

Note: [a] data refers to experience during the past 24 hours. [b] data refers to experience during the past week. [x] group differences between the indicated group and the other two groups. [y] group differences between the two indicated groups. Typical alcohol use significantly differed between groups, $F(2, 130) = 4.807$, $p = .010$. In laboratory session two, number of alcoholic drinks in the past week significantly differed between groups, $F(2, 102) = 3.484$, $p = .034$.

* $p < .05$

Table 7

Examination of Group Equivalency for Relevant Variables from the Screening Questionnaire, Lab Session I and Lab Session II between Nonusers, OC users, and Men: Raw Frequencies and Percentages.

Variable	Nonusers *n* = 40	OC users *n* = 58	Men *n* = 37
	Frequency (Percentage)		
Diagnosis of attention problem *			
Yes	0 (0.0%)	0 (0.0%)	3 (8.1%)
No	40 (100.0%)	58 (100.0%)	34 (91.9%)
Tobacco use			
Yes	2 (5.0%)	1 (1.7%)	1 (1.7%)
No	38 (95%)	57 (98.3%)	36 (97.3%)
Sess. 1 alcohol past 24 hrs			
Yes	4 (10.3%)	3 (5.2%)	4 (10.8%)
No	35 (89.7%)	55 (94.8%)	33 (89.2%)
Sess. 1 caffeine past 24 hrs *			
Yes	16 (40.0%)	10 (17.2%)	10 (27.0%)
No	24 (60.0%)	48 (82.8%)	27 (73.0%)
Sess. 1 Medication use past 2 hrs			
Yes	2 (5.0%)	2 (3.4%)	2 (5.4%)
No	38 (95.0%)	56 (96.6%)	35 (94.6%)
Sess. 1 Drug use past 24 hrs			
Yes	2 (5.0%)	0 (0.0%)	0 (0.0%)

No	38 (95.5%)	58 (100.0%)	37 (100.0%)
Sess. 2 alcohol past 24 hrs			
Yes	3 (7.5%)	4 (7.0%)	5 (14.7%)
No	37 (31.1%)	53 (93.0%)	29 (85.3%)
Sess. 2 caffeine past 24 hrs			
Yes	15 (37.5%)	12 (21.1%)	9 (25.0%)
No	25 (62.5%)	45 (78.9%)	27 (75.0%)
Sess. 2 Medication use past 2 hrs			
Yes	3 (7.5%)	7 (12.5%)	1 (2.8%)
No	37 (92.5%)	49 (87.5%)	35 (97.2%)
Sess. 2 Drug use past 24 hrs			
Yes	2 (5.1%)	1 (1.8%)	0 (0.0%)
No	37 (94.9%)	56 (98.2%)	36 (100.0%)

Note: Diagnosis of an attention problem significantly differed between groups, X^2 (2, N = 135) = 8.127, p = .017. Caffeine consumption in the past 24 hours significantly differed between groups in laboratory session one, X^2 (2, N = 135) = 6.274, p = .043.

* $p < .05$

squares can also be seen in Table 6 and 7, respectively. Caffeine consumption in the past 24 hours was found to significantly differ between groups in laboratory session one, X^2 (2, N = 135) = 6.274, p = .043. In laboratory session two, number of alcoholic drinks in the past week significantly differed between groups, F(2, 102) = 3.484, p = .034. Since caffeine consumption in the past 24 hours prior to laboratory session one could have an effect on an individual's attention and memory (see review in Ruxton, 2008) it was used as a covariate in the main analyses. In addition, since the number of alcoholic drinks in the past week significantly differed between groups in laboratory session two, it was noted that this could have an impact on an individual's consolidation of the emotional information from laboratory session one. However, due to the large number of participants who did not answer this question, possibly because they did not consume any alcohol, a large portion of the sample would be lost if it were used as a covariate. Therefore, it was decided that since typical alcohol use was already deemed a covariate (see above), it would likely account for any variance that might be accounted for by the number of alcoholic drinks in the past week.

Group equivalency for participants on a laboratory measure of attention was also examined given that differences in attention could account for any differences in memory. Attention was assessed using the CalCap, or more specifically, the Choice Reaction Time d' score. The Choice Reaction Time test was chosen to examine group equivalency in attention, as the internal consistency is quite high (r = .81 to .96; Miller, 1990) and it includes a measure of d', a sensitive indicator of performance on the attention task, providing an index of an individual's ability to accurately discriminate target stimuli from distracter stimuli. OC users, nonusers, and men did not significantly

differ in attention based on the Choice Reaction Time d' score, $F(2, 132) = 0.547$, $p = .580$. Since there was no evidence of differential performance on the attention scores between the groups (see above in Table 6), it was not used as a covariate in the main analyses.

To summarize, based on evidence of group differences noted above, two covariates were identified for use in all analyses. These were: typical alcohol use and caffeine consumption in the 24 hours prior to laboratory session one.

Main Analyses

Hypothesis 1. It was hypothesized that OC users and men would have enhanced memory for emotional gist information in comparison to neutral gist information (e.g., a larger emotional gist to neutral gist ratio) across tasks when compared to nonusers. To test this hypothesis, a MANCOVA was conducted to examine group differences (OC users, nonusers, men) in the ratio of scores for recall of emotional gist: neutral gist. The groups were compared on emotional gist: neutral gist scores for two dependent variables: (a) the LTM recall portion of the Emotional Visuospatial task and (b) the LTM recall portion of the Emotional Story task. Follow-up ANCOVAs were used to examine group differences on each individual test. Both typical alcohol use and caffeine consumption in the 24 hours prior to laboratory session one were included as covariates, given group differences noted above. Two sets of analyses were carried out: one including outliers and one excluding identified outliers for the dependent variables. Please see Table 8 and 9 for the unadjusted means and standard deviations of scores for emotional gist to neutral gist ratios both with and without outliers. Visual inspection of the means suggested that the means were not in the direction of the hypothesis.

Table 8

Hypothesis 1: Unadjusted Means and Standard Deviations of Scores for Emotional Gist to Neutral Gist Ratios (Data includes Outliers).

	Emotional Gist to Neutral Gist Ratio		
Task	Nonusers	OC users	Men
	n = 39	*n* = 57	*n* = 34
	Means (Standard Deviations)		
Emotional Visuospatial Task	2.25 (1.30)	2.20 (1.19)	2.20 (0.96)
Emotional Story Task	1.12 (0.27)	1.06 (0.45)	1.04 (0.19)
Phase 2 (slides 5-8)	1.45 (0.58)	1.71 (0.92)	1.38 (0.66)

Note: While data reported here is unadjusted for covariates, all analyses controlled for typical alcohol use and caffeine consumption.

Table 9

Hypothesis 1: Unadjusted Means and Standard Deviations of Scores for Emotional Gist to Neutral Gist Ratios (Data excludes Outliers).

	Emotional Gist to Neutral Gist Ratio		
Task	Nonusers	OC users	Men
	n = 38	*n* = 55	*n* = 33
	Means (Standard Deviations)		
Emotional Visuospatial Task	2.27 (1.31)	2.21 (1.21)	2.24 (0.95)
Emotional Story Task	1.11 (0.27)	1.01 (0.23)	1.03 (0.19)
Phase 2 (slides 5-8)	1.45 (0.58)	1.69 (0.91)	1.38 (0.66)

Note: While data reported here is unadjusted for covariates, all analyses controlled for typical alcohol use and caffeine consumption.

For the analysis including outliers, the overall multivariate effect was non-significant, $F(4, 250) = 0.200$, $p = .938$, as were both univariate effects: for the Emotional Visuospatial task, $F(2, 125) = 0.013$, $p = .987$: and Emotional Story task, $F(2, 125) = 0.392$, $p = .677$. For the analysis excluding identified outliers, the overall multivariate effect was also non-significant, $F(4, 248) = 1.143$, $p = .337$, as were both univariate effects: for the Emotional Visuospatial task, $F(2, 124) = 0.012$, $p = .988$: and Emotional Story task, $F(2, 124) = 2.324$, $p = .102$. Thus, no significant group effects were found for long-term memory of emotional gist information compared to neutral gist information for the Emotional Visuospatial task, nor for the Emotional Story task. Again, please see Table 8 and 9 for the unadjusted means and standard deviations of scores for emotional gist to neutral gist ratios both with and without outliers. Given that the means were not in the direction of the hypothesis, follow-up nonparametric Kruskal-Wallis analyses were not completed.

Further analyses were conducted for the Emotional Story task based on Nielsen et al.'s (2011) findings that the enhancement of total slide recall was driven by enhanced slide recall in the emotional component of the emotional story, phase 2 (slides 5 to 8). Therefore, another ANCOVA was completed using emotional gist to neutral gist ratios pertaining to recall of only slides 5 to 8 of the emotional and neutral stories. The results remained non-significant. For the analysis including outliers, there was no group effect, $F(2, 125) = 2.521$, $p = .084$. For the analysis excluding outliers, there was also no evidence of group differences, $F(2, 124) = 2.185$, $p = .117$.

Hypothesis 2. It was hypothesized that nonusers would have enhanced memory for emotional versus neutral details across memory conditions (e.g., a larger emotional

detail to neutral detail ratio) when compared to OC users and men. To test hypothesis 2, a MANCOVA was conducted to examine group differences (OC users, nonusers, men) in ratio scores for recall of emotional detail: neutral detail. Again the groups were compared on the emotional detail: neutral detail scores for two dependent variables: (a) the LTM recall portion of the Emotional Visuospatial task and (b) the LTM recall portion of the Emotional Story task. Follow-up univariate ANCOVAs were used to examine group differences on each individual test. Both typical alcohol use and caffeine consumption in the 24 hours prior to laboratory session one were included as covariates, given group differences noted above. Please see Table 10 and 11 for means and standard deviations of the emotional detail to neutral detail ratios from both sets of analyses. Visual inspection of the means suggested that the means were not in the direction of the hypothesis.

For the analysis including outliers, the overall multivariate effect was non significant, $F(4, 250) = 0.191$, $p = .943$, as were both univariate effects: the Emotional Visuospatial task, $F(2, 125) = 0.382$, $p = .683$, and Emotional Story task, $F(2, 125) = 0.004$, $p = .996$. For the analysis excluding identified outliers, the overall multivariate effect was also non-significant, $F(4, 244) = 0.097$, $p = .983$, as were both univariate effects: the Emotional Visuospatial task, $F(2, 122) = 0.076$, $p = .926$: and Emotional Story task, $F(2, 122) = 0.121$, $p = .886$. Thus, no significant group differences were found for long-term memory of emotional detail information compared to neutral detail information for either the Emotional Visuospatial task or the Emotional Story task. Given that the means were not in the direction of the hypothesis, follow-up nonparametric Kruskal-Wallis analyses were not conducted.

Table 10

Hypothesis 2: Unadjusted Means and Standard Deviations of Scores for Emotional Detail to Neutral Detail Ratios (Analyses including Outliers).

	Emotional Detail to Neutral Detail Ratio		
Task	Nonusers	OC users	Men
	n = 39	*n* = 57	*n* = 34
	Means (Standard Deviations)		
Emotional Visuospatial Task	2.69 (1.53)	2.73 (1.65)	3.09 (1.80)
Emotional Story Task	1.31 (0.80)	1.28 (0.65)	1.27 (0.55)
Phase 2 (slides 5-8)	1.41 (0.75)	1.54 (0.76)	1.43 (0.64)

Note: While data reported here is unadjusted for covariates, all analyses controlled for typical alcohol use and caffeine consumption.

Table 11

Hypothesis 2: Unadjusted Means and Standard Deviations of Scores for Emotional Detail to Neutral Detail Ratios (Analyses excluding Outliers).

	Emotional Detail to Neutral Detail Ratio		
Task	Nonusers	OC users	Men
	n = 38	*n* = 56	*n* = 33
	Means (Standard Deviations)		
Emotional Visuospatial Task	2.71 (1.54)	2.75 (1.66)	2.91 (1.49)
Emotional Story Task	1.24 (0.67)	1.23 (0.54)	1.29 (0.54)
Phase 2 (slides 5-8)	1.35 (0.63)	1.49 (0.69)	1.44 (0.64)

Note: While data reported here is unadjusted for covariates, all analyses controlled for typical alcohol use and caffeine consumption.

Further analyses were conducted for the Emotional Story task based on Nielsen et al.'s (2011) findings that the enhancement of total slide recall was driven by enhanced slide recall in the emotional component of the emotional story, phase 2 (slides 5 to 8). Group differences were re-examined in emotional detail to neutral detail ratios pertaining to recall of only slides 5 to 8 of the emotional and neutral story. The results remained the same and were non-significant. For the analyses including outliers, the group effect was non-significant, when outliers were included, $F(2, 125) = 0.698$, $p = .499$: and excluded, $F(2, 122) = 0.778$, $p = .462$.

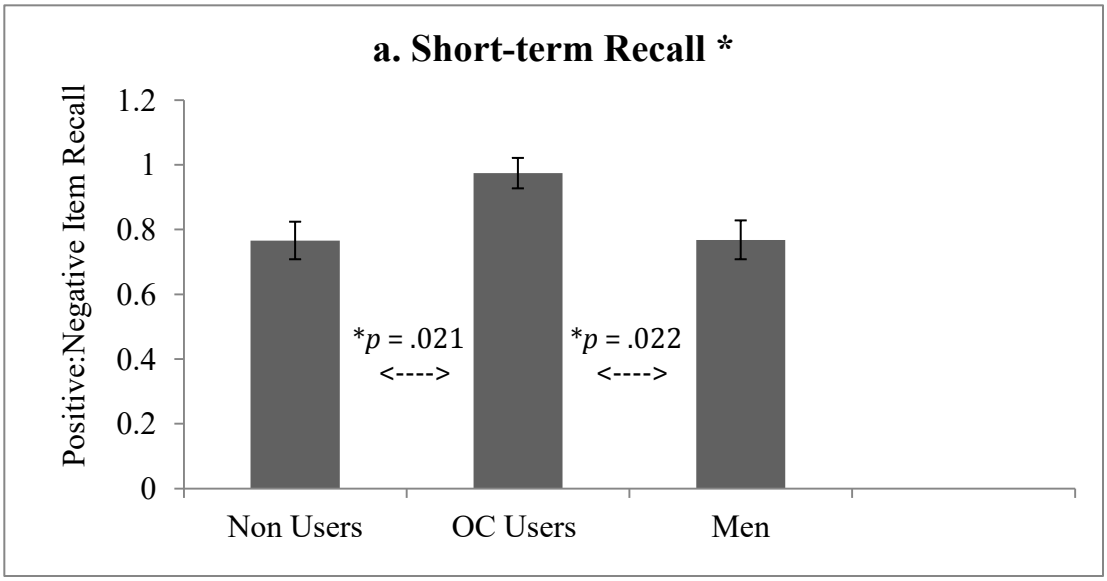
Hypothesis 3. A third MANCOVA was conducted to test whether there were any group differences (OC users, nonusers, men) in relative recall of positive (P) and negative (N) stimuli (i.e., P:N). This hypothesis was exploratory and nondirectional in nature. The groups were compared on two dependent measures: STM ratio of positive to negative items recalled (P:N STM) and the LTM ratio of positive to negative items recalled (P:N LTM) from the Emotional Visuospatial task. The ratios of positive to negative recalled stimuli were computed using the Emotional Visuospatial task only, as the Emotional Story task did not contain any positive stimuli (but only negative and neutral stimuli). Both typical alcohol use and caffeine consumption in the 24 hours prior to laboratory session one were included as covariates, given group differences noted above.

In the first set of analyses, including outliers, a significant overall multivariate group effect using Pillai's trace was found for positive to negative item recall, $F(4, 252 = 2.628$, $p = .035$. A follow-up ANCOVA revealed a significant univariate group effect for positive to negative item STM recall, $F(2, 126) = 5.39$, $p = .006$. Follow-up pairwise

comparisons revealed that OC users recalled relatively more positive than negative items (M = 0.97, SD = 0.44) (or relatively less negative than positive items) compared to both nonusers (M = 0.78, SD = 0.24; p = .021) and men (M = 0.76, SD = 0.28; p = .022) (See Figure 1). No significant difference in the ratio of positive to negative item recall was found for LTM, $F(2, 126) = 1.276$, p = .283. However, the direction of the means suggested that the pattern of recall was in the same direction with OC users (M = 0.92, SD = 0.42) having the largest ratio of positive to negative item recall compared to nonusers (M = 0.83, SD = 0.35) and men (M = 0.80, SD = 0.44) (see Figure 1).

Given the above finding that OC users showed greater relative immediate recall of positive to negative items, group differences in the immediate recall of both positive and negative emotionally valenced items were examined using two ANCOVAs. The first ANCOVA revealed that short-term recall of negative items differed significantly between groups, $F(2,128) = 3.824$, p = .024 (see Figure 2). Pairwise comparisons revealed that OC users (M = 5.17, SD = 1.84) recalled significantly fewer negative items than nonusers (M = 5.97, SD = 1.61; p = .020). Although short-term recall of positive items did not differ significantly between groups, $F(2,128) = 1.748$, p = .178, the direction of the means suggested that OC users (M = 4.48, SD = 1.43) recalled more positive items than nonusers (M = 4.28, SD = 1.72) and men (M = 3.92, SD = 1.57) (see Figure 2).

In the second set of analyses, where the outliers were excluded, the significant overall multivariate effect disappeared for positive to negative item recall, $F(2,123) = 1.048$, p = .354. However, the univariate group effect for positive to negative item STM recall remained significant, $F(2,123) = 4.65$, p = .011. Again, pairwise comparisons indicated that OC users recalled relatively more positive to negative items (M = 0.93, SD



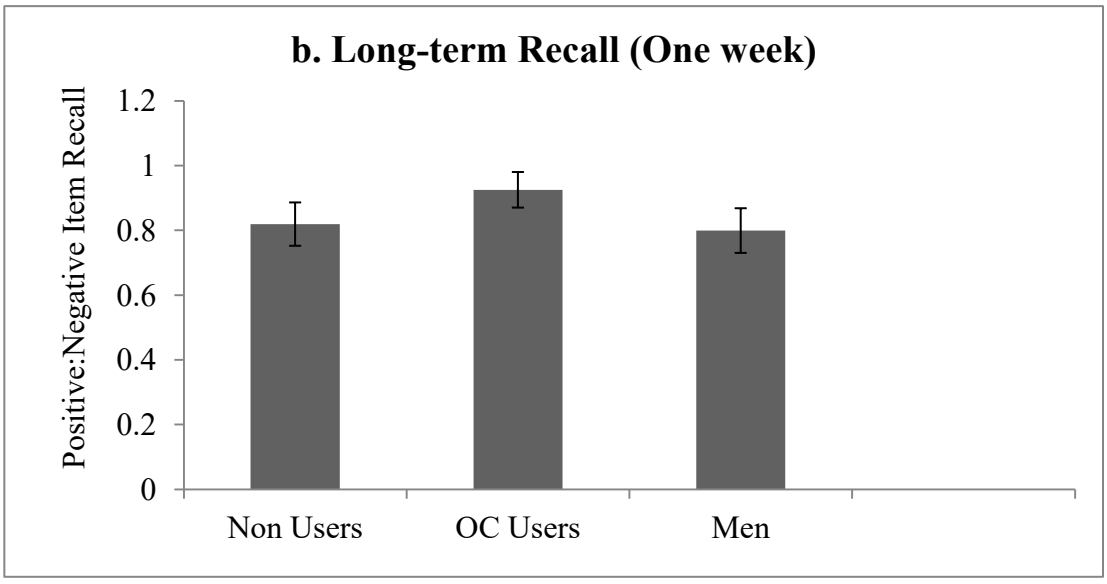


Figure 1

Group Differences Between Nonusers, OC users, and Men on the Ratio of Positive to Negative Items Recalled on the Emotional Visuospatial Task. (a). OC users had significantly larger positive to negative item ratios than nonusers (p = .021) and men (p = .022) for short-term item recall on the emotional visuospatial task, $F(2, 126) = 5.39$, p = 006. (b). No group differences were found for positive to negative ratios for long-term item recall, $F(2, 126) = 1.276$, p = .283. Error bars represent ±1 SEM. * $p < .05$

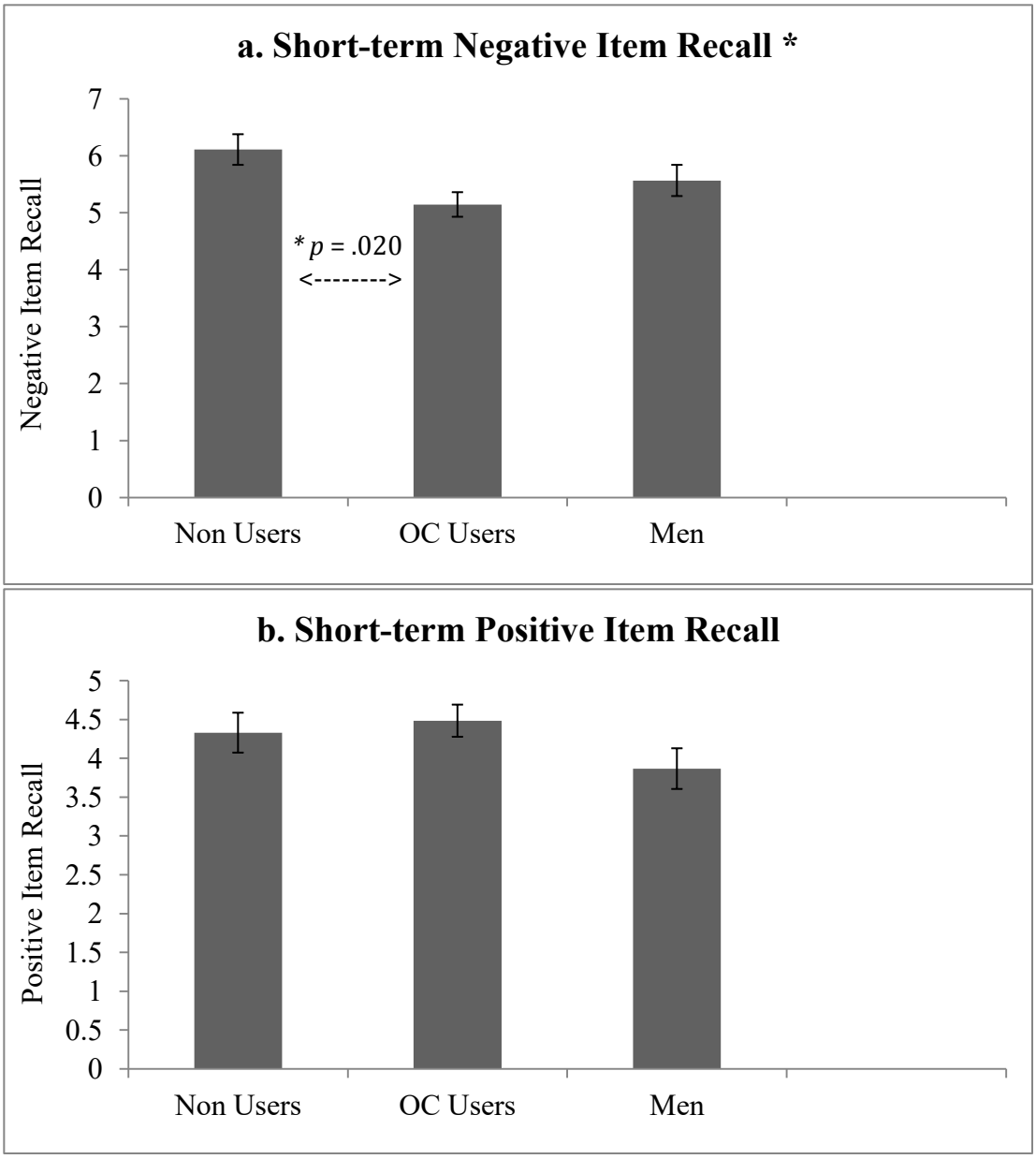


Figure 2

The Short-term Negative Item Recall and Short-term Positive Item Recall of the Emotional Visuospatial Task Among Groups (Non users, OC users, men). (a). There was a significant group difference for negative item recall, $F(2,128) = 3.824$, $p = .024$. Pairwise comparisons revealed that OC users recalled significantly fewer negative items than nonusers ($p = .020$) (b). No significant differences between OC users, nonusers, and

men in positive item recall for short-term memory, $F(2,128) = 1.748$, $p = .178$. Error bars represent ±1 SEM. * $p < .05$

= 0.34) (or relatively less negative to positive items) compared to both nonusers (M = 0.78, SD = 0.24; p = .035) and men (M = 0.76, SD = 0.28; p = .038). As with outliers in the analysis, no significant difference in the ratio of positive to negative item recall was found for long-term recall, $F(2,123) = 1.048$, p = .354, when excluding identified outliers. However, the direction of the means still suggested that the pattern of recall was in the same direction of short-term recall with OC users (M = 0.88, SD = 0.35) having the largest ratio of positive to negative item long-term recall when compared to nonusers (M = 0.80, SD = 0.29) and men (M = 0.80, SD = 0.44).

A follow-up ANCOVA examining group differences in short-term negative item recall revealed that short-term recall of negative items still differed significantly between groups, $F(2,125) = 3.846$, p = .024. Follow up pairwise comparisons revealed that OC users (M = 5.25, SD = 1.78) significantly differed from the nonusers (M = 6.03, SD = 1.60; p = .019) in short-term negative item recall. That is, OC users recalled significantly fewer negative items than nonusers. Again, a follow-up ANCOVA examining group differences in short-term positive item recall revealed no significant group differences, $F(2,125) = 1.555$, p = .215. Although no main significant group differences were found for short-term recall of positive items, the direction of the means suggested that OC users (M = 4.43, SD = 1.41) recalled more positive items than nonusers (M = 4.32, SD = 1.73) and men (M = 3.92, SD = 1.57).

In order to ensure that non-normal distributions cannot account for the above findings, a follow-up Kruskal-Wallis analysis of ranks was conducted to evaluate differences among the three groups (OC users, nonusers, and men) on the ratio of positive to negative STM item recall. Again, two sets of analyses were carried out: one including

outliers and one excluding identified outliers from the dependent variable (ratio of positive to negative STM item recall). In the analysis including outliers, the test was significant suggesting group differences, X^2 (2, N = 135) = 8.58, p = .014. Pairwise comparisons among the three groups (OC users, nonusers, and men) were conducted using the Mann-Whitney U test. The results of these tests again indicated significant differences between OC users and nonusers (p = .041) and between OC users and men (p = .006). The relative recall of positive to negative stimuli was significantly higher for OC users in both comparisons.

In the analysis excluding identified outliers, the test was also significant, X^2 (2, N = 132) = 7.08, p = .029. Again, follow up testes were conducted to evaluate pairwise differences among the three groups (OC users, nonusers, and men) using the Mann-Whitney U test. The results of these tests indicated a significant difference between OC users and men (p = .012) but no longer a significant difference between OC users and nonusers (p = .072). Thus, the relative recall of positive to negative stimuli was significantly greater for OC users compared to men.

Another follow-up Kruskal-Wallis analysis of ranks was conducted to evaluate differences among the three groups (OC users, nonusers, and men) on short-term negative item recall. In the analysis including outliers, the test was non-significant suggesting no group differences, X^2 (2, N = 135) = 5.06, p = .080. Although the effect for group differences in short-term negative item recall was no longer significant, it still suggested a weak trend. In the analysis excluding outliers, the test was also non-significant suggesting no group differences, X^2 (2, N = 132) = 4.75, p = .093.

Supplementary Analyses

Three sets of supplementary analyses were conducted as part of the present study. These analyses explored menstrual cycle phase effects on task performance in nonusers, group differences in mood and affect (between OC users and nonusers), and re-examination of Hypothesis 3 using negative affect scores after viewing the emotional stimuli in session one as a covariate.

Menstrual cycle phase analyses. Menstrual cycle phase effects in nonusers were examined to see if menstrual cycle phase was associated task performance for the dependent variables from hypotheses 1, 2 and 3. For the variables in hypothesis 1 there was no overall menstrual cycle phase effect, $F(4,68) = 0.079$, $p = .988$, and univariate ANCOVAs indicated no menstrual cycle phase effects for emotional gist to neutral gist ratios on the Emotional Visuospatial task, $F(2,34) = 0.098$, $p = .907$, or the Emotional Story task, $F(2,34) = 0.045$, $p = .956$. For the variables in hypothesis 2 there also was no evidence of an overall menstrual cycle phase effect, $F(4,68) = 0.696$, $p = .598$, and no univariate menstrual cycle phase effects for emotional detail to neutral detail ratios of the Emotional Visuospatial task, $F(2,34) = 0.566$, $p = .573$, or the Emotional Story task, $F(2,34) = 0.661$, $p = .523$. For the two dependent variables in hypothesis 3 there was no overall menstrual cycle phase effect in the MANCOVA, $F(4,68) = 0.270$, $p = .896$, and no univariate menstrual cycle phase effects for positive to negative item recall ratios for the short-term memory, $F(2,34) = 0.070$, $p = .932$, or long-term memory tests, $F(2,34) = 0.544$, $p = .585$. Please refer to Table 12 for the means and standard deviations of task performance for the three menstrual cycle phase groups from the above analyses.

Table 12

Task Performance as a function of Menstrual Cycle Phase in Nonusers: Means and Standard Deviations

Task Performance Score	Menstrual Cycle Phase		
	Menses	Periovulatory	Mid Luteal
	n = 16	*n* = 11	*n* = 12
	Means (Standard Deviations)		
Emotional Visuospatial Task Emotional Gist: Neutral Gist	2.17 (1.21)	2.38 (1.79)	2.22 (0.93)
Emotional Story Task Emotional Gist: Neutral Gist	1.11 (0.25)	1.10 (0.33)	1.13 (0.27)
Emotional Visuospatial Task Emotional Detail: Neutral Detail	2.96 (1.48)	2.50 (1.47)	2.53 (1.71)
Emotional Story Task Emotional Detail: Neutral Detail	1.42 (0.91)	1.40 (0.90)	1.09 (0.52)
Emotional Visuospatial Task P:N STM	0.76 (0.29)	0.78 (0.21)	0.80 (0.20)
Emotional Visuospatial Task P:N LTM	0.77 (0.31)	0.83 (0.23)	0.90 (0.48)

Note: *N* = 39.

Menstrual cycle analyses were re-run using the menstrual cycle phases Nielsen and colleagues used in their 2013 study examining the influences of sex and menstrual cycle phase at encoding for memory of gist and detail. They used different menstrual cycle phases than the ones used in the present study. However, when the data was re-examined using the same cycle phases as Nielsen and colleagues (follicular phase days 1 to 14, luteal phase days 15 to 30), there was no menstrual cycle effect for emotional versus neutral gist information for the story task, $F(1, 35) = .277$, $p = .602$, and no menstrual cycle effect for emotional versus neutral detail information for the story task, $F(1,35) = .044$, $p = .836$. While not significant, it is worth noting that a trend for a follicular phase advantage was noted for recall of emotional versus neutral detail information on the Emotional Visuospatial task, $F(1,35) = 3.584$, $p = .067$. This is the opposite phase effect found by Nielsen et al. (2013) for the story task, but could partly reflect different phase advantages for different types of material (i.e., follicular phase advantage for visuospatial material and luteal phase advantage for verbal material).

OC use and mood/affect. Scores on the PANAS were examined to see if any group differences in positive or negative affect existed between OC users, nonusers, and men. Each participant filled out the PANAS a total of three times: once at the beginning of laboratory session one (baseline measure), once at the end of laboratory session one (after viewing the emotional stimuli), and once more during laboratory session two. MANCOVAs were conducted to see if the groups differed on the PA and NA subscales of the PANAS during any of the three points in time (see Table 13 for means and standard deviations for all time points, mean, and range). The same covariates from the main analyses were used: typical alcohol use and caffeine consumption 24 hours prior to

Table 13

Examination of Positive and Negative Affect in Nonusers, OC users, and Men: Means and Standard Deviations

Affect Score	Nonusers	OC users	Men
	Means (Standard Deviations)		
Mean PA	26.92 (7.15)	25.41 (6.02)	28.39 (6.33)
Mean NA*	15.48 (5.96)[x]	13.40 (2.77)	12.56 (2.60)
Lab 1 PA before	28.47 (8.14)	26.48 (6.68)	29.03 (6.27)
Lab 1 NA before	14.28 (5.73)	13.02 (2.79)	12.91 (3.23)
Lab 1 PA after	26.50 (7.53)	24.17 (6.71)	28.12 (7.42)
Lab 1 NA after*	15.75 (7.14)[x]	13.41 (4.12)	12.89 (3.30)
Lab 2 PA	25.81 (8.37)	25.57 (6.65)	28.03 (7.86)
Lab 2 NA*	16.42 (7.58)[y]	13.76 (4.44)	11.89 (2.49)[y]
PA Range	7.04 (0.67)	5.91 (0.54)	6.61 (0.69)
NA Range*	5.59 (5.48)[y]	4.29 (4.25)	2.97 (2.21)[y]

Note: *N* ranged from 122 to 133 for MANCOVA and ANCOVA analyses. [x] group differences between the indicated group and the other two groups. [y] group differences between the two indicated groups. Affect scores were derived from the PA and NA subscales of the PANAS.

* $p < .05$

laboratory session one. First, a mean PA and NA level was computed using all three time points. There was no significant difference in mean PA level between groups, $F(2,117) = 1.829$, $p = .165$. Therefore, OC users ($M = 25.41$, $SD = 6.02$), nonusers ($M = 26.92$, $SD = 7.15$), and men ($M = 28.39$, $SD = 6.33$) did not differ in mean PA. However, mean NA level significantly differed between groups, $F(2,121) = 5.201$, $p = .007$. Follow-up pairwise comparisons showed that nonusers ($M = 15.48$, $SD = 5.96$) had significantly higher NA than OC users ($M = 13.40$, $SD = 2.77$; $p = .014$) and men ($M = 12.56$, $SD = 2.60$; $p = .002$).

There were no differences in PA level, $F(2,117) = 1.609$, $p = .204$, or NA level, $F(2,121) = 1.237$, $p = .294$, at the beginning of laboratory session one. Thus, PA and NA did not differ between groups prior to exposure to the emotional stimuli. The PA subscale did not differ between groups at the end of laboratory session one, after viewing the emotional stimuli, $F(2,117) = 2.608$, $p = .078$. Although examination of the means suggested that OC users had the lowest PA scores ($M = 24.17$, $SD = 6.71$), followed by nonusers ($M = 26.50$, $SD = 7.53$), and men ($M = 28.12$, $SD = 7.42$). The NA subscale showed a significant difference between groups at the end of laboratory session one, $F(2,121) = 4.363$, $p = .015$. Follow-up pairwise comparisons revealed that nonusers ($M = 15.75$, $SD = 7.14$) had significantly higher negative affect than both OC users ($M = 13.42$, $SD = 4.11$; $p = .039$) and men ($M = 12.89$, $SD = 3.30$; $p = .024$). This might suggest that viewing the emotional stimuli increased NA in nonusers, impacting negative mood to a greater extent.

For laboratory session two, only the NA subscale significantly differed between groups, $F(2,121) = 5.890$, $p = .004$. Follow up pairwise comparisons showed that

nonusers (M = 16.42, SD = 7.58) significantly differed from men (M = 11.89, SD = 2.49; p = .003) but did not significantly differ from OC users (M = 13.76, SD = 4.44; p = .099). Nonusers had the highest scores, indicating they were experiencing more negative affect than men during laboratory session two. The PA subscale did not differ between OC users (M = 25.58, SD = 6.65), nonusers (M = 25.81, SD = 8.37), and men (M = 28.03, SD = 7.86) during laboratory session two, $F(2,117) = 0.966$, p = .384.

Affect variability was also examined by looking at the range of PA and NA subscale scores between all three time points. No significant differences in PA variability between OC users, nonusers, and men were found, $F(2,128) = .896$, p = .411. Therefore, OC users (M = 5.91, SD = 0.54), nonusers (M = 7.04, SD = 0.67), and men (M = 6.61, SD = 0.69) did not differ in the range of their PA scores. However, there was a significant group difference in NA variability, $F(2,128) = 3.457$, p = .034. Follow-up pairwise comparisons revealed that nonusers (M = 5.59, SD = 5.48) significantly differed from men (M = 2.97, SD = 2.21; p = .029), suggesting that nonusers experienced more variability in negative affect than men.

Re-examination of hypothesis 3 using negative affect as a covariate. The above analyses suggested that OC users had a lower mean NA level than nonusers at the end of the first laboratory session. This suggests the possibility that OC use could be at least partially responsible for the reduced NA in this group. While the group differences in mood could be OC-related or otherwise-explained, it was considered important to determine if the group differences in NA after session one might account for the above findings of differential immediate recall of positively-and negatively-valenced items between OC users and nonusers. Thus, the analyses to test hypothesis 3 were re-run to

see if level of negative affect after viewing the emotional stimuli was driving the significant results (i.e., to determine if the higher negative affect in the nonusers after session one could account for their better scores on the test of immediate recall of negative items as compared to the OC users). Hence, NA level at the end of laboratory session one was included as an additional covariate in the main analyses for hypothesis 3. Including this additional covariate did not change the results entirely. In the analyses including outliers the significant univariate group effect for positive to negative item STM recall held, $F(2, 121) = 4.776$, $p = .010$. Follow-up pairwise comparisons revealed that OC users ($M = 0.97$, $SD = 0.44$) significantly differed from men ($M = 0.76$, $SD = 0.28$; $p = .021$) but no longer significantly differed from nonusers, although a weak trend remained ($M = 0.79$, $SD = 0.24$; $p = .060$) in the short-term ratio of positive to negative item recall. As above, no significant difference in the ratio of positive to negative item recall was found for LTM, $F(2, 118) = 0.881$, $p = .417$ between OC users ($M = 0.93$, $SD = 0.42$), nonusers ($M = 0.84$, $SD = 0.35$), and men ($M = 0.80$, $SD = 0.44$).

Follow-up ANCOVAs examining group differences in short-term positive item recall and negative item recall revealed that short-term negative item recall remained significantly different between groups, $F(2,123) = 3.382$, $p = .037$. Follow-up pairwise comparisons revealed that OC users ($M = 5.18$, $SD = 1.86$) recalled significantly fewer negative items than nonusers ($M = 5.97$, $SD = 1.59$; $p = .011$). Thus, this difference was even stronger after controlling for NA. Including negative affect as a covariate also did not change the results for short-term recall of positive items. Short-term positive item recall did not significantly differ between OC users ($M = 4.48$, $SD = 1.45$), nonusers ($M = 4.35$, $SD = 1.74$), and men ($M = 3.92$, $SD = 1.57$), $F(2,123) = 2.194$, $p = .116$.

In the analyses excluding identified outliers, the results indicated that the univariate effect for the ratio of positive to negative LTM item recall was again non-significant, $F(2,118) = 0.881$, $p = .417$, with no significant difference between OC users ($M = 0.88$, $SD = 0.35$), nonusers ($M = 0.81$, $SD = 0.29$), and men ($M = 0.80$, $SD = 0.44$). However, the univariate effect for the ratio of positive to negative STM item recall remained significant, $F(2,118) = 4.008$, $p = .021$. Follow-up pairwise comparisons revealed that OC users ($M = 0.93$, $SD = 0.35$) significantly differed from men ($M = 0.76$, $SD = 0.28$) but no longer significantly differed from nonusers ($M = 0.79$, $SD = 0.24$) in the ratio of positive to negative STM item recall. Follow-up ANCOVAs examining group differences in short-term positive item recall and negative item recall revealed that short-term negative item recall significantly differed between groups, $F(2,120) = 3.429$, $p = .036$. Follow-up pairwise comparisons revealed that OC users ($M = 5.26$, $SD = 1.80$) significantly differed from the nonusers ($M = 6.03$, $SD = 1.58$; $p = .031$) in short-term negative item recall, recalling fewer negative items than nonusers. Although short-term positive item recall did not significantly differ between groups, $F(2,120) = 2.144$, $p = .122$, the direction of the means suggested that OC users ($M = 4.43$, $SD = 1.44$) recalled slightly more positive items than nonusers ($M = 4.39$, $SD = 1.74$) and men ($M = 3.92$, $SD = 1.57$).

Discussion

Summary of Results

The present study examined whether OC use alters memory for general gist information versus specific details of emotional stimuli (Hypotheses 1 and 2) and the relative recall of positive and negative stimuli (Hypothesis 3). The results indicated no

group differences between OC users, nonusers, and men in either short-term or long-term recall of central gist information versus specific details of the emotional stimuli used (Emotional Story task and Emotional Visuospatial task). Thus, there was no support for the first two hypotheses of the present study, where it was hypothesized that OC users and men would have enhanced memory for gist in the emotional memory conditions compared to neutral conditions (Hypothesis 1) and nonusers would show the opposite effect, having enhanced memory for detail in the emotional memory conditions compared to neutral conditions (Hypothesis 2). However, the results indicated a difference in the relative recall of positive and negative stimuli in the Emotional Visuospatial task when short-term memory was tested. It was found that OC users recalled relatively more positive than negative items than nonusers and men. Furthermore, this effect was mainly driven by the fact that OC users recalled fewer negative items than nonusers during short-term item recall for the Emotional Visuospatial task. It was also found that nonusers experienced greater negative affect levels than OC users after viewing the emotional stimuli than OC users. When group differences in negative affect were controlled, OC users still recalled more positive to negative items (or less negative to positive items) and fewer negative items than nonusers.

No support for hypotheses 1 or 2 in the relative recall of emotional gist and emotional detail to neutral gist and neutral detail. There was no support for the first two hypotheses in this study. These results are discussed together here given that many of the same possible explanations are relevant when interpreting the results. Firstly, there was no evidence that OCs affect relative memory for emotional versus neutral gist information (Hypothesis 1). No significant differences between OC users, nonusers, and

men were found for enhanced long-term memory of emotional gist information compared to neutral gist information on either the Emotional Visuospatial task or Emotional Story task. Thus, the hypothesis that OC users and men would have enhanced memory for emotional gist information compared to neutral gist information across tasks when compared to nonusers was not supported.

Secondly, there was no evidence that OCs affect relative memory for emotional versus neutral detail information (Hypothesis 2). No significant differences between OC users, nonusers, and men were found for long-term memory of emotional detail information compared to neutral detail information for the Emotional Visuospatial task or Emotional Story task. Thus, the hypothesis that nonusers would have enhanced memory for emotional detail information compared to neutral detail information across tasks when compared to OC users and men was not supported.

The findings for Hypothesis 1 were inconsistent with findings from Nielsen et al. (2011) as they found that women using hormonal contraception exhibited enhanced memory of gist in the emotional compared with neutral story conditions. The findings for Hypothesis 2 were also inconsistent with findings from Nielsen et al. (2011) as they found that naturally cycling women (nonusers) exhibited enhanced memory for story details with emotional compared to neutral story conditions. However, it is worth noting that the present study included a potentially more sensitive within-subjects design where long-term recall of emotional versus neutral gist information was compared within the *same* participants, whereas Nielsen and colleagues compared recall of emotional versus neutral gist information between *different* participants within the same group. Very few studies have looked at the long-term memory of gist and detail information for emotional

memory tasks. The present study and the study by Nielsen et al. (2011) are the only two to look specifically at differences between OC users and nonusers. There is an additional study by Nielsen and colleagues (2014) that looks at differences in emotional memory for gist and detail information between OC users and nonusers, however, there is the added influence of a post learning stressor. Consequently, there is little other research to relate the results of this study too.

The study by Nielsen, Ahmed, and Cahill (2014) explored how a post learning stressor might modulate the influence of OC status on memory for gist and detail in an emotional versus neutral story condition. Their study used the same emotional and neutral stories as the present study; however, participants in their study only viewed either the emotional version or neutral version of the story. Another difference in their study was the presence of a stressor. Immediately after viewing the emotional or neutral story, a cold pressor stress (CPS) or a control procedure was administered and one week later, a surprise free recall test was administered to participants. It was found that nonusers who viewed the emotional version of the story and were administered the CPS procedure recalled the most details overall and more gist from the emotional compared to neutral story version. They also exhibited greater cortisol increases to the CPS procedure compared to OC users. In OC users, the CPS procedure did not affect memory for gist or detail from the emotional or neutral story in any way. These findings suggest that postlearning stress differentially affects memory for gist and detail from an emotional story depending on OC status. Although we did not employ a post-learning stressor in the current study, the findings that nonusers who received the CPS procedure recalled more gist from the emotional compared to neutral story version is not in line with

Hypothesis 1 as we predicted that nonusers would recall more detail from the emotional story compared to the neutral story condition. However, the Nielsen et al. (2014) findings that nonusers who received the CPS procedure recalled the most details overall is in line with Hypothesis 1 but inconsistent with our results as we found no group differences in the recall of emotional detail information (without the presence of a post-learning stressor). The finding that OC users who were administered the CPS procedure did not differ in the recall of gist or detail from the emotional compared to neutral story is consistent with our results from Hypothesis 2, as the present study did not find that OC users recalled more gist from the emotional compared to neutral story condition (without the presence of a post-learning stressor). However, both the findings are inconsistent with what was predicted in Hypothesis 2 (i.e., higher emotional gist: neutral gist). A possible explanation for this could be that different generations of synthetic progestins differentially modulate emotional memory (Mordecai et al., 2008). Thus, it is possible that a particular generation of progestin is driving the effects of OCs on emotional memory and that the samples of OC users tested differed from the Nielsen et al. (2011) sample. The possibility that OC status might interact with postlearning stress to modulate memory for emotional information, and given the fact that the present study did not involve the presence of a stressor after viewing the stories, might also account for the non-significant differences found in the present study.

Cahill, Gorski, Belcher, and Huynh (2004) examined whether sex-related differences exist in the recall of gist versus detail using the same emotional story task. However, their study did not examine effects of OCs and only used the emotional version of the story to test surprise recall and recognition one week later. Similar to our findings

for Hypothesis 1, the study found no differences in recall of story gist information when considering the performance of actual men and women. However, the study revealed a significant difference when considering males and females as determined by their BEM Sex-Role Inventory scores, revealing that "BEM" males (i.e., participants scoring high on the "masculine" scale) showed enhanced recall of gist information while "BEM" females (i.e., participants scoring high in the "feminine" scale) did not. This is to some extent inline with our proposed hypothesis (Hypothesis 1) in that men would have enhanced memory for gist compared to nonusers but is inconsistent with our results, as we found no difference in the recall of gist information. Cahill and colleagues also found enhanced recall of detail in both males and females as determined by their BEM Sex-Role Inventory scores. This effect appeared larger in "BEM" females than in "BEM" males. This is to some extent in line with our second proposed hypothesis (Hypothesis 2) in that nonusers (females) would have enhanced memory for detail compared to men but inconsistent with our findings, as we found no difference in the recall of detail information. However, similar to our findings for Hypothesis 2, their study found no differences in recall of story detail information when considering the performance of actual men and women. It may be that sex related traits (i.e., the extent to which one displays masculine or feminine characteristics), rather than actual sex per se, may be a more sensitive indicator of sex-related influences in the recall of emotional information and a possible reason why we did not see any differences (between nonuser females and males) in the type of information recalled (gist versus detail) when emotional memory performance was tested in the current study.

Lastly, a study by Nielsen, Ahmed, and Cahill (2013) examined the effect of sex and menstrual cycle phase at encoding for memory of gist and detail information of either an emotionally arousing or neutral story. The emotionally arousing and neutral story were the same two stories used in the present study. Again this study only had participants watch either the emotionally arousing version or the neutral version of the story. It was found that men exhibited enhanced memory for gist, but not for detail, in the emotional compared with neutral story condition. These findings are in line with Hypothesis 1 of the current study but inconsistent with our results as we did not find enhanced memory for emotional gist compared to neutral gist in men. One reason for our different findings may be that only viewing the emotional story allowed participants to retain more information, as they did not have to split retention between the neutral version of the story and the emotional version, as was the case in the current study. This could be a possible reason why we did not see any differences in the type of information recalled (gist versus detail) when recall of the emotional and neutral stories were tested in the present study.

There are at least eight possible reasons for the current findings of no difference between OC users, nonusers, and men on relative recall of emotional and neutral gist and detail information, which may explain why the present study was unable to replicate the Nielsen et al. (2011) findings. A number of possible reasons concern differences in methodology between the current study and the Nielsen et al. (2011) study. First, Nielsen and colleagues employed a between-subjects design, while the current study employed a within-subjects design. That is, Nielsen and colleagues only exposed each participant to either the emotional version of the story or the neutral version, not both versions, as did

the current study. While our within-subjects design has many strengths in that each participant was compared with themselves on the emotional and neutral tasks, having to view both stories may have caused participants to have to split story retention between the two versions and thus reduce the amount of information remembered from both. In the Nielsen study, nonusers did recall more emotional details (*M* = 7.25, *SD* = 4.82) than nonusers did in the present study (M = 3.38, SD = 2.98), whereas the recall of neutral detail was similar in both studies (*M* = 3.56, *SD* = 2.71) versus (M = 3.10, SD = 2.91) respectively. However, in the Nielsen study nonusers recalled fewer emotional gist elements (*M* = 3.56, *SD* = 1.89) compared to the present study (M = 8.95, SD = 2.77), and fewer neutral gist elements (*M* = 3.38, *SD* 3.30) than the present study (M = 8.25, SD = 2.69). OC users did recall more emotional details (*M* = 5.76, *SD* = 2.77) and neutral details (*M* = 4.53, *SD* = 2.58) in the Nielsen study compared to the recall of emotional (M = 2.89, SD = 2.11) and neutral (M = 2.61, SD = 2.45) detail in the present study. However, in the Nielsen study OC users recalled fewer emotional gist (*M* = 5.94, *SD* = 2.95) and neutral gist elements (*M* = 3.18, *SD* =2.93) than OC users in the present study (M = 7.89, SD = 3.22) and (M = 7.86, SD = 3.08) respectively. Thus, the possibility that splitting story retention between both stories in the present study reduced the amount of information recalled seems to only apply to the recall of story detail but not story gist. Second, in the current study, participants may have been distracted by other lab tasks such as the Emotional Visuospatial task and the CalCap, which were not part of the study by Nielsen and colleagues. Having to complete additional tasks besides the Emotional Story task may have put additional information processing demands on participants, hindering the amount of information encoded and retained. However, participants were

not asked to remember any of the information (i.e., surprise recall tasks) and one memory task was more verbal and the other more visuospatial in nature. Thirdly, another difference in methodology involved the collection of recall data. The participants in the previous study verbally recalled story information while the examiner recorded the information for the free recall portion. The participants in the current study recalled story information on their own, writing down the recalled story information on a form provided. Perhaps being able to answer the questions on their own allowed participants to feel less pressure, resulting in a lower performance level (i.e., not feeling the pressure to impress or please the examiner and as a result not trying as hard to answer every question correctly or to provide as much information).

Fourth, low effort by the participants may also be a possible reason why the current study did not find any significant results for Hypotheses 1 and 2. A lack of participant effort when recall was tested would have resulted in not having enough recalled information to provide comprehensive scores of gist versus detail, which could have resulted in the non-significant findings. This possibility is related but distinct from possibility three noted above, as possibility three has to do with poorer performance because of a lack of pressure to please or impress the examiner due to the method of collecting recalled information while possibility five has to do with a simple lack of participant effort and/or motivation to recall information in general. A fifth possible explanation concerns task difficulty. Details were much harder to remember as they often referred to specific elements from the photos as opposed to gist, which often referred to the narrated story line for the Emotional Story task. In addition, providing participants with only 60 seconds to encode information during the Emotional

Visuospatial task may have been too short for participants to remember the location of the items or more of the items themselves (i.e., a mean of 13.18 for STM and 8.79 for LTM out of 30 were recalled). Thus, the tasks may have been too difficult for some participants, resulting in a lack of recalled data to work with.

Sixth, the current study found a group difference in negative affect level after viewing the emotional stimuli (i.e., higher negative affect in free-cyclers), whereas, Nielsen et al. (2011) did not examine negative affect after viewing the stimuli. While it is possible that the higher negative affect of the free-cyclers after viewing the stories might have increased their emotional gist to neutral gist recall and decreased their emotional detail to neutral detail recall, we are not aware of any evidence that negative affect causes this pattern of recall. While Nielsen and colleagues examined trait anxiety, they only measured this prior to exposure to the emotional story. However, they did measure pupillary arousal in response to the stories and found no group differences. It is worth noting that negative affect level and pupillary response are not the same. The difference seen in the current study where nonusers showed greater NA levels than OC users and men after viewing the emotional stimuli may have influenced how the story was processed and retained due to the emotional state of the individual and consequently influenced memory differently for gist versus detail of the story and/or items. Seventh, it may be that the sample of OC users in the Nielsen et al. (2011) study was more masculine than the sample of OC users in the present study (e.g., Oinonen, Jarva, & Mazmanian, 2008), which may have made the performance of OC users more similar to men in the Nielsen study. Although Nielsen et al. (2011) did not test men, they hypothesized that men would have higher emotional gist to neutral gist ratios, similar to the OC users in

their study. Finally, consistent with our findings, it is possible that these three groups do not differ in their relative recall of emotional and neutral gist and detail information. Given the strengths and sensitivity of our within-subjects design, this possibility should not be excluded. This is further emphasized by the fact that our analyses directly compared OC users and nonusers whereas Nielsen and colleagues only compared memory for gist and detail within each group. Overall, the current study did not provide any evidence to suggest that OCs influence relative recall of emotional versus neutral information, whether that be general gist information or specific detail information.

OCs associated with lower recall of negative stimuli and higher relative recall of positive to negative stimuli (Hypothesis 3). A significant group difference between OC users, nonusers, and men was found in the ratio of positive to negative items recalled for short-term, but not long-term, memory of the Emotional Visuospatial task. These results suggested that OC users recalled relatively more positive than negative items (or relatively less negative than positive items) compared to both nonusers and men when short-term memory was assessed. Examination of the positive and negative short-term item recall revealed that OC users also recalled significantly fewer negative items than nonusers. This suggests that any effect of OCs on emotional valence of recall was stronger for negatively valenced than positively valenced items, with OCs possibly decreasing recall of items with a negative valence. Thus, there was evidence to support hypothesis 3, indicating group differences between OC users, nonusers, and men in relative recall of positive and negative stimuli. In addition, nonusers experienced higher negative affect levels than OC users and men after viewing the emotional stimuli and experienced greater negative affect variability than men.

Given that this was not a randomized placebo design, one can only speculate about the possible reasons why nonusers recalled significantly more negative items than OC users. The first possibility is that the higher endogenous hormone levels in free cyclers may play a role in better memory for negative stimuli and that OCs dampen both endogenous hormone levels and memory for negative stimuli. Nonusers, being free-cyclers, would have had higher hormone levels (especially during certain phases of the menstrual cycle) than OC users given that OC use reduces hormone levels across the menstrual cycle (Coenen et al., 1996; Fleischman et al., 2010). While no other studies have explicitly examined group differences in recall of positive and negative stimuli, the finding that nonusers had better recall of negative stimuli in the Emotional Visuospatial task fits with the findings from Solis-Ortiz and Corsi-Cabrera (2008) who found evidence that high levels of estrogen may enhance visuospatial memory during a modified version of a Localization Test (although the stimuli in this study were not negative). Also similar to the findings from the current study, Phillips and Sherwin (1992) found delayed recall of visual stimuli to be significantly higher in the luteal phase (higher estrogen) compared to menses. These studies suggest that high levels of estrogen may enhance memory, which is consistent with the current findings. While an estrogen-memory enhancement effect could explain why nonusers have better recall, it is not clear why estrogen would have selective enhancement on recall of negative versus positive stimuli. One possibility is that there is more adaptive value for estradiol to be associated with recall of negative stimuli versus positive stimuli (e.g., avoidance of noxious stimuli to maximize survival). Thus, women may have evolved to remember negative stimuli (e.g., aggressive men or dangerous situations), and possibly avoid such stimuli, when estrogen levels were high

and they were more likely to conceive or even when they were pregnant. In contrast, Gasbarri et al. (2008) found that high levels of estradiol could have a negative effect on a delayed matching-to-sample working memory task when using stimuli with negative emotional valence, which is inconsistent with our findings. As noted in the above paragraph, the findings from the present study suggested that nonusers, who likely have higher estradiol levels, have better short-term recall of negative stimuli. Although different memory tasks were used (i.e., recall of items from an emotional visuospatial task versus recognition of emotional facial expressions), both this study and the current study tested short-term working memory using emotional stimuli.

As noted above, one possible explanation as to why nonusers recalled significantly more negative items than OC users might involve the higher levels of estradiol and the effect of estrogen on acetylcholine. Estrogen has been known to facilitate synthesis of acetylcholine, known for its role in memory, through estrogen-induced increases in choline acetyltransferase (McEwen & Parsons, 1982). This may be a possible mechanism by which estrogens or estradiol can improve memory function. Given that OC use decreases estrogen levels (Flelschman et al., 2010) we might predict poorer memory in OC users, which may explain why OC users recalled significantly less negative items than nonusers in the Emotional Visuospatial task when short-term memory was tested. Moreover, research has shown estradiol to increase spine density in the hippocampus in region CA1, where dendritic spines have been implicated in spatial memory function (Gould, Woolley, Frankfurt, & McEwen, 1990; Luine, Attalla, Costa, & Frankfurt, 2006; MacLusky, Luine, Hajszan, Prange-Kiel, & Leranth, 2005; Woolley, 1998). Murphy and Segal (1996) found that hippocampal neurons, known for their

involvement in memory, grown in culture for 2 to 3 weeks showed a twofold increase in dendritic spine density after being exposed to 17-β-estradiol. These findings suggest that estrogens may also play a major role in neuronal plasticity and that neuronal plasticity can affect memory. Thus, higher estradiol in nonusers may facilitate recall of visuospatial material, possibility through facilitation of dendritic spine growth in CA1 with estradiol. It is feasible to hypothesize that the difference in memory between OC users and nonusers could be influenced by the effect of OC use on circulating levels of estradiol and the potential influence of estradiol on neuronal plasticity and the synthesis of acetylcholine. Since nonusers are likely to have higher estrogen and estradiol levels given that OC use decreases estrogen levels, it is not surprising that the current study found nonusers to have better short-term memory of negative stimuli. However, it is not clear how or why the effect is stronger for negatively-valenced stimuli than positively-valenced stimuli for such a spatial navigation explanation.

Another possible explanation for why nonusers recalled significantly more negative items than OC users might involve the presence of higher progestero /ne levels in nonusers compared to OC users given that OC use causes a stabilization of hormone levels across the menstrual cycle (Coenen et al., 1996; Fleischman et al., 2010). Andreano and Cahill (2010) found that women in the mid-luteal phase, where progesterone is high, had significantly enhanced activity in the hippocampus and amygdala in response to negative images when compared to those in the early follicular phase. Similarly, van Wingen et al. (2008) demonstrated that high levels of synthetic progesterone (400mg of micronized progesterone administered orally) significantly increased amygdala responses to emotional images (angry and fearful faces) compared to

neutral ones. Perhaps a high level of progesterone in nonusers is associated with enhanced activity in the amygdala when viewing emotionally negative stimuli, which in turn results in better memory or recall of the negative information. It has also been found that women in the luteal phase (high progesterone) have increased heart rates while viewing negative videos (Ossewarrde et al., 2010), which may indicate an enhanced reaction to the negative stimuli and thus better memory for stimuli with negative valence in nonusers who likely have higher progesterone levels than OC users. In another study, Ferree, Kamat, and Cahill (2011) looked at spontaneous intrusive recollections (SIRs), which are known to follow emotional events in clinical and nonclinical populations, after exposure to emotional films. They found that SIR frequency significantly correlated with salivary progesterone levels in free-cycling women, and that women in the luteal phase (higher progesterone levels) reported significantly more SIRs than women in the follicular phase. These findings suggest that in nonusers SIRs may be more common during heightened levels of progesterone (i.e., during the luteal phase). Given that OC use stabilizes hormone levels and that as a result, nonusers are likely to have higher progesterone levels (Coenen et al., 1996; Fleischman et al., 2010), it is not surprising that the current study found nonusers to have better recall of emotionally negative stimuli possibly due to progesterone's influence on enhanced activity in the amygdala when viewing negative stimuli, enhanced heart rates while viewing negative stimuli, or the frequency of SIRs after viewing negative stimuli.

The findings of group differences in affect may also help explain why the current study found that OC users recalled less negative items than nonusers and relatively less negative than positive items than nonusers and men. At the end of laboratory session

one, nonusers were in more of a negative mindset (higher NA levels after viewing the emotional stimuli) and perhaps this negative mindset made nonusers more likely to recall more negative items. It seems as though nonusers experienced a stronger negative affect response than OC users and men to the emotional stimuli used in the present study. Given that there were no group differences in positive or negative affect prior to viewing the emotional stimuli, it could be possible that OCs cause a differential response to emotional stimuli and differential effects on NA level, which affect recall of negative stimuli. However, even though nonusers experienced more negative affect than OC users and men after exposure to the emotional stimuli, the significant group effect for short-term recall of positive to negative items and negative items remained after negative affect was controlled. Thus, the group differences in affect cannot account for the group difference in recall of negative stimuli or the recall of positive to negative stimuli. There was no significant difference in negative affect reactivity (affect change) when comparing NA levels prior to viewing the emotional stimuli and NA levels after viewing the emotional stimuli. There was also no significant change in positive affect reactivity. For affect variability, it was found that groups did not differ in PA variability but nonusers and men statistically differed in NA variability, with nonusers showing more variability in negative affect than men. Past research on differences between OC users and nonusers in terms of positive and negative affect that is both consistent and inconsistent with the present findings are discussed below.

The results of the current study fit with those of Ott, Sayegh, Shew, and Fortenberry (2005) who found that women experienced a week-to-week decrease in negative mood during OC use. This study involved the use of a daily diary and results

suggested that as OC use continues, adolescent women experience a drop or blunting of negative affect. The present study found OC users to have lower mean NA across three time points (beginning of laboratory session one, end of laboratory session one, and laboratory session two) and lower NA levels in response to emotional stimuli, which fits with the idea that OC use may have a blunting effect on negative affect.

The results of the current study are both consistent and inconsistent with those found by Jarva and Oinonen (2007) who found that OC users experienced a blunted positive affect response to mood induction tasks when compared with nonusers and men. These results suggest that OC use may have a stabilizing effect on positive affect where OCs reduce the degree of positive affect change that women experience in response to environmental events. Similarly, both studies found no differences in negative affect reactivity between groups. In contrast, Jarva and Oinonen found a difference in positive affect reactivity between groups that the current study did not. However, the present study found negative affect levels to differ between groups in response to emotional stimuli, with nonusers experiencing more negative affect than OC users and men after exposure. Thus, OC users had lower NA levels than nonusers, suggesting a blunting effect on negative affect with OC use, which is similar yet different to the findings from Jarva and Oinonen that suggest OC use is associated with a blunted *positive* affect response. Although the present study did not employ intentional mood induction tasks like Jarva and Oinonen (2007), the emotional stimuli used in the present study did produce group differences in affect level after exposure. This suggests that the emotional stimuli produced an affective response in participants, similar to a mood induction task. However, the findings between these two studies were inconsistent. Perhaps this was due

to differences between the mood induction tasks and the emotional stimuli themselves, such as differences in content, which produced different affective responses in OC users, nonusers, and men.

Studies examining differences in affect reactivity between OC users and nonusers are very few. In addition to the Jarva and Oinonen (2007) study mentioned in the preceding paragraph, two other studies have looked at differences in mood reactivity between OC users and nonusers. West et al. (2001) found that OC users experienced an increased mood response to stressful tasks and Rubino-Watkins et al. (1999) found that OC users had greater negative affective response to increased frequency of daily stress, but less agitated depression in response to increased stress intensity. Both studies focused on a reaction to stress and thus differed from the present study in terms of how the affective response was induced (i.e., a reaction to stress versus a reaction to emotional stimuli). The findings from the present study suggest no differences between OC users and nonusers in positive or negative affect reactivity, however our study did not include an intentional mood manipulation. Although it is possible that the stimuli presented might have incidentally induced mood in the present study. Perhaps if we had stressed our participants during the laboratory sessions we would have found a difference in affective reactivity. Furthermore, perhaps these results suggest that the response to emotion-inducing stimuli will differ between OC users and nonusers only in certain situations or depending on the situation. However, the limited number of studies and inconsistency of results suggest that this area of research regarding affect reactivity deserves further investigation.

With regards to affect variability, the present study found no differences in PA variability between OC users, nonusers, and men. However, there was a significant difference between nonusers and men in NA variability, with nonusers experiencing more variability in negative affect than men. The finding that OC users and nonusers did not differ in PA or NA variability is equivocal with past research. There is evidence that OC users and nonusers experience similar mood changes across the menstrual cycle (Marriott & Faragher, 1986; McFarlane et al. 1988). Furthermore, studies specifically examining level of NA across the menstrual cycle seldom find differences between OC users and nonusers (e.g., Almagor & Ben-Porath, 1991). This is consistent with findings from the present study that suggest OC users and nonusers experience similar NA and PA variability.

However, there is also evidence that OC users and nonusers do not experience similar mood changes across the menstrual cycle. A review by Oinonen and Mazmanian (2002) on studies on affect, suggested that OC users experience less day-to-day mood variability than nonusers (e.g., Graham & Sherwin, 1993; Paige, 1971; Sutker et al., 1983; Walker & Bancroft, 1990). Another study by Rasgon et al. (2003) found that bipolar women taking OCs reported similar mood levels in the first seven days and last seven days of the menstrual cycle, whereas nonusers reported significant mood changes between those time periods. In addition, a study by Warner and Bancroft (1988) found that OC users experienced fewer peaks of well-being across the menstrual cycle and fewer troughs during menses than nonusers. This difference in NA variability was found in the pill free period. Although we tested some women during the pill free period (i.e., those in the menses phase) we did not see any differences in NA variability between OC

users and nonusers. The findings of the past studies suggest that OCs may act as mood stabilizers, causing users to have less change in day-to-day mood. This is inconsistent with the findings from the present study where no differences were found to suggest less affect variability with OC use. Nonetheless, caution should be used when comparing these results to the present study due to the fact that the current study was not designed with the specific main goal of examining group differences in affect. As a result there are relevant differences in design between this study and previous research (i.e., day-to-day mood change versus mood change due to exposure to emotional stimuli). Differences in study design may be why the present study did not find similar results. Also in the present study, affect variability only took into account mood change due to exposure to emotional stimuli (beginning and end of laboratory session one) and mood change over a one week time frame (laboratory session two) which may not capture a full range of variability in mood that other studies may capture when looking at day-to-day mood change across the menstrual cycle (i.e., an entire month).

In terms of possible reasons for why nonusers experienced higher NA levels after exposure to emotional stimuli than OC users, or how OCs could have a blunting effect on NA, a few explanations exist. First, it could be that the higher levels of endogenous progesterone, presumably seen in nonusers (Coenen et al., 1996; Fleischman et al., 2010), might enhance reactions to emotionally arousing stimuli, in particularly negative stimuli. It has been found that women in the luteal phase (higher progesterone levels) interpret mildly negative faces as strongly negative (Derntl, Kryspin-Exner, Fernbach, Moser, & Habel, 2008a), which suggests that nonusers might be interpreting negative stimuli to be more emotionally negative than do OC users, which thus increases their NA level after

viewing the emotional stimuli. Also in terms of reaction to emotionally arousing stimuli, it has been found that women in the luteal phase have increased heart rates while viewing negative videos (Ossewarrde et al., 2010), which may indicate an enhanced reaction to the negative stimuli and thus an increase in NA level. As discussed above, an increase in amygdala activity to negative stimuli (Andreano & Cahill, 2010; van Wingen et al., 2008) and an increase in spontaneous intrusive recollections (Ferree et al., 2011) during heightened levels of progesterone (i.e., during the luteal phase) may also indicate an enhanced reaction to the negative stimuli and thus an increase in NA level.

A second possible reason for group differences in negative affect might involve OC induced changes in cortisol responsivity (i.e., an OC blunting effect). OC use has been found to be associated with a blunted cortisol response to stressors (e.g., Kirschbaum et al., 1995, 1996, 1999; Rohleder, Wolf, Piel, & Kirschbaum, 2003) and in addition, Kuhlmann and Wolf (2005) have found that cortisol impairs memory in nonusers, but not in OC users. Thus, OC users may be less sensitive and less likely to experience alterations in cortisol. Although OC users and nonusers did not significantly differ in stress level, nonusers did have higher stress ratings than OC users in the present study. Given that cortisol is positively related to NA (Buchanan, al'Absi, & Lovallo, 1999) a blunted cortisol response in OC users could have resulted in fewer fluctuations in NA and may help explain why nonusers experienced higher NA levels after exposure to emotional stimuli than OC users and how OCs might blunt NA in OC users.

Lastly, the survivor effect (e.g., Kutner & Brown, 1972) may help explain the results of the present study. It is possible that the OC user group consists of women who have not had any negative side effects with OC use. Such women who experienced

negative mood side effects would be more likely to be in the nonuser group due to discontinuation of OC use. Thus it is possible that the survivor effect could explain the finding that nonusers experienced higher NA levels after exposure to emotional stimuli than OC users and that OCs may have a blunting effect on NA as: (1) the OC user group is a survivor group of women less likely to have negative mood responses to hormones or high negative affect or negative mood problems in general, and (2) the nonuser group could include women who are more likely to get depressed or have negative mood problems in general and this may be why nonusers experienced higher negative affect.

Implications

Research examining the effect of OC use on emotional memory is of importance given that the lifetime use of OCs is about 82% (Mosher & Jones, 2010) and that 59% of women who discontinue OCs do so because of side effects (Rosenberg & Waugh, 1998). The frequent use of OCs and the high number of side effects necessitates the need for more research on the emotional and cognitive side effects of OCs in order to improve the health and well-being of women. More specifically, this study magnifies the importance of further exploring the brain's emotional memory mechanisms and the possible differences between OC users and nonusers.

While we did not find a difference between OC users, nonusers, and men in the recall of emotional gist and emotional detail, important implications of our findings still exist. Although we were unable to replicate findings from Nielsen et al. (2011) our findings still suggest that men and women who experience the same emotional stimuli, or an emotional event in the real world, may process that information in very different ways. Knowing how memory for emotional events differ on average between men and women

may have important implications for understanding how emotional disorders, such as depression or posttraumatic stress disorder (PTSD) exhibit a gender-related susceptibility. Women are significantly more likely to suffer from depression (Kendler, Thornton, & Prescott, 2001) and PTSD (Breslau, Davis, Andreski, Peterson, & Schultz, 1997; Tolin & Foa, 2006) after a trauma than men are. This suggests that the greater prevalence of these disorders in women versus men may not be due to the trauma itself but perhaps a differential sensitivity or different way of processing the event. Thus, further investigation into the recall of emotional gist versus emotional detail and differences between men and women, as well as the possible influence of OC use, is warranted for these reasons. That is, this line of research is important as it may uncover possible side effects of OC use on emotional memory and possible explanations for emotional disorders that exhibit gender related susceptibility.

The current study's finding that OC users recall relatively less negative than positive stimuli than nonusers and men on a short-term visuospatial memory test could have important implications. Again, this suggests that men and women may process information in different ways or remember certain information differently depending on the emotional valence of that information. The difference was found in the relative recall of items, with no difference with respect to the visuospatial location of the items. Thus, the difference is likely due to the emotional valence of the item itself. With that said, the implications discussed above regarding emotional disorders might suggest that OCs could have a protective effect on gender-related susceptibility if OC users are recalling relatively less negative than positive stimuli than nonuser females and males. Furthermore, OC users recalled significantly fewer negative items than nonusers, which

could be seen as further evidence to suggest a protective effect with OC use against the retention of aversive or negative information. This could decrease the likelihood of suffering from depression or PTSD after a trauma for OC users if they are recalling less negative stimuli and relatively less negative than positive items than nonusers.

The finding from the present study that suggests a blunting effect of OC use on negative affect might also have significant implications for women. Not only would OC users fail to experience "normal" mood responses, they would also miss out on the unpleasant "lows" of negative affect that nonusers may experience. Hence, OC use may offer a protective factor against negative experiences, resulting in lower negative affect levels for users. This may be a benefit for OC users that could increase quality of life and possibly affect health and OC discontinuation rates. OC users who fail to experience the lows that nonusers may experience may be happier, may be less susceptible to depression or other affective disorders, and those who make the connection between OC use and blunted NA may continue to use OCs. Recently, it has been reported that OC use is associated with reduced levels of depressive symptoms (Keyes et al. 2013), which supports the notion that OCs may have a blunting effect on negative affect. A possible downside to a blunting of negative affect with OC use could be the possibility that if OC users are failing to experience "normal" mood responses, more specifically less negative affect in response to sad or traumatic information or events, they could be seen as harsh, cold, unemotional, or less empathetic by others which could have the potential to hinder intimate and personal relationships. Also, given the fact that some women do report depression or negative affect while taking OCs (e.g., Kulkarni, 2007), and given the possibility of the survivor effect confound, the results should be interpreted with caution.

All in all, it is important that women are made aware of the potential emotional side effects of OC use so that they can properly interpret any side effects and make informed decisions about their birth control methods.

Strengths and Limitations of the Present Study

As noted above, one limitation of the present study, as in most studies, is that the findings of this study may be influenced by the survivor effect (Kutner & Brown, 1972), in that women who experience negative OC effects would likely have already discontinued their use, and would therefore not be included in the sample of OC users, leaving an unrepresentative sample of women. The study is also limited in fully demonstrating the effect of OCs on emotional memory because the OC users were self-selected users (i.e., not randomly assigned). A placebo controlled randomized controlled trial would be ideal to address this issue as there may be differences between women who choose to take OCs and those who do not. Such differences may play a role in the group differences found in the present study. That is, women who choose to take OCs may be women who have lower negative affect to begin with. Thus, the findings could potentially underestimate or overestimate any emotional or cognitive differences between OC users and nonusers that may have influenced the results. Another caveat to our study is whether OC women were tested during the "on" or "off" active contraception weeks. OC women in the menses phase ($N = 16$) during laboratory session one were tested during the "off" active contraception week which may have influenced the results, as research has shown differential memory effects in OC users that were in "on" and "off" weeks (Mordecai, Rubin, & Maki, 2008). In addition, although we measured attention, we had no measure of arousal like Nielsen et al.'s (2011) assessment of pupillary

response. However, it is worth noting that they did not find any group differences. Furthermore, we did have self-report measures of excitement and alertness within the PANAS that measure somewhat similar constructs. Scores on these items did not differ between OC users (excitement: $M = 2.45$, $SD = 1.08$; alertness: $M = 3.20$, $SD = 1.11$), nonusers (excitement: $M = 2.16$, $SD = 0.97$; alertness: $M = 2.93$, $SD = 1.01$), and men (excitement: $M = 2.58$, $SD = 1.11$; alertness: $M = 3.14$, $SD = 1.08$).

Another potential limitation of the present study may be the fact that our participants had to recall both a similar neutral and emotional story and as a result there is the possibility that the emotional story may have affected recall of the neutral one or vise versa. Also, the short exposure time for the Emotional Visuospatial task (i.e., 60 seconds) may have not been long enough to provide a significant lasting memory of the stimuli one week later when long-term memory was tested (i.e., a mean of 8.79 out of 30 items were recalled). As a result, the test may not have been sensitive enough to fully detect sex differences or effects of OCs. Lastly, a minor limitation of the present study concerns group equivalency. For sex, there were more female participants ($N = 98$) than male participants ($N = 37$) and for OC status, there were more OC users ($N = 58$) than nonusers ($N = 40$). It would have been ideal to have equal groups, however, difficulties in the recruitment of males and nonusers made this difficult to achieve, resulting in smaller sample sizes for these two groups.

This study has a number of strengths. First, the present study is unique in that it is the first to examine whether past findings of effects of OCs on emotional memory extends to memory for visuospatial material. Thus, the present study represented a comprehensive test of the "gist versus detail OC effect" (i.e., a replication and extension).

Second, the present study included a more sensitive within-subjects design than the Nielsen et al (2011) study, as we were able to calculate emotional gist, emotional detail, neutral gist, and neutral detail scores across participants within the same group. Another strength of the present study is that our analyses directly compared OC users and nonusers, whereas Nielsen and colleagues only compared memory for gist and detail within each group. Given that Nielsen et al. (2011) concluded that OC users recalled relatively more emotional gist information and nonusers recalled relatively more emotional details, the present study directly tested each of these hypotheses by comparing OC users and nonusers directly. Thus, the present study looked at ratios in order to reflect the conclusions that Nielsen and colleagues drew. Therefore, this is the first study to directly compare OC users and nonusers for recall of general information (gist) versus specific details of emotional and neutral stimuli. Furthermore, while Nielsen et al. (2011) examined the effects of OCs on memory for sad or traumatic material, this is the first study that examined how OCs affect memory for both positively- and negatively-valenced stimuli. Thus, the study explored differences in emotional memory according to positive and negative valence across all groups. The present study also measured attention to ensure group equivalency and that a group difference in attention was not a potential confound (due to either sampling bias or an OC effect). However, the current study did control for both typical alcohol use and caffeine consumption in the 24 hours prior to laboratory session one, given group differences on these variables. Unlike Nielsen et al. (2011), this was another strength of the present study as these variables could have possible effects on an individual's memory and/or cognition and influence performance on the laboratory tasks and subsequent results. Additional strengths of the

present study include controls for menstrual cycle phase and examination of menstrual cycle effects in nonusers. This was an improvement over the study by Nielsen and colleagues. Another improvement was the inclusion of men in the present study, which allowed for the possibility of exploring any possible sex differences in emotional memory and the recall of gist versus detail. Lastly, the sample size of the present study (N= 135) was much larger than Nielsen et al.'s (2011) sample (N = 66).

Directions for future research

The current study suggests that future studies examining any effects of OC use on memory for emotional stimuli should focus on two tasks. The first important task would be to replicate the current finding of an altered memory response to emotional stimuli in OC users (i.e., increased recall of the ratio of positive to negative stimuli and reduced recall of negative stimuli). The second task would be to attempt to determine the cause of the memory alteration. One way to examine causal factors would be to compare the effects of monophasic and multiphasic preparations on emotional memory (i.e., examine dosage and hormone variability), or to examine whether different formulations have different effects on emotional memory (i.e., examine different hormones or types of hormones). A second way to examine causal factors would involve examining whether polymorphisms on specific hormonal genes (e.g., estrogen or progesterone genes) are associated with individual differences in OC-related emotional recall. It is also important that future research address whether the observed recall effects are the result of OCs altering encoding, consolidation, retrieval, or all three. That is, determining whether hormone levels influence encoding, consolidation, or retrieval when it comes to the overall recall of negative or positive stimuli. Understanding the mechanism(s) by which

OCs alter recall of emotional stimuli will be an important next step after replicating the current finding. Furthermore, it may be that OC users, nonusers, and men have differing brain activations during the processing of emotional stimuli, which may then affect subsequent recall. Studies involving fMRI imaging of brain regions activated when viewing and recalling emotional stimuli in OC users and nonusers would be an interesting direction for future research.

Although the gist versus detail effect for memory of a narrated visual story was not replicated in the present study using a within-subjects design and did not extend to visuospatial material, it would be of interest to further examine the gist versus detail effect to determine whether it extends to other types of memory. In particular, looking at effects with facial recognition could be interesting, given the emotional salience of faces. This would help researchers determine if the gist versus detail effect is a more global or if it is specific to a narrated visual story (e.g., Nielsen et al., 2011). In regards to the narrated visual story used by Nielsen and colleagues (2011), also used in the present study, it would be useful to re-create the emotional version of the story so that it contains both positive and negative elements as opposed to only negative. That way, researchers could examine differences in the relative recall of positive to negative story elements. In addition, the emotional version of the story would then represent a more comprehensive assessment of "emotional" memory when comparing emotional gist to neutral gist or emotional detail to neutral detail. Furthermore, it may be that long-term memory for positive emotionally arousing information or stimuli may differ from memory for negative emotionally aversive information or stimuli. That is, perhaps differences in the

recall of central gist versus detail information may depend to some extent on the content of the to-be-remembered stimuli.

Lastly, further studies in the area could include measures of lateralized amygdala function between sexes (i.e., Cahill et al., 2001; Cahill & van Stegeren, 2003; Cahill, Uncapher, Kilpatrick, Alkire, & Turner, 2004) in order to examine amygdala-related memory processes in the recall of emotional information. Cahill and colleagues (2001; 2004) found evidence indicating that activity in the right amygdala in males, and the left amygdala in females relates to significantly enhanced memory for emotional events. Cahill and van Stegeren (2003) found evidence to support the hypothesis that emotional arousal enhances long-term memory for gist information in men via activation of right amygdala/hemisphere function, and enhances long-term memory for detail information in women via activation of left amygdala/hemisphere function. These two studies, which used the same emotional story task as the present study (emotional version only), showed that gender strongly influenced amygdala-related memory processes and thus may influence hemispheric specialization of the amygdala. It would be interesting to see if OC use influences amygdala-related memory processes and hemispheric lateralization in response to emotional stimuli as well. Perhaps OC users would show a bias toward the processing of global aspects or the gist of emotional information (more like men) while nonusers would show a bias toward the processing of more local aspects or details of the same information (more like women).

Summary and Conclusions

One past study has suggested that OC use is associated with altered memory for an emotional story (i.e., Nielsen et al., 2011) and one study has suggested that OC use

and stress is associated with altered memory for an emotional story (i.e., Nielsen et al., 2014). The purpose of the present study was to replicate Nielsen et al.'s (2011) findings and to further examine how OCs influence emotional memory by comparing the performance of OC users, nonusers, and men on two memory tasks: (a) a new Emotional Visuospatial task and (b) Nielsen et al.'s (2011) Emotional Story task. More specifically, the present study examined the relative recall of positive and negative stimuli (Hypothesis 3) and whether memory is altered for general central information (gist) versus specific details of the emotional stimuli used (Hypotheses 1 and 2). The results indicate that no group differences in the recall of general gist information versus specific details of the emotional stimuli were present in the current study (no support for hypotheses 1 and 2). However, the results indicate a difference in the relative recall of positive and negative emotional stimuli. OC users recalled relatively more positive than negative items than nonusers and men in the Emotional Visuospatial task when short-term memory was tested. Furthermore, this effect was mainly driven by the fact that OC users recalled fewer negative items than nonusers during short-term item recall for the Emotional Visuospatial task. It was also found that nonusers experienced greater negative affect levels after viewing the emotional stimuli than OC users. However, the group differences in negative affect could not explain the previous findings. Nevertheless, the group differences in affect suggest the possibility of a blunting effect of OC use on negative affect. These results might suggest that OCs cause a differential response to emotional stimuli, differential effects on negative affect, and differential short-term recall of negative stimuli.

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Appendix A

Email Announcement

Pilot Study on Hormones and Cognition

You are invited to participate in a pilot study looking at **whether items belonging to a visuospatial memory task are positive, negative, or neutral in emotional valance.** We are seeking both female and male participants. The study will require you to come into the Health Hormones and Behaviour Laboratory and will take no more than 15 minutes to complete. If you wish to participate in this study or have any questions please contact Brandi Person at bperson@lakeheadu.ca

This study has been reviewed and approved by the Lakehead University Research Ethics Board.

Thank-you, your time and participation is greatly appreciated.

Sincerely,

Brandi Person, H.B.A.
M.A. Student
Department of Psychology
Lakehead University
955 Oliver Road
Thunder Bay, Ontario P7B 5E1
email: bperson@lakeheadu.ca

Dr. Kirsten Oinonen Ph.D., C. Psych
Associate Professor
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955 Oliver Road
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Appendix B

Cover Letter and Consent Form

Pilot Study on Hormones and Cognition

Dear Potential Participant,

This study is being conducted by Brandi Person and Dr. Kirsten Oinonen from the Health Hormones and Behaviour Laboratory (HHAB LAB) in the department of Psychology at Lakehead University. The main purpose of this study is to collect data to help develop a visuospatial memory task for a larger study on hormones and cognition. The data will be used in Brandi Persons' Masters thesis on this topic, as well other exploratory research questions in the HHAB LAB. Participation in the study will involve recording whether each item belonging to a visuospatial memory task is positive, negative, or neutral on a form provided. This study will take no more than 15 minutes to complete. There are no obvious risks involved in participating in this study. This study is open to Lakehead University students who are 18 years or older as well as members of the general public who are 18 years or older.

Your participation in this study is completely anonymous and voluntary and you have the right to withdraw at any time without penalty or explanation. All records of your participation will be kept confidential and reports of the study will not reveal or identity. There is no request for you to provide an email address or any other identifying information other than basic demographic data.

University regulations state that all data must be stored for a minimum of five years; data will be kept in a secure location by Dr. Oinonen and will remain confidential and anonymous. If you have any questions or concerns regarding the study please contact Brandi Person or Dr. Oinonen. This study has been approved by the Lakehead University Ethics Board (807-343-8283 or research@lakeheadu.ca) and they can also be contacted if you have any questions related to the ethics of the research and would like to speak to someone outside of the research team.

Upon completion of the study, interested participants are welcome to contact one of the researchers to request a summary of the results. Thank you very much for your time. We very much appreciate your contribution to our research.

Consent:
I have read and understood the above information and I agree to participate in this study under theses conditions. I also understand that I am free to withdraw from the study at any time without penalty or other consequence.
[ ] I understand that my consent to the above is implied if I check this box and choose to continue with this study.

Brandi Person, H.B.A.
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Appendix C

Debriefing Form

Thank you for participating in the Pilot Study on Hormones and Cognition. Portions of the data you provided will be used to develop a visuospatial memory task for a Master's thesis by Brandi Person under the supervision of Dr. Kirsten Oinonen. Specifically, the data will be used to verify the emotional valence of items belonging to the visuospatial memory task. For the thesis, the visuospatial memory task will be used to investigate differences in emotional memory between men and women, within women (between oral contraceptive users versus free-cycling women) and across the menstrual cycle. Additional exploratory research questions will also be examined.

Please be assured that all data will remain completely anonymous and confidential. If you would like to receive a summary of the results of the study, please email one of the researchers and, upon completion of the final study, a summary of the results will be emailed to you. Please note that providing your email address does not jeopardize your anonymity. This research project was approved by the Lakehead University Research Ethics Board (807-343-8283).

Sometimes people can feel upset when thinking about their mood or viewing emotional material. If you feel as though you would like to talk to a mental health practitioner for any reason please consider the resources listed below:

- Lakehead University Health and Counseling Centre: 343-8361
- Thunder Bay Counseling Centre : 626-1880
- Catholic Family Development Centre: 345-7323
- Thunder Bay Crisis Response (24 hours): 346-8282
- Emergency services are available at the Thunder Bay Health Sciences Centre

Thank you very much for your time. We very much appreciate your contribution to our research. Sincerely,

Brandi Person, H.B.A.
bperson@lakeheadu.ca

Kirsten Oinonen, Ph.D., C. Psych
koinonen@lakeheadu.ca

Heath, Hormones, and Behaviour Lab
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Appendix D

Participant #: _____

Screening Questionnaire

---

1) Age: _____

2) Sex (Circle your answer): male female other

3) Height: _____ (feet & inches) or _____ (cm)

4) Weight: _____(pounds) or _____ (kg)

5) Ethnicity, please check one:

_____ Aboriginal

_____ White

_____ Black/African

_____ Asian

_____ Latino or Hispanic

_____ Other, please specify _____

6) Today's date: _____ _____ _____

Day of week (e.g., Monday)	Day of Month (e.g., 5th)	Month: (e.g., May)

7) a) Are you currently taking any medications? (Circle your answer) YES NO

b) If YES, what medications are you taking? (Please list):

_____

_____

_____

_____

8) Please list any medical or psychological conditions which you have been diagnosed with (e.g., hypothyroidism, depression, asthma, cancer, diabetes, etc.).-

_____
_____
_____
_____

9) Are you *currently* diagnosed with or being treated for a mood related disorder (e.g., depression, bipolar disorder, manic depression)? (Circle your answer)
YES NO MAYBE

10) Have you *ever been* diagnosed or treated for a mood related disorder (e.g., depression, bipolar disorder, manic depression)? (Circle your answer)
YES NO MAYBE

11) a) Do you smoke cigarettes? (Circle response) YES NO

b) If you are a smoker, how many cigarettes on average do you smoke each day?_____

12) How often do you normally consume alcohol? Circle one number from 0 to 4.

Never	once or twice a month	once or twice a week	three to four times a week	almost every day
0	1	2	3	4

13) What is the average or typical number of drinks you have when/if you drink? (Circle one number).

None	one to three	four to seven	eight to twelve	more than 12
0	1	2	3	4

14) How often do you use recreational/illegal drugs such as marijuana, ecstasy, hash, cocaine, LSD, etc.?

Never	once or twice a month	once or twice a week	three to four times a week	almost every day
0	1	2	3	4

15) How often do you consume caffeine (e.g., coffee, tea, colas, chocolate)?

Never	once or twice a month	once or twice a week	three to four times a week	every day
0	1	2	3	4

16) How stressed have you felt in the past week? Circle one number from 1 to 7.

Not at all Extremely

Stressed						Stressed
1	2	3	4	5	6	7

17) Do you have any problems with your vision?

(Circle your answer) YES NO

If yes, what is it? Circle all that apply:
A. eye glasses or contacts
B. eye surgery
C. eye disease
D. eye injury
E. other _____

18) Have you ever suffered a brain injury or other medical condition that had a significant effect on your memory?

(Circle your answer) YES NO

19) Have you ever been diagnosed with a memory problem?

(Circle your answer) YES NO

20) Have you ever been diagnosed with an attention problem? (e.g. Attention deficit and hyperactivity disorder (ADHD))

(Circle your answer) YES NO

21) How does your memory for visual information (e.g., images, pictures, objects) compare to other people of your same age and sex?

Very Poor	Below Average	Slightly Below Average	Average	Slightly Above Average	Above Average	Excellent
0	1	2	3	4	5	6

22) How does your memory for verbal information (e.g., things you hear or read) compare to other people of your same age and sex?

Very Poor	Below Average	Slightly Below Average	Average	Slightly Above Average	Above Average	Excellent
0	1	2	3	4	5	6

23) How does your memory for emotional information or experiences (e.g., emotional things that happen to you or others) compare to other people of your same age and sex?

Very	Below	Slightly Below	Slightly Above	Above

Poor	Average	Average	Average	Average	Average	Excellent
0	1	2	3	4	5	6

24) Please check the highest education level you have completed:

____ Less than a high school diploma

____ Graduated high school or have high school equivalent

____ Current College or University undergraduate student

____ Graduated College or University

____ Current graduate or doctoral student

____ Completed graduate school

25) What is your current education level: (Please check one)

____ Not in school

____ In college

____ First year university

____ Second year university

____ Third year university

____ Fourth year (+) university

____ Graduate student

26) What is your current grade point average? (e.g., 55%, 72%) _____
If unsure, or currently not in school, what was your past/most recent grade point average? _____

27) Compared to the average person, how **emotionally involved** do you get when watching or hearing about an emotional story or event? Please circle one.

Much less Involved	Slightly less Involved	Average level of involvement	Slightly more Involved	Much more Involved
0	1	2	3	4

28) During an average week, how many hours of sleep do you get each night?

_____ hours

29) How many minutes of moderate to intense exercise do you normally get each week? Please circle one.

0 minutes	1-49 minutes	50-99 minutes	100-149 minutes	150 or more minutes

30) During the past week, how many days did you met the daily food requirements for each food group?

Milk & Alternatives: 2 servings: _____ day(s)

Meat & Alternatives: 2 servings (female), 3 servings (male): _____ day(s)

Grain Products: 6-7 servings (female), 8 servings (male): _____ day(s)

Fruits & Vegetables: 7-8 servings (female), 8-10 servings (male): _____ day(s)

31) Please rate the following questions on a scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

1. I am often confused about what emotion I am feeling.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

2. It is difficult for me to find the right words for my feelings.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

3. I have physical sensations that even doctors don't understand.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

4. I am able to describe my feelings easily.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

5. I prefer to analyze problems rather than just describe them.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

6. When I am upset I don't know if I am sad, frightened, or angry.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

7. I am often puzzled by sensations in my body.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

8. I prefer to just let things happen rather than to understand why they turned out that way.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

9. I have feelings that I cant quite identify.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

10. Being in touch with emotions is essential.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

11. I find it hard to describe how I feel about people.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

12. People tell me to describe my feelings more.

Strongly	Slightly	Neither agree	Slightly	Strongly

disagree	disagree	nor disagree	agree	agree
1	2	3	4	5

13. I don't know what's going on inside me.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

14. I often don't know why I am angry.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

15. I prefer talking to people about their daily activities rather than their feelings.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

16. I prefer to watch "light" entertainment shows rather than psychological dramas.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

17. It is difficult for me to reveal my innermost feelings, even to close friends.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

18. I can feel close to someone, even in moments of silence.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

19. I find examination of my feelings useful in solving personal problems.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

20. Looking for hidden meanings in movies or plays distracts from their enjoyment.

Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
1	2	3	4	5

THE FOLLOWING QUESTIONS ARE FOR FEMALES ONLY:

32) Are you currently taking any type of hormonal contraceptive (e.g., oral contraceptives, the Pill, Depo Provera, hormonal patch, Implanon implant, NuvaRing)?

(Circle your answer) YES NO

33) If you are currently using an oral contraceptive, please check the type of oral contraceptive you are currently taking.

Oral Contraceptives:

[ ] Alesse
[ ] Brevicon 0.5/35
[ ] Brevicon 1/35
[ ] Cyclen
[ ] Demulen 30
[ ] Loestrin 1.5/30
[ ] Marvelon
[ ] MinEstrin 1/20
[ ] Min-Ovral
[ ] Norinyl
[ ] Ortho 1/35
[ ] Ortho 0.5/35
[ ] Other: _____

[ ] Ortho-Cept
[ ] Ortho 7/7/7
[ ] Ortho 10/11
[ ] Synphasic
[ ] Tri-Cyclen
[ ] Triphasil
[ ] Triquilar
[ ] Demulen 50
[ ] Norlestin 1/50
[ ] Ovral
[ ] Ortho-Novum 1/50

Injected Contraceptives:

[ ] Depo-Provera
[ ] Lunelle
[ ] Other: _____

Contraceptive Patch:

[ ] Ortho-Evra
[ ] Other: _____

Vaginal Ring:

[ ] NuvaRing
[ ] Other: _____

34) If you are currently using an oral contraceptive, how long have you been taking this particular oral contraceptive?

_____years and _____months

35) What best describes your history with oral contraceptives?
[ ] Current user
[ ] Previous user
[ ] Never user

36) If you have **previously taken hormonal contraceptives** but are not using one right now, how many years and months has it been **since you last took oral**

contraceptive?

_____years and _____months

37) How long in total have you taken oral contraceptives?

_____years and _____months

38) What is the average length of your menstrual cycle right now (i.e., how many days are there from the first day of one period to the day before your next period: most people range between 25 and 35 days)?_____

39) What is your average length of menstruation (i.e. how many days does your period usually last)? Most people's periods last between 1 and 7 days.
_____ days

40) How old were you when you first started menstruating? _____ years old

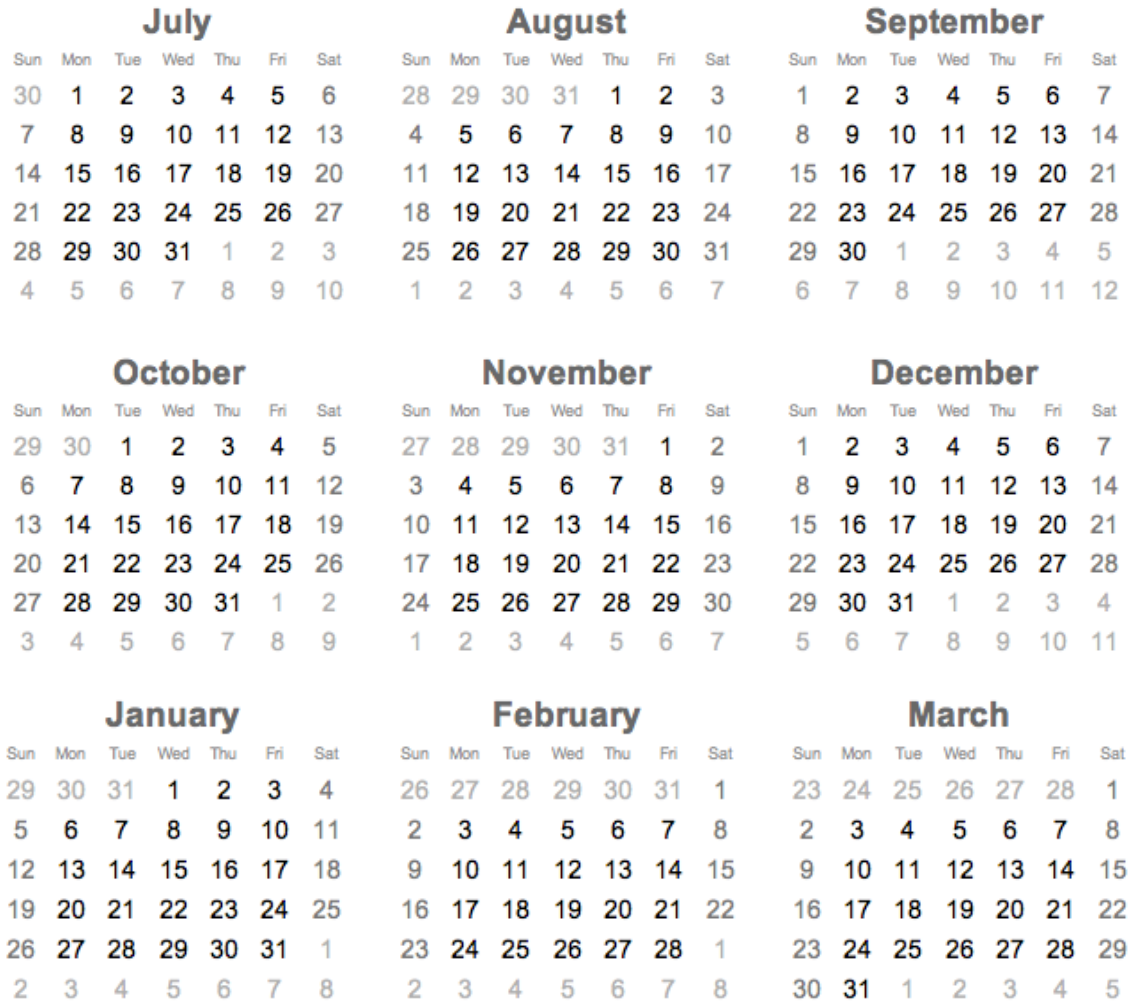
41) Which statement best describes your menstrual cycle right now? (Put an 'X' beside your response)
____ I have not had my period in the past three months.
____ Some months I get my period and some months I don't.
____ I usually get my period every month, but it is irregular and I cannot predict when it will start.
____ I usually get my period within two to three days of when I expect it.
____ My period is like clockwork and the same number of days elapse between periods each month.
____ I am going through menopause
____ I am currently pregnant
____ I am currently lactating

42) Are you currently menstruating (i.e., today)? (Circle your answer) YES NO

43) If you are currently menstruating, for how many days have you had your period (including today)? _____

44) If you are not currently menstruating, what day are you at in your cycle (day 1 = the first day of your last period)? _____

45) Using the calendars below, please **indicate** the **first** day of your **last** menstrual period. If you are not completely sure, please estimate the day that you believe you started menstruating on. Also, please **indicate** the day that you believe your **next** period will start.



July

Sun	Mon	Tue	Wed	Thu	Fri	Sat
30	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	1	2	3
4	5	6	7	8	9	10

August

Sun	Mon	Tue	Wed	Thu	Fri	Sat
28	29	30	31	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
1	2	3	4	5	6	7

September

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12

October

Sun	Mon	Tue	Wed	Thu	Fri	Sat
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9

November

Sun	Mon	Tue	Wed	Thu	Fri	Sat
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
1	2	3	4	5	6	7

December

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	1	2	3	4
5	6	7	8	9	10	11

January

Sun	Mon	Tue	Wed	Thu	Fri	Sat
29	30	31	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1
2	3	4	5	6	7	8

February

Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	1
2	3	4	5	6	7	8

March

Sun	Mon	Tue	Wed	Thu	Fri	Sat
23	24	25	26	27	28	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	1	2	3	4	5

First day of your last menstrual period (i.e., first day of bleeding): _____
The day you believe your next period will start: _____

46) How confident are you that the day indicated above was the first day of your last period? (Circle the best response)

0%		25%		50%		75%		100%
0	1	2	3	4	5	6	7	8

47) How confident are you that the day indicated above is the day that you will next get your period? (Circle the best response)

0%		25%		50%		75%		100%
0	1	2	3	4	5	6	7	8

48) Do you think that you have started to go through menopause?

YES NO MAYBE

49) Are you currently pregnant? YES NO MAYBE

50) Are you currently breastfeeding or lactating? YES NO MAYBE

Appendix E

Participant #: _____

Laboratory Session I Questionnaire

Date: _____

Time: _____

1) Have you consumed any alcohol in the past 24 hours? (Circle your answer)

YES NO

   a. If yes, please indicate the **number of standard alcoholic drinks** you consumed in the past 24 hours (1 standard drink is equivalent to a 12 ounces of 5% alcoholic beer, a 1.5 ounce serving of 40% hard liquor, or a 5 ounce glass of wine with 12% alcohol): _____ drink(s)

2) Have you consumed any caffeine prior to coming to the lab today? (Circle your answer)

YES NO

   a. If yes, please indicate the **number of standard servings** (1 standard serving is equivalent to 10 fluid ounces or a small coffee/tea at Tim Hortons): _____ serving(s)

3) Have you consumed any recreational drugs other than alcohol or tobacco in the past 24 hours? (Circle your answer)

YES NO

4) Do you smoke tobacco cigarettes? (Circle your answer)

YES NO

   a. If yes, please rate your **current level of withdrawal symptoms** you are experiencing right now by circling the best answer.

none at all mild moderate severe extremely severe

0 1 2 3 4

5) Have you taken any medication that is typically used to alleviate symptoms of pain in the past 2 hours? (e.g., Tylenol, Advil, Midol, morphine) (Circle your answer)

YES NO

6) How many hours of sleep did you get last night? _____

7) What time did you get up this morning? _____

8) Please rate your current level of fatigue by circling the best answer.

none at all	mild	moderate	severe	extremely severe
0	1	2	3	4

9) Please rate your current level of stress by circling the best answer.

none at all	mild	moderate	severe	extremely severe
0	1	2	3	4

10) How stressed have you felt in the past 24 hours? Please circle the best answer.

not at all stressed	mildly stressed	moderately stressed	very stressed	extremely stressed
0	1	2	3	4

11) Please rate your current level of hunger by circling the best answer.

not at all hungry	mildly hungry	moderately hungry	very hungry	extremely hungry
0	1	2	3	4

12) Please rate your current level of interest by circling the best answer.

not at all interested	mildly interested	moderately interested	very interested	extremely interested
0	1	2	3	4

13) Please rate your current level of boredom by circling the best answer.

not at all bored	mildly bored	moderately bored	very bored	extremely bored
0	1	2	3	4

14) This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you *currently feel* this way. Use the following scale to record your answers.

	Very Slightly or not at all (1)	A little (2)	Moderately (3)	Quite a bit (4)	Extremely (5)
Interested	1	2	3	4	5
Distressed	1	2	3	4	5
Excited	1	2	3	4	5
Upset	1	2	3	4	5
Strong	1	2	3	4	5
Guilty	1	2	3	4	5
Scared	1	2	3	4	5
Hostile	1	2	3	4	5
Enthusiastic	1	2	3	4	5
Proud	1	2	3	4	5
Irritable	1	2	3	4	5
Alert	1	2	3	4	5
Ashamed	1	2	3	4	5
Inspired	1	2	3	4	5
Nervous	1	2	3	4	5
Determined	1	2	3	4	5
Attentive	1	2	3	4	5
Jittery	1	2	3	4	5
Active	1	2	3	4	5
Afraid	1	2	3	4	5

THE FOLLOWING QUESTIONS ARE FOR FEMALES ONLY:

15) Are you currently taking any type of hormonal contraceptive (e.g., oral contraceptives, the Pill, Depo Provera, hormonal patch, Implanon implant, NuvaRing)?

YES NO

a. If yes, please indicate what type of of hormonal contraceptive you are currently taking:

Oral Contraceptives:

[ ] Alesse
[ ] Brevicon 0.5/35
[ ] Brevicon 1/35
[ ] Cyclen
[ ] Ortho-Cept
[ ] Ortho 7/7/7
[ ] Ortho 10/11
[ ] Synphasic

Injected Contraceptives:

[ ] Depo-Provera
[ ] Lunelle
[ ] Other: _____

[ ] Demulen 30
[ ] Loestrin 1.5/30
[ ] Marvelon
[ ] MinEstrin 1/20
[ ] Min-Ovral
[ ] Norinyl
[ ] Ortho 1/35
[ ] Ortho 0.5/35
[ ] Other: _____

[ ] Tri-Cyclen
[ ] Triphasil
[ ] Triquilar
[ ] Demulen 50
[ ] Norlestin 1/50
[ ] Ovral
[ ] Ortho-Novum 1/50

Contraceptive Patch:
[ ] Ortho-Evra
[ ] Other: _____

Vaginal Ring:
[ ] NuvaRing
[ ] Other: _____

16) Are you currently menstruating? (Circle your answer)

YES NO

17) Using the calendars below, please **indicate** the **first** day of your **last** menstrual period. If you are not completely sure, please estimate the day that you believe you started menstruating on. Also, please **indicate** the day that you believe your **next** period will start.

July

Sun	Mon	Tue	Wed	Thu	Fri	Sat
30	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	1	2	3
4	5	6	7	8	9	10

August

Sun	Mon	Tue	Wed	Thu	Fri	Sat
28	29	30	31	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
1	2	3	4	5	6	7

September

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12

October

Sun	Mon	Tue	Wed	Thu	Fri	Sat
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9

November

Sun	Mon	Tue	Wed	Thu	Fri	Sat
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
1	2	3	4	5	6	7

December

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	1	2	3	4
5	6	7	8	9	10	11

January

Sun	Mon	Tue	Wed	Thu	Fri	Sat
29	30	31	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1
2	3	4	5	6	7	8

February

Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	1
2	3	4	5	6	7	8

March

Sun	Mon	Tue	Wed	Thu	Fri	Sat
23	24	25	26	27	28	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	1	2	3	4	5

First day of your last menstrual cycle: _____
The day you believe your next period will start: _____

18) How confident are you that the response provided above was the first day of your last period? (Circle the best response)

0%		25%		50%		75%		100%
0	1	2	3	4	5	6	7	8

19) How confident are you that the response provided above is the day that you will next get your period? (Circle the best response)

0%		25%		50%		75%		100%
0	1	2	3	4	5	6	7	8

Appendix F

Participant #: _____

Laboratory Session II Questionnaire

Date: _____

Time: _____

1) Have you consumed any alcohol in the past 24 hours? (Circle your answer)

YES NO

   a. If yes, please indicate the **number of standard alcoholic drinks** you consumed in the past 24 hours (1 standard drink is equivalent to a 12 ounces of 5% alcoholic beer, a 1.5 ounce serving of 40% hard liquor, or a 5 ounce glass of wine with 12% alcohol):
   _____ drink(s)

2) Over the last week, how many standard alcoholic drinks did you consume? (1 standard drink is equivalent to a 12 ounces of 5% alcoholic beer, a 1.5 ounce serving of 40% hard liquor, or a 5 ounce glass of wine with 12% alcohol):
   _____ drink(s)

3) Have you consumed any caffeine prior to coming to the lab today? (Circle your answer)

YES NO

   a. If yes, please indicate the **number of standard servings** (1 standard serving is equivalent to a 10 fluid ounces or a small coffee/tea at Tim Hortons): _____ serving(s)

4) Do you smoke tobacco cigarettes? (Circle your answer)

YES NO

   a. If yes, please rate your **current level of withdrawal symptoms** you are experiencing right now by circling the best answer.

none at all mild moderate severe extremely severe

0 1 2 3 4

5) Have you consumed any recreational drugs other than alcohol or tobacco in the past 24 hours? (Circle your answer)

YES NO

6) Have you taken any medication to alleviate symptoms of pain in the past 2 hours? (e.g., Tylenol, Advil, Midol,morphine) (Circle your answer)

YES NO

7) How many hours of sleep did you get last night? _____

8) What time did you get up this morning? _____

9) Please rate your current level of fatigue by circling the best answer.

none at all	mild	moderate	severe	extremely severe
0	1	2	3	4

10) Please rate your current level of stress by circling the best answer.

none at all	mild	moderate	severe	extremely severe
0	1	2	3	4

11) How stressed have you felt in the past 24 hours? Please circle the best answer.

not at all stressed	mildly stressed	moderately stressed	very stressed	extremely stressed
0	1	2	3	4

12) Please rate your current level of hunger by circling the best answer.

not at all hungry	mildly hungry	moderately hungry	very hungry	extremely hungry
0	1	2	3	4

13) Please rate your current level of interest by circling the best answer.

not at all interested	mildly interested	moderately interested	very interested	extremely interested
0	1	2	3	4

14) During both phases (i.e., lab sessions) of the study how bored did you feel? Please circle the best answer.

not at all bored	mildly bored	moderately bored	very bored	extremely bored
0	1	2	3	4

15) During the study, how well did you attend to or pay attention to the tasks you were asked to complete? Please circle the best answer.

not at all attentive	somewhat attentive	moderately attentive	very attentive	extremely attentive
0	1	2	3	4

16) During the first laboratory session did you do anything to intentionally try to remember the items, faces, or stories? (e.g., rehearsing) (Circle your answer)

YES NO

17) Did you do anything to intentionally remember the items, faces, or stories in between the laboratory sessions? (Circle your answer)

YES NO

18) During the study how emotional or emotionally involved did you feel during and after hearing the stories in the first sesssion? Please circle the best answer.

not at all emotional	mildly emotional	moderately emotional	very emotional	extremely emotional
0	1	2	3	4

19) During the first laboratory session to what extent were you able to relate to the story that you watched and listened to? (Circle your answer)

not at all	a little	moderately	quite a bit	extremely
0	1	2	3	4

a. Did you relate to anyone in the story? YES NO

b. If so, who did you relate to the most? (Please check one):

_____ The child

_____ The mother

_____ The father

_____ The surgeons

20) During your experience with the story, what perspective did you take? For example, did you experience the story from the viewpoint of any of the following (Please check all that apply):

_____ The child

_____ The mother

_____ The father

_____ The surgeons

_____ An outsider (yourself)

21) After the first laboratory session, did you talk to anybody about the details of the study? (Circle your answer)

YES NO

22) This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you *currently feel* this way. Use the following scale to record your answers.

	Very Slightly or not at all (1)	A little (2)	Moderately (3)	Quite a bit (4)	Extremely (5)
Interested	1	2	3	4	5
Distressed	1	2	3	4	5
Excited	1	2	3	4	5
Upset	1	2	3	4	5
Strong	1	2	3	4	5
Guilty	1	2	3	4	5
Scared	1	2	3	4	5
Hostile	1	2	3	4	5
Enthusiastic	1	2	3	4	5
Proud	1	2	3	4	5
Irritable	1	2	3	4	5
Alert	1	2	3	4	5
Ashamed	1	2	3	4	5
Inspired	1	2	3	4	5
Nervous	1	2	3	4	5
Determined	1	2	3	4	5
Attentive	1	2	3	4	5
Jittery	1	2	3	4	5

Active	1	2	3	4	5
Afraid	1	2	3	4	5

THE FOLLOWING QUESTIONS ARE FOR FEMALES ONLY:

1) Are you currently taking any type of hormonal contraceptive (e.g., oral contraceptives, the Pill, Depo Provera, hormonal patch, Implanon implant, NuvaRing)?

YES NO

a. If yes, please indicate what type of hormonal contraceptive you are currently taking:

Oral Contraceptives:

[ ] Alesse
[ ] Brevicon 0.5/35
[ ] Brevicon 1/35
[ ] Cyclen
[ ] Demulen 30
[ ] Loestrin 1.5/30
[ ] Marvelon
[ ] MinEstrin 1/20
[ ] Min-Ovral
[ ] Norinyl
[ ] Ortho 1/35
[ ] Ortho 0.5/35
[ ] Other: _____

[ ] Ortho-Cept
[ ] Ortho 7/7/7
[ ] Ortho 10/11
[ ] Synphasic
[ ] Tri-Cyclen
[ ] Triphasil
[ ] Triquilar
[ ] Demulen 50
[ ] Norlestin 1/50
[ ] Ovral
[ ] Ortho-Novum 1/50

Injected Contraceptives:

[ ] Depo-Provera
[ ] Lunelle
[ ] Other: _____

Contraceptive Patch:

[ ] Ortho-Evra
[ ] Other: _____

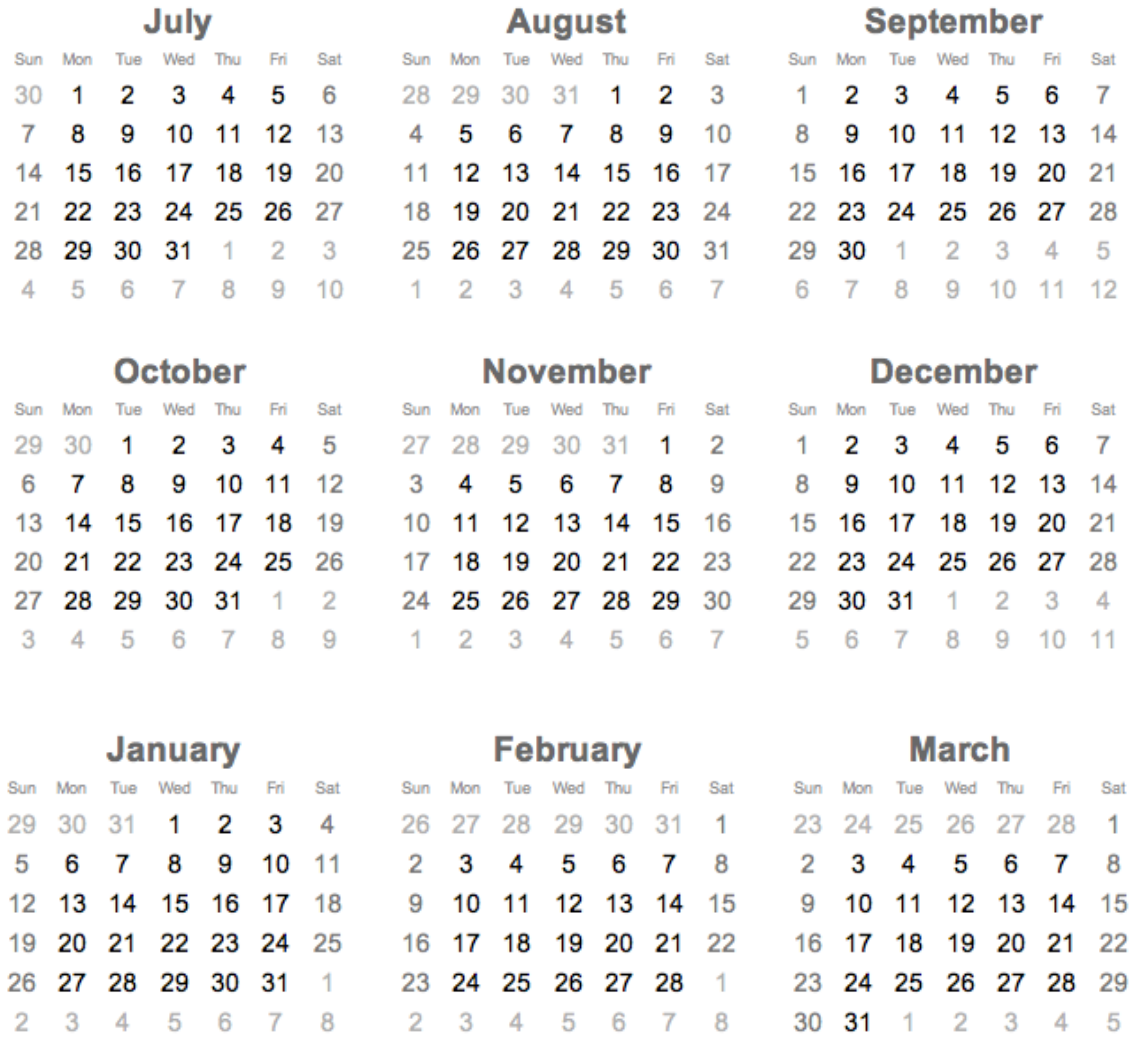
Vaginal Ring:

[ ] NuvaRing
[ ] Other: _____

2) Are you currently menstruating? (Circle your answer)

YES NO

3) Using the calendars below, please **indicate** the **first** day of your **last** menstrual period. If you are not completely sure, please estimate the day that you believe you started menstruating on. Also, please **indicate** the day that you believe your **next** period will start.



July

Sun	Mon	Tue	Wed	Thu	Fri	Sat
30	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	1	2	3
4	5	6	7	8	9	10

August

Sun	Mon	Tue	Wed	Thu	Fri	Sat
28	29	30	31	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
1	2	3	4	5	6	7

September

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12

October

Sun	Mon	Tue	Wed	Thu	Fri	Sat
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9

November

Sun	Mon	Tue	Wed	Thu	Fri	Sat
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
1	2	3	4	5	6	7

December

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	1	2	3	4
5	6	7	8	9	10	11

January

Sun	Mon	Tue	Wed	Thu	Fri	Sat
29	30	31	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1
2	3	4	5	6	7	8

February

Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	1
2	3	4	5	6	7	8

March

Sun	Mon	Tue	Wed	Thu	Fri	Sat
23	24	25	26	27	28	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	1	2	3	4	5

First day of your last menstrual cycle: _____
The day you believe your next period will start: _____

4) How confident are you that the response provided above was the first day of your last period? (Circle the best response)

0%		25%		50%		75%		100%
0	1	2	3	4	5	6	7	8

5) How confident are you that the response provided above is the day that you will next get your period? (Circle the best response)

0%		25%		50%		75%		100%
0	1	2	3	4	5	6	7	8

Appendix G

Class-Wide Email Announcement

Study on Hormones and Cognition

You are invited to participate in a psychology study looking at **individual differences in several cognitive tasks with respect to sex and hormonal changes.** We are seeking both **Female and Male** participants to complete a 20-minute screening questionnaire and two lab sessions (1 week apart) that will be 45 to 60 minutes in duration. If you wish to complete the screening questionnaire using a hard copy, please contact the researchers at bperson@lakeheadu.ca. If you would like to complete the questionnaire online, please click on the link listed below.

Students enrolled in Introductory Psychology or other select Psychology courses (where bonus points are permitted) will receive 0.5 bonus points for completing the screening questionnaire and 1.5 bonus points for each lab session completed (for up to 3.5 bonus points).

This study has been reviewed and approved by the Lakehead University Research Ethics Board.

Please follow the link below to participate in the online screening questionnaire:
https://www.surveymonkey.com/s/hormones_cognition

If you have any questions regarding this study please email Brandi Person at bperson@lakeheadu.ca.

Thank-you, your time and participation is greatly appreciated.

Sincerely,

Brandi Person, H.B.A.
M.A. Student
Department of Psychology
Lakehead University
955 Oliver Road
Thunder Bay, Ontario P7B 5E1
email: bperson@lakeheadu.ca

Dr. Kirsten Oinonen Ph.D., C. Psych
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955 Oliver Road
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Appendix H

Communications Bulletin

PARTICIPANTS NEEDED FOR STUDY ON HORMONES AND COGNITION.

Researchers are looking for MEN and WOMEN to participate in a study that involves completing a screening questionnaire and two lab sessions (1 week apart). The lab sessions involve completing a variety of interesting cognitive tasks and short questionnaires.

This study has received ethical approval by the Lakehead University Ethics Board.

Please click on the following link to learn more or to participate in the study: https://www.surveymonkey.com/s/hormones_cognition

You can also email Brandi Person at bperson@lakeheadu.ca to participate in the study or if you would like further information on the study.

Appendix I

Recruitment Poster

Lakehead UNIVERSITY

Male and Female Participants Needed:
Researchers in the department of Psychology are looking for volunteers to participate in a study on
HORMONES AND COGNITION

Participants will complete a short screening questionnaire and participate in two laboratory sessions one week apart. Participants will be asked to complete a variety of interesting cognitive tasks.

- Receive up to **3.5 bonus points** towards eligible Psychology courses
- Be entered into a draw for two **$50 VISA** gift cards

This study has received ethical approval by the Lakehead University Research Ethics Board.

For more information and details on how to participate please email: bperson@lakeheadu.ca

Hormones & Cognition Study bperson@lakeheadu.ca
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Appendix J

Online Recruitment Site Advertisement

Study on Hormones and Cognition

Researchers in the Department of Psychology at Lakehead University are conducting a study investigating individual differences in cognitive performance with respect to sex and hormonal changes. We are looking for men and women who are 18 years of age or older, to complete a screening questionnaire and two lab sessions (1 week apart). The screening questionnaire will take 20 minutes and can be completed using the link below. The lab sessions will take 45 to 60 minutes each and involve completing a variety of interesting cognitive tasks and short questionnaires in the Health Hormones and Behaviour Laboratory (HHABLAB) in the department of Psychology at Lakehead University. All responses will be kept anonymous and confidential.

This study has been approved by Lakehead University's Research Ethics Board.

For full details and/or to participate please email bperson@lakeheadu.ca, phone (807) 343-8096, or go to the following website:
https://www.surveymonkey.com/s/hormones_cognition

Appendix K

Personal Email Announcements to Non-Lakehead Student Individuals

Study on Hormones and Cognition

You are invited to participate in a psychology study being conducted at Lakehead University looking at **individual differences in cognitive performance that relate to sex and hormones.** We are seeking both **Female and Male** participants to complete a 20-minute online screening questionnaire (see link below). Anyone who is 18 years or older can participate.

Following completion of the screening questionnaire, participants will be contacted via email and asked to participate in two lab sessions (1 week apart) that will take 45 to 60 minutes to complete. The lab sessions will involve participating in several interesting cognitive tasks and completing short questionnaires.

This study has been reviewed and approved by Lakehead University Research Ethics Board.

Please follow the link below to participate in the online questionnaire:
https://www.surveymonkey.com/s/hormones_cognition

If you have any questions regarding this study please email Brandi Person at bperson@lakeheadu.ca.

Thank-you, your time and participation is greatly appreciated.

Sincerely,

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Appendix L

Letter to Participants

Study on Hormones and Cognition

Dear Potential Participant,

This study is being conducted by Brandi Person and Dr. Kirsten Oinonen from the Health Hormones and Behaviour Laboratory (HHABLAB) in the department of Psychology at Lakehead University. The main purpose of this study is to examine **individual differences in several cognitive tasks with respect to sex and hormonal changes**. The data will be used in Brandi Persons' Masters thesis on this topic as well as to examine additional research questions in the laboratory. Participation in the study involves completing a screening questionnaire followed by two lab sessions with the second session to be completed one week after the first. The first and second sessions will take approximately 45 to 60 minutes to complete. The screening questionnaire can be completed online (but participants may have the option to complete a hard copy version). Both sessions involve answering personal questions about your health, mood, and behaviour. There are no obvious risks involved in participating in this study other than the fact that some participants may feel uncomfortable answering some personal questions or may experience minor positive or negative changes in their mood that would normally occur on a daily basis. Please note that you are not required to answer all questions and can skip any question that makes you uncomfortable. This study is open to Lakehead University students who are 16 years or older as well as members of the general public who are 18 years or older.

Lakehead University Psychology students may receive up to 3.5 bonus points for participation (0.5 bonus points for the Screening Questionnaire and 1.5 bonus points per laboratory session). Participants who complete the study in its entirety will be entered into a draw for one of two $50 VISA gift cards. Your participation in this study is completely voluntary and you have the right to withdraw from, or refuse to participate in any part of the study, at any time without explanation or penalty. All records of your participation will be kept confidential and reports of the study will not reveal your identity. However, your name and contact information (e.g., email address) is requested during the screening questionnaire so you can be contacted to participate in the two sessions and to link your responses from both sessions. Your email address will only be used to contact you regarding the study and will be kept confidential. Once the study is complete, all identifying information, including email address, will be removed. At that point, no one, including the researchers, will be able to connect any information gathered to a specific individual. There is no obligation to provide an email address or any other identifying information, however such information is required if you are a student in the Lakehead University Psychology Research Pool and you wish to receive bonus points. All identifying information will be removed once bonus points have been recorded and participants will remain anonymous in any publications or presentations of research findings.

University regulations state that all data must be stored for a minimum of five years; data will be kept in a secure location by Dr. Oinonen and will remain confidential and anonymous. If you have any questions or concerns regarding the study please contact Brandi Person or Dr. Oinonen. This study has been approved by the Lakehead University Ethics Board (807-343-8283 or research@lakeheadu.ca) and they can also be contacted if you have any questions related to the ethics of the research and would like to speak to someone outside of the research team.

Upon completion of the study, interested participants are welcome to contact one of the researchers to request a summary of the results. Thank you very much for your time. We very much appreciate your contribution to our research.

Brandi Person, H.B.A.
M.A. Student
Lakehead University
955 Oliver Road
Thunder Bay, Ontario P7B 5E1
email: bperson@lakeheadu.ca

Dr. Kirsten Oinonen Ph.D., C. Psych.
Associate Professor
Department of Psychology
Lakehead University
955 Oliver Road
Thunder Bay, Ontario P7B 5E1
email: koinonen@lakeheadu.ca
(807) 343-8096

Appendix M

Consent Form A

Dear Potential Participant,

I have read and understood the cover letter for the Hormones and Cognition Study conducted by Brandi Person and Dr. Oinonen in the HHAB laboratory in the Department of Psychology at Lakehead University. I agree to participate in this research and understand the following:

1. I am being invited to participate so that I may contribute to the understanding of how hormonal changes influence cognitive performance.
2. I am a volunteer, can withdraw at any time from this study, and may choose not to answer any question.
3. This study will involve my commitment to two laboratory sessions that will take approximately 45 to 60 minutes to complete.
4. There are no known serious risks involved in participating in this study. Benefits include (a) learning about research processes, (b) a first-hand experience with experimental processes, (c) knowledge that you are contributing to important research questions and (d) the receipt of bonus points if enrolled in Introductory Psychology at Lakehead University.
5. I will remain anonymous in any publications or presentations of research findings. All data will remain confidential and will only be accessed by the researchers, who have been trained in research ethics. At the end of the study, the data I have provided will be associated with a participant number, and not my name, e-mail address, or any other identifying information.
6. The data will be securely stored for at least 5 years by Dr. Oinonen at Lakehead University.
7. For the duration of the study, the researchers and I will have ongoing communication via the e-mail address(es) or the telephone number that I have provided below. This information will not be used for any other reason.
8. If I am a Lakehead University Psychology student eligible for bonus points I will receive up to 3.5 bonus points (if applicable) for participation (0.5 bonus points for the Screening Questionnaire and 1.5 bonus points per laboratory session).
9. I will be entered into a draw for one of two $50 VISA gift cards if I complete the study in its entirety.
10. Upon completion of my participation, I will receive a more detailed written explanation about the rationale underlying this study.
11. I may contact the researchers if I would like to receive a summary of the findings.

By providing any information below, I agree to the above.

First Name: _____

Phone number(s): _____

E-mail address(es): _____

Psychology Course and Professor at Lakehead (for bonus points, if applicable):
_____

Lakehead Student Number (for bonus points, if applicable): _____

Appendix N

Debriefing Form A

Thank you for completing the Screening Questionnaire for the Hormones and Cognition Study. You will receive 0.5 bonus points for your participation in this stage if you are in the Psychology Research Pool and have provided the relevant course information. If you are selected to participate in the next stages of the study you be contacted by one of the researchers (i.e. Brandi Person) via the email address you provided. You will be asked to participate in the next stage of the study by participating in Laboratory Session I. If applicable, Lakehead University Psychology Research Pool participants can receive 1.5 bonus points for the completion of Laboratory Session I. You will then be asked to participate in the next stage of the study by participating in Laboratory Session II one week later. The session will be scheduled at the end of Laboratory Session I. An additional 1.5 bonus point is provided for participating in Laboratory Session II. In addition, participants who complete the study in its entirety will be entered into a draw for one of two $50 VISA gift cards.

Please be assured that your name and contact information will remain confidential and will be removed from the Screening as well as the Laboratory Questionnaires. Once we have connected your data together there will be no way to identify your responses and they will remain completely anonymous. Please keep a copy of this for your records. If you have any questions or concerns regarding this study, please contact Brandi Person or Dr. Oinonen. You may also contact Lakehead University's Research Ethics Board, which has approved this study, at 807-776-7289.

Thank you very much for your time. We very much appreciate your contribution to our research.

Sincerely,

Brandi Person, H.B.A.
bperson@lakeheadu.ca

Kirsten Oinonen, Ph.D., C. Psych
koinonen@lakeheadu.ca
807-343-8096

Health, Hormones, and Behaviour Lab
Department of Psychology
Lakehead University
955 Oliver Road
Thunder Bay, ON
P7B 5E1

Appendix O

Consent Form B

Dear Participant,

I have previously read and understood the cover letter for the Hormones and Cognition Study conducted by Brandi Person and Dr. Oinonen in the Department of Psychology at Lakehead University. I agree to participate in this research and understand the following:

1. I have been selected to participate in the next stage of the study. This stage involves the completion of a variety of cognitive tasks and questions in the HHAB laboratory in the Department of Psychology at Lakehead University (less than 1 hour in time).
2. In one weeks time I will be asked to return to the HHAB laboratory to participate in a second laboratory session where I will complete a variety of cognitive tasks (less than 1 hour in time).
3. I will be asked to respond to questions of a personal nature that include, but are not limited to, the following: personal health, mood, behaviour, and the menstrual cycle (for women).
4. I am a volunteer, can withdraw at any time from this study, and may choose not to complete any part or question in the study.
5. There are no known serious risks involved in participating in this study. Benefits include a) learning about research processes, (b) a first-hand experience with experimental processes, (c) knowledge that you are contributing to important research questions and (d) the receipt of bonus points if enrolled in eligible Psychology courses at Lakehead University.
6. I will remain anonymous in any publications or presentations of research findings. All data will remain confidential and will only be accessed by the researchers, who have been trained in research ethics. At the end of the study, the data I have provided will be associated with a participant number, not my name, e-mail address, or any other identifying information.
7. The data will be securely stored for at least 5 years by Dr. Oinonen at Lakehead University.
8. If I am a Lakehead University Psychology student I will receive up to 3.5 bonus points (if applicable) for participation (0.5 bonus points for the Screening Questionnaire and 1.5 bonus points per laboratory session).
9. I will be entered into a draw for one of two $50 VISA gift cards if I complete the study in its entirety.
10. Upon completion of my participation, I will receive a more detailed written explanation about the rationale underlying this study.
11. I may contact the researchers if I would like to receive a summary of the findings at the end of the study.

I have read and understood the above information and agree to participate in this study on Hormones and Cognition:

Name: _____

Signature: _____

Date: _____

Appendix P

Emotional Story: Recall Form
(Same for Neutral and Arousing Conditions)

DETAILS: For the slides that you remembered, please write down as many details as you can recall about each slide. WRITE ONE ITEM OF DETAIL PER LINE. Full sentences are not necessary and no detail is too small. There is no time limit, so please take your time.

Number of slide: Details:

Appendix Q

Debriefing Form B

Thank you for participating in the Hormones and Cognition Study. The data you provided will be used to complete a Master's thesis by Brandi Person under the supervision of Dr. Kirsten Oinonen. It will also be used to examine other exploratory research questions within the HHABLAB. For the thesis, the data will specifically be used to investigate differences in emotional memory between men and women, within women (between oral contraceptive users versus free-cycling women) and across the menstrual cycle. Additional exploratory research questions will also be examined. Given that this study involves examining certain aspects of memory, it was essential that you, as a participant, not be fully aware of this at the onset of the study. This was done in order to ensure that the findings were not influenced in any way by participants rehearsing or engaging in strategies to enhance memory either within or between sessions.

Given that this study involves some aspects of which participants are not fully informed of at the start, it is very important that you not discuss your experiences with other students until the end of the school year (April 2014). If participants have prior knowledge of the fact that we are examining memory it may influence their results, and the data we collect would be not be reliable. Because you will be given a copy of this feedback to take home, please do not make it available to other students. If you do not keep this form, please dispose of it rather than leaving it somewhere where other students might read it. Please feel free to discuss with the researchers any thoughts or feelings you have about the study right away.

Please be assured that your name and contact information will be removed from the data collected and there will be no way to identify your responses. All your responses will remain completely anonymous and confidential. If you would like to receive a summary of the results of the study, please email one of the researchers and, upon completion of the study, a summary of the results will be emailed to you. This research project was approved by the Lakehead University Research Ethics Board (807-343-8283).

Psychology students at Lakehead University who have completed the entire study will receive 3.5 bonus points (if applicable). All volunteers will be entered into a draw for one of two $50 VISA gift cards upon completion of the study.

If you would like further information on the topic please refer to the references listed below.

Nielsen, S.E., Ertman, N., Lakhani, Y.S., & Cahill, L. (2011). Hormonal contraception usage is associated with altered memory for an emotional story. *Neurobiology of Learning and Memory, 96,* 378-384. doi:10.1016/j.nlm.2011.06.013

Oinonen, K.A. & Mazmanian, D. (2002). To what extent do oral contraceptives influence mood and affect? *Journal of Affective Disorders, 70*, 229-240. doi:10.1016/S0165-0327(01)00356-1

Sometimes people can feel upset when thinking about their mood or viewing emotional material. If you feel as though you would like to talk to a mental health practitioner for any reason please consider the resources listed below:

- Lakehead University Health and Counseling Centre: 343-8361
- Thunder Bay Counseling Centre : 626-1880
- Catholic Family Development Centre: 345-7323
- Thunder Bay Crisis Response (24 hours): 346-8282
- Emergency services are available at the Thunder Bay Health Sciences Centre

Thank you very much for your time. We very much appreciate your contribution to our research. Sincerely,

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bperson@lakeheadu.ca

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Appendix R

Non-normal Dependent Variables by Group (Nonusers, OC users, and Men).

Variable	Outliers	Normality
Emotional Gist: Neutral Gist Ratio (Story Task)	OC user (108)	Leptokurtic
Emotional Detail: Neutral Detail Ratio (Story Task)	Nonuser (72), OC user (101)	Slight positive skew
Positive: Negative Item Recall Ratio (Visuospatial Task)	Nonuser (49), OC users (51, 157), Men (4)	Slight positive skew, Leptokurtic

Note: The numbers in parentheses refer to the participant numbers with outlying data points. As noted in the text, all analyses were completed both including and excluding the outliers relevant to that analysis.