Women’s performance on sexually dimorphic tasks:

The effect of hormonal fluctuations

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Abstract

This study examined the effect of hormonal fluctuations on women’s performance on sexually dimorphic cognitive tasks. Thirty-six participants were recruited through introduction to psychology courses at three colleges. Participants were assessed using the Woodcock-Johnson Test of Cognitive Ability III (WJ III COG), which is a commonly-used, widely accepted measure of cognitive ability, yet not previously used to evaluate women’s cognitive ability in regard to hormonal fluctuations.

In this study, participants’ cognitive ability was assessed using two split-half forms of six subtests (four which have been found to be sexually dimorphic; two which were not found to be sexually dimorphic in regard to this particular evaluation, but have on other cognitive evaluations). Participants were assessed once during their predicted menses phase and once during their predicted ovulation phase. Raw scores and rates of the subtests between the phases were compared. Results indicated that there were no significant differences on sexually dimorphic tasks between phases of the menstrual cycle. Although in this study cognitive ability remained consistent throughout the menstrual cycle, further research must be conducted before it can be concluded that sex hormones do not affect cognitive functioning.
**Table of Contents**

Dedication ......................................................................................................................... i
Acknowledgements ........................................................................................................... ii
Abstract .............................................................................................................................. v
Chapter 1: Introduction ................................................................................................. 1
Chapter 2: Review of Literature ..................................................................................... 7
  Menstrual Cycle ............................................................................................................. 7
  Negative Effects of the Menstrual Cycle .................................................................... 9
  Physical and Emotional Symptoms ........................................................................... 10
    Behavioral Factors .................................................................................................... 12
    Cognitive Ability ...................................................................................................... 12
  Early Studies of Women’s Ability .............................................................................. 13
  Sexual Dimorphism .................................................................................................... 14
  Brain Changes during the Menstrual Cycle ............................................................... 15
  Phase Identification ................................................................................................... 17
  Cognitive Ability and Sexual Dimorphism ............................................................... 18
  Hormonal Contraceptives ......................................................................................... 19
  Conclusion .................................................................................................................... 20
Chapter 3: Method .......................................................................................................... 22
  Participants ................................................................................................................... 22
  Procedures and Measures ......................................................................................... 23
Chapter 4: Results ........................................................................................................... 27
  CHC Factor: Crystallized Intelligence/Comprehension Knowledge ......................... 27
Appendices .................................................................................................................50

Appendix A: Directions at First Screening Session .................................................50

Appendix B: Research Questionnaire .................................................................52

Appendix C: Directions at First Individual Meeting ..............................................55

Appendix D: Meeting Questionnaire ..................................................................57

Curriculum Vitae .....................................................................................................59
Chapter 1
Introduction

It has long been speculated that certain phases of a woman’s menstrual cycle can negatively affect her physically, emotionally, and behaviorally (Barclay, Petitto, Labrum, & Carter-Jessop, 1991; Bond, Critchlow, & Wingrove, 2003; Braun, 2005; Carr-Nangle, Johnson, Bergeron, & Nangle, 1994; Deuster, Ader, & South-Paul, 1999; Hendrick, 2007; Kibler et al., 2005; Natale & Albertazzi, 2006; Sabin & Slade, 1999; Sanders, Warner, Backstrom, & Bancroft, 1983; Silberstein & Merriam, 2000). Some symptoms that have been linked to the hormonal fluctuations that make up these phases of the menstrual cycle in women are headaches, irritability, and anxiety. Moreover, it has been suggested that the hormonal fluctuations of the menstrual cycle may even affect a woman’s cognitive ability. Some findings have suggested that women perform better on certain tasks during menses, when estrogen levels are their lowest. Such tasks include visuospatial/spatial ability tasks, on which men typically demonstrate higher performance than women (Hampson, 1990a; Hampson, 1990b; Hampson, Ellis, & Tenk, 2008; Hampson & Kimura, 1988; Kimura, 1992, 2000, 2002; Kimura & Hampson, 1994; Phillips & Silverman, 1997; Wharton et al., 2008).

The idea that men and women are physically different is a widely accepted notion, yet the possibility that men and women perform differently on cognitive tasks has been a topic of much debate (Denmark & Paludi, 2008). However, findings suggest that there are some cognitive tasks that are considered sexually dimorphic, meaning one gender performs significantly better than the other. Such findings have typically been determined to be the product of brain structure differences. More recently, researchers have begun to investigate whether differences in the endocrine system are actually the main cause for sexually dimorphic performance on cognitive
tasks (Kolb & Whishaw, 2003). Thus, studying the natural fluctuation of hormones during a woman’s menstrual cycle may help to determine if women’s performance on sexually dimorphic cognitive tasks changes when different sex hormones are high or low at the time of testing.

Though some research has found that estrogen and progesterone have strong effects on sexually dimorphic tasks, the tests used in these studies to evaluate women’s performance are not the most widely accepted or utilized tests of cognitive performance at this time. Some of the tests used in the research were the Rod and Frame Test published in 1968, which measures perceptual-spatial ability; the Purdue Pegboard published in 1968, which measures fine and gross motor activity; the Manual Sequence Box test published in 1977, which is an unnormed test expected to measure manual dexterity; the ETS Kit and Factor-Referenced Cognitive Tests published in 1976, which measure a variety of cognitive abilities (i.e., reasoning, verbal ability, spatial ability, memory); the Oral Fluency Test published in 1968, and the Expressional Fluency Test published in 1958, which were used to measure verbal fluency; and also some tests that were developed by the researchers themselves for the purpose of their study (Hampson, 1990a; Hampson, 1990b; Hampson & Kimura, 1988; Kimura, 1992, 2000; Kimura & Hampson, 1994). Even in the most recent study of cognitive functioning during the menstrual cycle by Wharton et al. (2008), tests such as the Mental Rotation Task published in 1978, which measures spatial ability and ability to mentally rotate visual objects, and a recognition memory task based on words selected from Francis and Kucera norms in 1982, meant to measure memory, were used to study cognition. Overall, most prior studies of effects of hormones on cognitive functioning used only one specific cognitive task, tests that were outdated, or did not actually use tests that measure cognitive ability at all. Thus, results of those studies cannot generalize to the measures of cognitive performance that are most commonly used to make important diagnostic and/or
eductional decisions today. According to Canter (2003), Flanagan, Ortiz, Alfonso, and Dynda (2007), and Kamphaus (2008), two norm-referenced, standardized, recently updated tests that are frequently used to make these decisions are the Wechsler Intelligence Scale for Children IV (WISC-IV) and the Woodcock-Johnson Test of Cognitive Abilities III (WJ III COG).

At this time, the Cattell-Horn-Carroll (CHC) Theory is considered one of the most research-supported models of human cognition (Fiorello & Primerano, 2005; Flanagan & Harrison, 2005; Flanagan et al., 2008; Kamphaus, 2008; Sanders, McIntosh, Dunham, Rothlisberg, & Finch, 2007). “CHC Theory integrates three prominent theories of cognitive ability, Cattell’s original Gf-Gc Theory, Horn and Cattell’s expanded Gf-Gc Theory, and Carroll’s Three-Stratum Model” (Sanders et al., 2007, p. 119). The CHC Theory states that cognitive functioning (g) can be subdivided into both broad and narrow abilities that can be organized in clusters that are genetically, functionally, and developmentally related. This theory is hierarchical in nature, consisting of three levels/strata. Thus, 70 narrow abilities comprise the 10 broad abilities, which are all subsumed under g or general ability (Fiorello & Primerano, 2005; Flanagan & Harrison, 2005; Sanders et al., 2007). Figure 1 demonstrates the broad abilities and narrow abilities that make up the CHC Theory. Each of the broad abilities can be described in further detail for a deeper understanding of what constitutes intelligence. Figure 2 describes each of the broad abilities in greater detail.

One test that has its roots in the CHC Theory of intelligence is the WJ III COG (Fiorello & Primerano, 2005; Flanagan & Harrison, 2005; Sanders et al., 2007). Given that the CHC theory of intelligence has much empirical support and that the WJ III COG measures this theory of intelligence, use of the WJ III COG to measure the cognitive ability of women is supported.
It is potentially more helpful to study the performance of women who take hormonal contraceptives, in order to identify which hormone, if any, has the greatest effect on sexually dimorphic cognitive tasks (Wharton et al., 2008). Since many studies of women’s cognitive performance throughout their menstrual cycle do not account for the possible effects of hormonal contraceptives on the results, an accurate interpretation of their findings may be missing unless this variable is considered. According to the National Center for Health Statistics, approximately 60 percent of women between the ages of 15 and 44 use some form of contraceptive. Of those women, 19 percent use some type of oral hormonal contraceptive (i.e., “the pill”). More specifically, 17 percent of women between the ages of 15 and 19 used some form of the pill, in comparison to 31 percent of women between the ages of 20 and 24 (Mosher, Martinez, Chandra, Abma, & Willson, 2004). Thus, based on the Wharton et al. (2008) study which considered several hormonal contraceptives, including Yasmin, the current study had intended to determine if the use of Yasmin/Ocella or Yaz significantly affects performance on cognitive tasks. Yasmin/Ocella and Yaz are the only oral hormonal contraceptives that contain drospirenone, which is an antiandrogenic progestin, meaning that the progestin was not derived from a testosterone (Bayer Inc., 2007). Both Yasmin/Ocella and Yaz contain 3 milligrams of drospirenone, but Yasmin/Ocella contains 0.03 milligrams of ethinyl estradiol, while Yaz contains 0.2 milligrams of this hormone. Thus, of all oral hormonal contraceptives, Yasmin/Ocella and Yaz are the least androgenic, which leads to the hypothesis that users of these contraceptives would be less likely to perform well on sexually dimorphic tasks favoring men, because the level of male sex hormones would be lower in their system than women who are naturally cycling (Wharton et al., 2008). However, upon collecting data for two semesters, it was found that only five eligible participants took the oral hormonal contraceptive, Yaz and/or
Yasmin/Ocella. Furthermore, those five students were identified during the first semester of research.

According to many recent news and medical articles, this decline in participants taking Yaz and/or Yasmin/Ocella may not be a coincidence. One article published on NPR.org explains, “After Yaz came out in 2006, it quickly became America's No. 1 birth control pill, bringing Bayer $800 million last year. But now thousands of women are suing Bayer because they say Yaz caused them serious harm. Sales have dropped 15 percent in the past year” (Knox, 2010). This article, as well as many others (Singer, 2009a; Singer, 2009b; Stephenson, 2009), goes on to explain the many lawsuits brought against Bayer for misleading advertising that didn’t adequately outline the serious side effects that could and have affected many of its users. Thus, as the current research continued, different forms of birth control, such as Loestrin 24 and Nuvaring, were becoming more regularly identified as common hormonal contraceptives. Although these contraceptives contained the hormone ethinyl estradiol which is also found in Yaz and Yasmin/Ocella, none of the contraceptives listed by potential participants contained the hormone drosperinone, which was going to be examined in this study due to its antiandrogenic qualities.

The present study addressed whether or not the hormonal fluctuations caused by a woman’s natural (without use of hormonal contraceptives) menstrual cycle affect cognitive ability on sexually dimorphic tasks. Female participants were evaluated with a commonly used, updated cognitive measure with high validity and reliability at two different phases of the menstrual cycle. These phases are the late follicular (ovulation) phase and the menstrual phase (menses). Scores from the two phases were compared to determine if there are significant differences between the phases. It was predicted that cognitive ability would fluctuate
significantly on sexually dimorphic tasks between the two phases of the menstrual cycle due to hormonal fluctuations. Although these cognitive fluctuations may exist, there is no indication in the current literature that they are taken into account when scheduling evaluations and examinations for females.

This study was designed to answer the following research question:

Does cognitive performance on sexually dimorphic tasks vary between the ovulation (late follicular) phase and the menstrual phase of college women’s natural menstrual cycle?

- **Hypotheses:**
  - Female college students will demonstrate higher performance on cognitive tasks that typically favor women during the ovulation phase than during the menstrual phase.
  - Female college students will demonstrate lower performance on cognitive tasks that typically favor men during the ovulation phase than during the menstrual phase.
Chapter 2

Review of the Literature

Starting in adolescence, females are affected by physical and emotional issues caused by the hormonal fluctuations of their menstrual cycle (Bond, Critchlow, & Wingrove, 2003; Curtis, 1981; Denmark & Paludi, 2008; Dougherty, Bjork, Cherek, Moeller, & Huang, 1998; Reilly, 2000; Sabin & Slade, 1999). Some research in women’s health has suggested that these hormonal fluctuations, known as phases of the menstrual cycle, may also affect a woman’s cognition or intellectual ability (Hampson, 1990a; Hampson, 1990b; Hampson & Kimura, 1988; Phillips & Silverman, 1997; Sommer, 1972). However, the findings of these studies are inconsistent and often outdated (Kimura & Hampson, 1994). Hormonal contraceptives and age may play a part in these inconsistent research results (Wharton et al., 2008). Another factor that may affect the results of these studies is the reliability and validity of the instruments used to determine intellectual ability. The impact of hormonal fluctuations caused by the menstrual cycle on cognitive ability in women would be of particular interest to those who base important decisions on such data, such as school psychologists or clinicians. The following literature review examines research regarding the menstrual cycle’s effects on physical, emotional, behavioral, and cognitive functioning of women. The review also considers how hormonal contraceptives may impact women’s functioning.

Menstrual Cycle

Females begin to experience their menstrual cycle starting in adolescence. Menarche is the name given to a female’s first menstrual cycle which is identified by the onset of menstrual bleeding, also known as menses. In the United States, 12 years is the average age that a female adolescent experiences her Menarche. However, Menarche may take place as young as age eight
or as old as age 15 (Nelson, 2007). Therefore, in schools, the most common grade level that females begin experiencing their menstrual cycle is approximately 7th grade, but some may start their menstrual cycle as early as 3rd grade.

The menstrual cycle involves a complex interaction of hormones that prepares female primates (e.g., humans, apes, and some species of monkeys) for pregnancy. In humans, the menstrual cycle is regulated by four hormones. One hormone is the follicle-stimulating hormone (FSH), which is produced by the pituitary gland. Another hormone also produced by the pituitary gland is the luteinizing hormone (LH) (Denmark & Paludi, 2008). Both FSH and LH are considered to be gonadotropic hormones, which means that these hormones affect the ovaries (The Columbia Encyclopedia, 2008). The other two hormones that are involved in the menstrual cycle are estrogen and progesterone (sometimes referred to as estradiol and progestin, respectively), which are produced by the ovaries and affect the uterus (Denmark & Paludi, 2008). Each of these four hormones plays a different role in preparing a woman for pregnancy.

The average menstrual cycle lasts about 28 days, but menstrual cycle lengths can vary from 21 to 40 days. Based on the average menstrual cycle, the phases can be described in ranges of days that each phase lasts. An issue that comes up in menstrual cycle research is that the phases are not consistently defined. Generally, the fluctuations of hormones help to identify the different phases, but depending on the researchers’ interpretation of the cyclical changes, there may be more or fewer phases. Most researchers agree that the very first day of menstruation is considered to be day one of the menstrual cycle. This is when estrogen and progesterone are at their lowest levels in a woman’s body. Menses may last three to seven days. Some researchers consider “menstruation” to be a phase in itself. The follicular phase of the menstrual cycle may either be considered to encompass the menstruation phase or may be considered to begin after
menstruation (Braun, 2005; Denmark & Paludi, 2008; Doria, 1999; Kimura, 2000). What defines this phase is that a new uterine lining begins to form until approximately day 14 when FSH and LH are at their highest. Estrogen is also at its highest around day 14 (Denmark & Paludi, 2008). Around day 14 when ovulation occurs, a matured ovum is released into the fallopian tube. This is sometimes considered the ovulation phase of the menstrual cycle (approximately days 13 to 15) (Braun, 2005). The next phase is referred to as the luteal phase (approximately days 15 to 28). During this phase, estrogen drops drastically and then begins to rise again (not to the highest level that it was during ovulation), while progesterone continues to rise. Around day 24, both progesterone and estrogen decrease rapidly and menses begin after day 28, starting the menstrual cycle over (Denmark & Paludi, 2008). Some, however, refer to the drop in progesterone and estrogen in the luteal phase of the menstrual cycle as the “premenstrual” phase (approximately days 24 to 28) (Kimura, 2000).

**Negative Effects of the Menstrual Cycle**

Many researchers have studied how these hormonal fluctuations that comprise the different phases of females’ menstrual cycle affect their physical, behavioral, and emotional states. Negative changes such as headaches, lower energy levels, weight gain, cramps, breast sensitivity, acne, joint/muscle pain, tension, irritability, mood swings, anxiety, depression, and fatigue are some symptoms that have been linked to certain phases of the menstrual cycle (Barclay et al., 1991; Bond, Critchlow, & Wingrove, 2003; Braun, 2005; Carr-Nangle et al., 1994; Deuster, Adera, & South-Paul 1999; Hendrick, 2007; Kibler et al., 2005; Natale & Albertazzi, 2006; Sabin & Slade, 1999; Sanders et al., 1983; Silberstein & Merriam, 2000). One of the most common conditions associated with the menstrual cycle is known as Premenstrual Syndrome (PMS). Premenstrual Syndrome is a combination of some of the previously-
mentioned symptoms, which vary for each woman. PMS occurs one to two weeks before menstruation and typically recedes when menstruation begins (Hendrick, 2007). It is hypothesized that PMS is caused by hormonal fluctuations that take place prior to menses. The actual prevalence of PMS is not known, but it is estimated that approximately 75% of menstrual women experience some level of PMS (American Psychiatric Association [DSM-IV-TR], 2000; Deuster et al., 1999). Premenstrual Dysphoric Disorder (PMDD) is another condition that is associated with extreme physical and emotional symptoms that occur in the luteal phase of the menstrual cycle. PMDD warrants further research to become an official disorder in the Diagnostic and Statistical Manual of Mental Disorders. At this time, it is believed that the prevalence of PMDD is approximately three to five percent of all menstrual women (American Psychiatric Association [DSM-IV-TR], 2000). Negative symptoms related to phases of the menstrual cycle, such as PMS and PMDD, have been of interest to researchers for a multitude of reasons.

**Physical and Emotional Symptoms.** One of the reasons researchers have been interested in symptoms associated with hormonal changes in the menstrual cycle is due to what some studies refer to as disability. These studies state that symptoms that are commonly associated with the menstrual phases may impede a woman’s ability to perform or function as she would typically in daily life. For example, headaches and migraines related to the menstrual cycle may be considered a disability. It has been suggested that the higher levels of both progesterone and estrogen in the later luteal phase of the menstrual cycle may be a possible cause of the “menstrual migraine” (Kibler et al., 2005, p. 1183). Based on one study of this possible relationship, it was found that lower levels of luteal progesterone in naturally-cycling women (i.e., women not taking hormonal contraceptives) was inversely related to the number of
migraine headaches they experienced. Not only did luteal progesterone (including premenstrual phase) levels predict migraine activity, they also predicted higher disability ratings, meaning that women missed more days of “paid work or school, house-work, and nonwork family/leisure activities” based on the migraine disability assessment (Kibler et al., 2005, p. 1184).

Interestingly, further support that hormonal fluctuations cause menstrual migraines comes from research of women who use hormonal contraceptives, which alter the hormones of their menstrual cycle and ultimately many of the symptoms linked with their cycle. Due to hormonal contraceptives, migraines may become more prevalent and/or intense (Silberstein & Merriam, 2000). Therefore, research about women using hormonal contraceptives and hormone levels is helpful for understanding how the menstrual cycle affects women.

Of course, menstrual migraines are only one of the physical symptoms that may be related to hormonal changes of the menstrual cycle, but are representative of how physical symptoms may affect women’s daily lives. Some studies have looked at how the menstrual cycle affects physical performance in competitive sports and lifting. It has been found that as progesterone increases in the luteal phase, ventilation and heart rate also increase, which may negatively impact athletic performance (Birch & Reilly, 1999; Reilly, 2000). Other studies have looked at self-reports about physical symptoms related to the phases of the menstrual cycle, which may in turn affect a woman’s mood. For example, breast tenderness caused by hormonal fluctuations of the menstrual cycle may lead to irritability or weight gain due to water retention from hormonal fluctuations or may cause a woman to feel less satisfied with her body (Carr-Nangle et al., 1994; Sanders et al., 1983). Therefore, emotional symptoms cannot be completely separated from the physical symptoms of the menstrual cycle. Furthermore, some have found
that premenstrually, women who take hormonal contraceptives show similar feelings of depression, but at a less intense level than those who naturally cycle (Natale & Albertazzi, 2006).

**Behavioral Factors.** Physical and emotional symptoms related to the menstrual cycle may adversely affect women. Further, behavioral factors may be a culmination of the physical and emotional symptoms of the hormonal fluctuations associated with the menstrual cycle. With regard to conflict resolution, both women diagnosed with PMDD and women without such a diagnosis show an increase in physical and verbal aggression in dealing with relational conflicts during the premenstrual phase of the menstrual cycle (Bond, Critchlow, & Wingrove, 2003). Other behaviors have been associated with symptoms of the premenstrual phase, such as increased alcohol consumption (Deuster et al., 1999). There are some behaviors that have been commonly associated with PMS, such as crying; these are also more prevalent during the luteal phase (Hendrick, 2007). Although not explicitly stated, these behaviors seem to be a reaction to dealing with negative physical and emotional symptoms that seem to occur in the luteal phase of the menstrual cycle, when estrogen decreases at a rapid rate.

**Cognitive Ability.** Since physical, emotional, and behavioral factors have been linked closely to fluctuations in the hormones associated with the menstrual cycle, it is no surprise that researchers have been curious as to whether or not these same fluctuations affect a woman’s intellectual ability. There are many studies that suggest cognition is affected by the phases of the menstrual cycle, but there are also many studies that counter these findings. Inconsistencies among studies’ findings may be based on biases of the researcher hoping to find certain results or because of subject expectations if they are told the purpose of the study (Kimura & Hampson, 1994). Other possibilities include outdated, unreliable, invalid evaluations and/or the phases of the menstrual cycle during which women were tested. Furthermore, hormonal contraceptives are
often lumped together in studies of cognition, but not all hormonal contraceptives are the same. Therefore, the fluctuations of specific hormonal contraceptives may be masked by the others when examined as part of a group (Wharton et al., 2008).

**Early Studies of Women’s Ability**

The menstrual cycle’s effects on women’s abilities have long been a topic of much debate. Feminists often attempt to counter any studies that suggest a woman’s ability is hindered by the menstrual cycle, but often times the data suggest otherwise (Denmark & Paludi, 2008). In the early 1900s, the idea that women had the ability to do the same job a man could do was scrutinized. Yet, due to the World Wars, women had to step in and take over the jobs men were no longer around to occupy. Thus, the change of women’s roles in society led to a new interest in women’s abilities. One early study that looked at cognitive performance attempted to address the question of whether women’s cognitive performance was truly affected by her menstrual cycle, because at the time it was culturally assumed to be true (Lough, 1937). This study looked at 96 women between the ages of 17 and 24 in their first three years of college. The four phases studied by Lough were identified by physiologists and separated into the menstrual (also called the “destructive phase” (p. 359), the postmenstrual, the midmenstrual, and the premenstrual phases. Using the Hemmon-Nelson Test of Mental Ability to test women during the menstrual phase and during the midmenstrual phase, Lough found no statistical difference between the phases. This suggested that a woman’s menstrual cycle has no effect on her mental ability.

Similarly, in 1972, Sommer also examined women’s intellectual ability at different phases of the menstrual cycle. Sommer made the point that behavioral changes have been closely linked to phases of the menstrual cycle, but little research had examined women’s intellectual functioning with regard to these phases. Sommer’s study also concluded that there
was no significant difference in intellectual functioning between phases of the menstrual cycle. Yet, Sommer’s study used measures that were not made to measure intellectual function. Rather the measures were psychology tests given in a psychology college course throughout a semester.

**Sexual Dimorphism**

Sexual dimorphism is generally described as the physical differences between males and females in a given species (Human Development, 2009). Although sexual dimorphism is controversial regarding cognitive ability, in humans, sexual dimorphism is rarely of question when it comes to the endocrine (hormonal) system and its effects on the physical body. Thus, the understanding that the endocrine system is distinctly different between the human sexes and how they develop physically (e.g., testes vs. ovaries; breast size and function) leads many researchers to speculate about its effects on cognitive functioning in women as compared to men. It has been found that there are sex-related differences between the male and female brains, despite the fact that there are no gross anatomical differences. One sex-related difference is the menstrual cycle, which involves the pituitary gland and the hypothalamus (Halpern, 2000). This notion is a key factor in the debate about whether sex-hormones play a role in cognitive functioning.

Some tasks have been coined as *sexually dimorphic*, meaning that one sex typically outperforms the other in the given task. For example, men typically outperform women in the arena of gross motor tasks, such as playing darts, while women typically outperform men with their fine motor skills in areas like handwriting. Other areas in which men often outperform women include *targeting, spatial orientation, spatial visualization, disembedding, spatial perception, spatial navigation, geographical knowledge,* and *mathematical reasoning/problem solving*. Women typically outperform men in the areas of *mathematical computation, spatial*
memory, sensitivity to sensory stimuli, perceptual speed, sensitivity to facial and body expression, visual recognition memory, verbal fluency, and verbal memory (Kimura, 2000; Kolb & Whishaw, 2003). Some researchers have suggested that these differences in performance between genders are strictly due to cerebral organization, while others believe that sex hormones may also play a significant role in cognitive function (Kolb & Whishaw, 2003). Studying the hormonal fluctuations throughout a woman’s menstrual cycle is one way to determine if these may have an effect on cognitive abilities.

**Brain Changes during the Menstrual Cycle**

It is generally accepted that men and women are physically sexually dimorphic, that men and women tend to outperform one another on different cognitive tasks, and that ovulatory women experience monthly hormonal fluctuations causing physical, emotional, and behavioral changes throughout the menstrual cycle. Yet, another key piece of information that would further support or refute the possibility that cognitive ability may fluctuate throughout the menstrual cycle is whether or not the brain itself shows changes throughout the menstrual cycle.

As previously stated, at certain phases of the menstrual cycle, different and sometimes severe symptoms may arise, such as anxiety in women with PMDD. Yet, some women who have brain-related disorders, such as epilepsy, also experience a rise in symptoms at particular phases in the menstrual cycle. For example, women with epilepsy have reported an increase in seizures during the phase in which their estrogen levels increase and their progesterone levels decrease (Maguire, Stell, Rafizadeh, & Mody, 2005). Animal studies suggest a possible explanation for the fluctuation of neurological conditions throughout the menstrual cycle. Maguire et al. (2005) found that during phases when progesterone was high in mice, delta receptors in the brain were also high. The more delta receptors a nerve cell has, the less likely it
would fire when stimulated by electricity. However, when progesterone was low, delta receptors were also less prevalent, possibly causing heightened nerve cell activity, which may ultimately explain the increase of anxiety in women with PMDD and seizures in women with epilepsy.

Brain activity in the orbitofrontal cortex, an area of the brain associated with reward, decision-making, and emotional regulation, also changes throughout the menstrual cycle. One study found that during the follicular phase of the menstrual cycle, the orbitofrontal cortex showed higher activity when anticipating receiving a reward and when actually receiving it than during other phases of their cycle (Hooper, 2007). Another study found that the orbitofrontal cortex was also more active during the late-luteal/premenstrual phase than at the follicular phase when women read negative words (Brownlee, 2005). Thus, it appears that the activity of the orbitofrontal cortex responds to positive and negative experiences differently at different phases of the menstrual cycle.

Another function affected by the hormonal fluctuations of the menstrual cycle is the Auditory Brainstem Response (ABR). ABR is an electrical brain wave that is evoked from the brainstem in response to the presentation of a sound. It is thought to play an important role in relational experiences with partners. One study found that the increase in neural conduction time of the ABR coincides with a woman’s ovulation (Serra, Maiolino, Messina, Agnello, & Salvatore, 2003). Thus, ABR is another change in the brain that may be due to the rise or fall in hormones during the menstrual cycle.

Although there are some studies suggesting brain changes throughout the menstrual cycle, none of them directly demonstrate a change in cognitive performance. Yet, since neural activity has been demonstrated to change in several of the studies of the menstrual cycle, there may be a possibility that these changes could affect cognitive performance.
Phase Identification. Researchers interested in testing the effects of estrogen levels on sexually dimorphic task performance usually choose to compare either the preovulatory phase (late follicular) or the midluteal phase with the menstrual phase (menses). Both the preovulatory phase and the midluteal phase have high concentrations of estrogen, while the menstrual phase has the lowest amount of estrogen. Still, researchers differ in the way that they determine phases of the menstrual cycle. Some studies used a range of days to determine a woman’s phase. For example, researchers may determine that the “menstrual period” is 2 to 5 days after onset or that the “luteal/postovulatory” phase is between 24 to 28 days after onset of the cycle (Hampson, 1990\(^a\); Hampson, 1990\(^b\); Kimura, 2000; Mumenthaler, O’Hara, & Taylor, 2001; Phillips & Silverman, 1997). Other studies use the “counting forward method” or the “counting backward method” or a combination of the two, basically determining from the beginning of the menstrual cycle the approximate phase the woman is in based on the average number of days of her menstrual cycle (Vranic & Hromatko, 2008; Wharton, 2008). Basal Body Temperature methods have also been utilized to identify phases (Carr-Nangle et al., 1994). Yet, the most accurate way to determine actual menstrual phase is by hormone assays, which requires the collection of blood which is analyzed for hormone levels (Hausmann, Slabbekoorn, Van Goozen, Cohen-Kettenis, & Gunturkun, 2000; Kimura, 2000). A modern way for women to calculate the phase of their menstrual cycle is utilizing online sources which take into account the average length of the cycle, when the last menstrual cycle started, as well as current research on phase length (e.g., http://www.americanpregnancy.org/gettingpregnant/ovulationcalendar.html). A review of studies suggests that the most common method of determining menstrual phase in studies of cognitive performance is utilizing a general range of days that the phase usually occurs for most women.
Cognitive Ability and Sexual Dimorphism

Many of the more recent studies have taken into account the different sex hormones present in men and women when studying sexually dimorphic cognitive tasks. One such study by Phillips and Silverman (1997) noted that men typically outperform women on spatial tasks and hypothesized that this may be due to the lack of estrogen in men. Women have higher concentrations of estrogen than men, so these findings suggest that estrogen may impede performance on spatial tasks. Yet, Phillips and Silverman noted that concentrations of estrogen fluctuate throughout the menstrual cycle. Therefore, Phillips and Silverman decided to test women at their midluteal phase, when estrogen was high, and at their menstrual phase, when estrogen was low. Using the Vandenberg and Kuse Three Dimensional Rotations Test, it was found that women performed significantly better on the spatial tests during menses, when estrogen was lowest, than at the midluteal phase, when estrogen was high. Based on similar hypotheses, Mumenthaler et al. (2001) examined the influence of sex hormones on women’s spatial ability. Twenty-four female pilots were put through flight simulations during the menstrual and luteal phases of their cycle, but no significant difference in performance was found.

In 1990, Hampson studied women’s performance on sexually dimorphic tasks during the midluteal and the menstrual phases, specifically looking at spatial tasks on which men typically score higher and at tests of verbal fluency, fine manual skills, and perceptual speed, on which women typically score higher. Hampson found that women in their midluteal phase, when estrogen was high, performed better than women in their menstrual phase on tasks that women typically perform better on than men. Additionally, women in their menstrual phase performed better on spatial tasks than women in the midluteal phase. Hampson concluded that estrogen
levels may affect cognitive performance on sexually dimorphic tasks. Other studies have also supported that sexually dimorphic tests can be influenced by estrogen levels (Hampson & Kimura, 1988; Kimura, 1992).

**Hormonal Contraceptives**

Hormonal contraceptives not only change the hormone levels present in the phases of the menstrual cycle, but may help further pinpoint which hormones directly affect cognitive performance in women. Wharton et al. (2008) studied the effects of three types of oral, hormonal contraceptives and naturally-cycling hormones on a “Mental Rotation Task.” Unlike naturally-cycling women, those who use oral contraceptives do not experience a marked increase of estrogen. Also, oral contraceptive users typically have higher levels of progestin throughout their cycle. Therefore, Wharton et al. theorized that oral contraceptive users would perform better than naturally-cycling women on a sexually dimorphic task that tests visuospatial ability. Within the group of oral contraceptive users, Wharton et al. predicted that women taking second generation oral contraceptives would perform the best on visuospatial tasks, because this type of hormonal contraceptive has the same dose of progestin throughout the cycle, while third generation oral contraceptives fluctuate similarly to a woman’s natural cycle. Thus, it was hypothesized that third generation oral contraceptive users would perform most similarly to naturally-cycling women on the visuospatial tasks on which men typically perform better than women. The contraceptive, Yasmin (and Yaz), known as Ocella in generic form, actually has antiandrogenic properties, meaning that they have the least masculine properties, leading Wharton et al. to hypothesize that women using Yasmin would have the lowest performance compared to the other oral contraceptive users and the naturally-cycling women.
As predicted, Wharton et al. (2008) found no difference between naturally-cycling women and oral contraceptive users, when oral contraceptive users were grouped together. When looking more closely at each of the oral contraceptive groups, it was found that women using Yasmin performed worse than both naturally-cycling women and other oral contraceptive users on the Mental Rotation Task, supporting the researchers’ hypothesis. It was found that third generation users performed best on the Mental Rotation Task during the follicular and luteal phases when progestin was highest, suggesting that progestin may play a role in increased performance on tasks on which men typically perform better. These findings suggest that it is important not to group women who use hormonal contraceptives together, to prevent masking different effects.

Conclusion

In summary, starting in adolescence, females are affected by hormonal fluctuations that comprise phases of their menstrual cycle. These fluctuations have been found to affect women physically, emotionally, and behaviorally, especially in a negative way during the premenstrual phase of the cycle, when estrogen and progesterone are both high, and then drop drastically. However, research about the effects of these phases on a woman’s cognition has had inconsistent findings. Studies that have specifically looked at sexually dimorphic tasks, during times of high estrogen and low estrogen, have generally found that women may perform better on tasks that men typically perform well on during times of low estrogen (menses) and perform better on tasks that women typically perform better than men on during times of high estrogen. Nevertheless, studies claiming to have tested cognitive ability have used outdated tests, which are not widely used to make important decisions about a person’s ability. How different hormonal contraceptives affect a woman’s cognition has only recently been studied, also using an outdated
test. Therefore, further research into the effect of hormonal fluctuations and hormonal contraceptives on women’s performance on sexually dimorphic cognitive tasks taken from widely used, valid measures is necessary for generalization into fields that use this information to make important decisions about female’s cognitive ability.

This study sought to determine if hormonal changes during the menstrual cycle, specifically during the ovulation and menses phases, affect women’s cognitive ability on sexually dimorphic tasks. These tasks were taken from a widely used, valid measure based on the most widely accepted cognitive theories and current empirical evidence of cognitive ability assessment.
Chapter 3

Method

Participants

Participants were 36 college women from three colleges (one small, rural, private university; one small, rural, state university; and one large, suburban, state university). They attended screening sessions announced in their psychology courses. Potential participants were excluded if they self-reported: being outside the proposed age range (18-21 years); an abnormal menstrual cycle or no menstrual cycle; using hormonal contraceptives other than Yasmin/Ocella or Yaz; a diagnosis of Premenstrual Dysphoric Disorder (PMDD); and a diagnosed disability that would affect their cognition (e.g., learning disability, mental retardation). These exclusions were intended to reduce factors that may affect the outcomes of this study. Fifty-one women were originally recruited for the study, but five were later excluded from the study due to Yasmin/Ocella or Yaz no longer being considered for analysis based on new concerning information gained about antiandrogenic hormonal contraceptives. Another 10 women were excluded based on factors that cause their assessment to be considered inaccurate (e.g., use of hormonal contraceptives, incomplete evaluation, inaccurate prediction of phase, researcher error).

The final 36 participants had a mean age of 18.9 years (range 18-21 years) and a mean cycle length of 28.4 days (range 15-35 days, SD = 3.77). The group was made up of 61 percent Freshman, 25 percent Sophomores, 8 percent Juniors, and 2 percent Seniors. Seventy-five percent of women indicated their ethnicity as White, 6 percent Black, 8 percent Hispanic, 8 percent Asian, and 4 percent did not indicate an ethnicity. All 36 women indicated that they had never been married, one indicated previous pregnancy, and none indicated birthing a child. All
participants gave informed consent and the institutional review boards approved the study at their respective institutions.

**Procedure and Measures**

At each college, screening sessions were held, which potential participants from undergraduate psychology courses attended if they were interested in participating in the study. Extra credit was given to all participants who attended the screening session at each school. Extra credit was also given to students who continued to participate in the next two parts of the study.

Students who attended the screening sessions were given an introduction to the study (see Appendix A) and an informed consent form to read and sign. Once the informed consent form was returned to the researcher, participants were given a questionnaire (see Appendix B) that determined their fit for the study. This questionnaire was formed using a medical questionnaire as a guideline. The questionnaire also included random distracter questions (indicated by asterisks for purposes of reporting this study) in order to keep students from determining the studies specific purpose, since this could cause an expectation effect. Students who were outside the proposed age range, who had abnormal menstrual cycles or no menstrual cycle, were using a hormonal contraceptive, had a diagnosis of Premenstrual Dysphoric Disorder (PMDD), or who were diagnosed with a disability were excluded from this study to reduce factors that may affect the outcomes. With the information from the questionnaire that the participants completed, the dates of each participant’s ovulation and menstrual phase were determined by using the Ovulation Calculator (www.americanpregnancy.org). Whichever phase was approaching first (ovulation or menstrual) for the participant was the phase in which the researcher set up their
first meeting date and time. Participants were then contacted with their first participation date and were required to participate within 48 hours of that date.

The selected female college students then met with the researcher and were given an introduction. The specific purpose of the study was not disclosed; however, it was explained to the participants that they were going to be given a series of aptitude tests, which would be scheduled on two very specific days including the current meeting day (see Appendix C). The participant was then given the Meeting Questionnaire that included medical information (including information about her menstrual cycle and hormonal contraceptives), general demographic information, and some random distracters (see Appendix D).

Next, during this meeting, the researcher administered subtests of the Woodcock-Johnson Test of Cognitive Abilities III (WJ III COG) based on the following sexually dimorphic Cattell-Horn-Carroll Factors (Woodcock, McGrew, & Mather, 2001): Processing Speed (Subtest 6: Visual Matching, Subtest 16: Decision Speed), in which women typically perform better than men; Comprehension Knowledge (Subtest 1: Verbal Comprehension, Subtest 11: General Information), in which men typically perform better than women (Camarata & Woodcock, 2006). Also, the factor of Visual-Spatial Thinking (Subtest 3: Spatial Ability, Subtest 13: Picture Recognition) has often been assumed to be sexually dimorphic in favor of males in previous studies and was looked at in this study, although there is no research to suggest that this CHC factor is sexually dimorphic for the WJ III COG. As previously mentioned, the WJ III COG is a measure based on the CHC Theory. The WJ III COG holds high validity due to the generalizability of broad tests that address the CHC Theory. Based on alphas for all age groups between two and 90 on which the WJ III COG was normed, the WJ III COG has reliability that
ranges from .74 to .97 (McGrew & Woodcock, 2001). Figure 3 describes the tests that were used in this study and addresses if they have been found to be sexually dimorphic.

For purposes of this study, the WJ III COG was split into two forms (called Form 1 and Form 2). Each subtest was split as equally as possible (excluding those that could not be split: Visual Matching and Decision Speed) to include approximately the same number of points and the same level of difficulty, by alternating items for each form. Item sets and possible points for each form are presented in Figure 4. These were split in order to make direct comparisons of a woman’s cognitive ability between phases. Subtests that could not be split (e.g., timed tasks) were repeated in the second session.

During the first meeting, Form 1 of each subtest was given to the participants, regardless of the phase of their menstrual cycle. Form 2 of each subtest was given to the participants during their second meeting, regardless of their phase. The date of the second meeting was based upon information from the Meeting Questionnaire and the Ovulation Calculator. Participants were informed of the date of the second meeting after the first meeting questionnaire was reviewed.

Researchers calculated the raw score for each subtest on both Form 1 and Form 2. This data was used to complete the analyses.

At the end of the study, the researcher gave each individual who participated in the study a debriefing form that explained what the study has truly been measuring and who to contact if further questions may arise.

**Variable Definitions**

**Predictor Variable:** Phase of Menstrual Cycle.
THE EFFECT OF HORMONAL FLUCTUATIONS

- **Menstrual Phase**: The phase of a woman’s menstrual cycle in which conception has not occurred and the lining of the uterus breaks down, flowing out of the vagina. Estrogen and progesterone are at the lowest levels (approximately days 1 to 7).

- **Ovulation Phase (Late Follicular Phase)**: The phase of a woman’s menstrual cycle in which an egg is released from the ovary, due to the luteinizing hormone (LH), when estrogen levels are at their peak (approximately days 12 to 16).

**Outcome Variable: WJ III COG Subtests**

The following subtests were used to assess women’s cognitive ability on sexually dimorphic CHC factors. To assess the CHC factor, Processing Speed, on which women typically perform better than men, Subtest 6: Visual Matching and Subtest 16: Decision Speed were used. To assess the CHC factor Comprehension Knowledge, on which men typically perform better than women, Subtest 1: Verbal Comprehension and Subtest 11: General Information were used. Last, to assess the CHC factor, Visual-Spatial Thinking, which was not found to be sexually dimorphic on the WJ III COG, but has often been considered sexually dimorphic on other cognitive measures (favoring males), Subtest 3: Spatial Ability and Subtest 13: Picture Recognition) were used. For further information, see Figure 3.
Chapter 4

Results

This chapter reviews the results of the statistical analyses completed to identify potential differences in participants’ cognitive functioning between the phases of their menstrual cycle. The results for Crystallized Intelligence/Comprehension Knowledge (Gc), which includes subtests of Verbal Comprehension and General Information, are presented first. These are followed by the results for Processing Speed (Gs), which includes subtests of Visual Matching and Decision Speed. Finally, the results for Visual Processing/Visual-Spatial Thinking (Gv), which includes subtests of Spatial Relations and Picture Recognition, are presented. The repeated measures ANOVAs, which describe the differences between performance on each subtest of the WJ III COG that make up the sexually dimorphic cognitive abilities, are presented in Table 1.

CHC Factor: Crystallized Intelligence/Comprehension Knowledge

This cognitive ability had previously been identified as demonstrating sexually dimorphic traits favoring males on the WJ III COG.

Verbal Comprehension (Subtest 1). The results of analyses of variance for raw scores indicated no significant difference between phases of the menstrual cycle for Verbal Comprehension, \(F(1, 35) = 1.337, p = .26\). The means were 22.92 for the menstrual phase and 22.96 for the ovulation phase. Observed power was reported as .203 (partial eta\(^2\) value of .037). Observed power determines if an experiment was powerful enough to have detected an effect and >.80 is typically accepted as powerful.

General Information (Subtest 2). The results of analyses of variance for raw scores indicated no significant difference between phases of menstrual cycle for General Information,
The effect of hormonal fluctuations

\[ F(1, 35) = .670, p = .42. \] The means were 16.22 for the menstrual phase and 16.53 for the ovulation phase. Observed power was reported as .125 (partial \( \eta^2 \) value of .019).

**CHC Factor: Processing Speed**

This cognitive ability had previously been identified as demonstrating sexually dimorphic traits favoring females on the WJ III COG. Both subtests were given in their entirety during both phases due to these being based on rate.

**Visual Matching (Subtest 6)**. The results of analyses of variance for rates indicated no significant difference between phases of the menstrual cycle for Visual Matching, \[ F(1, 35) = .029, p = .87. \] The means were 17.97 for the menstrual phase and 18.03 for the ovulation phase. Observed power was reported as .053 (partial \( \eta^2 \) value of .001).

**Decision Speed (Subtest 16)**. The results of analyses of variance for raw scores/rates indicated no significant difference between phases of menstrual cycle for Decision Speed, \[ F(1, 35) = .085, p = .77. \] The means were 14.97 for the menstrual phase and 14.83 for the ovulation phase. Observed power was reported as .059 (partial \( \eta^2 \) value of .002).

The subtests Visual Matching and Decision Speed, which are timed tasks, were not able to be split in order to create two forms. Thus, a possible practice effect may have potentially occurred, because the participants were taking the same form during both trials of the study. To determine if a practice effect occurred, a paired samples \( t \)-test was used to analyze the subtests Visual Matching and Decision Speed. A paired samples \( t \)-test for the Visual Matching subtest revealed a statistically significant difference between the mean rate on the first trial (\( M = 17.58 \)) and second trial (\( M = 18.42 \)), \( t(35) = -2.808, p = .008 \). Likewise, a paired samples \( t \)-test for the Decision Speed subtest revealed a statistically significant difference between the mean rate on
the first trial ($M = 14.22$) and second trial ($M = 15.58$), $t(35) = -3.255$, $p = .003$. Means and standard deviations are reported in Table 2.

Therefore, this practice effect could mask a significant difference in performance on the trials in regard to phase of the menstrual cycle. In order to determine if such a masking effect occurred, an independent samples t-test was used to analyze these subtests. To control for the potential masking effect, participants’ scores were grouped by trial and phase (see Table 3 for results). The results of the t-test for these rates indicated no significant difference in performance between phase of the menstrual cycle for Decision Speed, $F(1, 35) = 1.34$, $p = .25$. The mean differences between first and second trials were -1.40 for the participants who were in their menstrual cycle during their first trial and -1.43 for the participants who were in their ovulation phase during their first trial. Further, the results of the t-test for the rates indicated no significant difference phase of the menstrual cycle for Visual Matching, $F(1, 35) = 1.40$, $p = .25$. The mean differences between first and second trials were -1.07 for the participants who were in their menstrual cycle during their first trial and -0.67 for the participants who were in their ovulation phase during their first trial. Consequently, when controlling for a potential practice effect, results indicate that performance on Processing Speed did not significantly differ between phases of menstrual cycle.

**CHC Factor: Visual Processing/Visual-Spatial Thinking**

This cognitive ability had previously been identified as demonstrating sexually dimorphic traits favoring males on other cognitive assessments, but not specifically for the WJ III COG.

**Spatial Relations (Subtest 3).** The results of analyses of variance for raw scores indicated no significant difference between phases of the menstrual cycle for Spatial Relations,
$F(1, 35) = .980, p = .33$. The means were 36.96 for the menstrual phase and 35.81 for the ovulation phase. Observed power was reported as .161 (partial eta$^2$ value of .027).

**Picture Recognition (Subtest 5).** The results of analyses of variance for raw scores indicated no significant difference between phases of menstrual cycle for Picture Recognition, $F(1, 35) = .186, p = .67$. The means were 26.19 for the menstrual phase and 26.39 for the ovulation phase. Observed power was reported as .070 (partial eta$^2$ value of .005).

The lack of main effect for phase is an important result as the highly similar means for suggest that cognitive abilities between phases were not different in this sample. This was the case for each cognitive task.
Chapter 5
Discussion

The current study examined the potential effect of hormonal fluctuations on cognitive ability at two points during female college students’ menstrual cycle. Previous studies have suggested hormone levels as the primary reason some cognitive abilities are considered sexually dimorphic (men or women tend to perform better than the opposite gender) (Hampson, 1990a; Hampson, 1990b; Hampson & Kimura, 1988; Kimura, 1992; Mumenthaler et al., 2001; Phillips & Silverman, 1997; Wharton et al., 2008). To determine if these findings could be repeated, this study sought to use improved study design by: limiting participant expectancy (i.e., not telling participants purpose of study prior to participating); including only participants who are naturally menstruating; concentrating on phases of the menstrual cycle in which estrogen and progesterone are at their highest and lowest points; using ovulation and menses prediction techniques that are used by the American Pregnancy Organization; and using commonly used, widely-accepted, updated cognitive measures, with high reliability and validity, focusing on cognitive tasks that have shown evidence of sexual dimorphism.

Overall, performance on cognitive tasks did not replicate most prior results, which found significant differences in cognitive performance on sexually dimorphic tasks between phases of the menstrual cycle (Hampson, 1990a; Hampson, 1990b; Hampson & Kimura, 1988; Kimura, 1992; Phillips & Silverman, 1997; Wharton et al., 2008). In contrast, these results were similar to studies by Mumenthaler et al. (2001), Sommer (1972), and Lough (1937) in which women demonstrated no significant difference between phases of their menstrual cycle on “cognitive” tasks. These overall findings suggest that women’s cognitive ability is not directly affected by hormonal levels present in her body. It should be noted that these results should be interpreted
with caution, because the sample size in this study did not produce the expected effect size that had been predicted a priori.

These results also suggest that prior research regarding women’s performance on sexually dimorphic cognitive tasks during their menstrual cycle may have been influenced by several different factors that were controlled for in this study.

First, expectancy was controlled for, in that participants were not told specifics about what the study was examining until after the assessments were administered. Participants were only given minimal, general information about what the study was looking for. Moreover, questionnaires included distracter questions to ensure that participants were not able to specifically determine which questions were directly related to the study. Thus, expectancy may have influenced women’s performance in prior studies.

Second, hormonal contraceptives were also controlled for, as women who reported they were not taking hormonal contraceptives were included in the study and those who were taking hormonal contraceptives were excluded. Previous studies commonly grouped participants who were naturally cycling and taking hormonal contraceptives together and results may have been skewed due to the influences of synthetic hormones.

Finally, the factor that almost none of the previous studies incorporate was utilizing commonly used, widely accepted cognitive measures based on the latest empirical research about cognition. The WJ III COG has high validity and reliability, in contrast to many measures used in prior studies. This factor may have played a role in results from prior studies.

**Limitations**

The present study presented several limitations, which should be considered when interpreting its results. First, this study used a relatively small sample of participants (n = 36).
Due to this small sample size, caution is recommended regarding the generalization of these results. The finding that the differences in means between the phases were negligible suggests that a larger sample size may reveal similar findings; however, it is possible that this sample was not representative. It is recommended that this study be continued to evaluate a larger sample of women.

Second, this study only evaluated women with a natural menstrual cycle. Therefore, including women who take hormonal contraceptives in future research regarding cognitive ability would increase the representativeness of the study for typical women in this age-range. If these women were included, but their data were analyzed separately, it would further determine if synthetic hormones actually play a role in cognitive ability on sexually dimorphic tasks.

Third, this study utilized an online ovulation calculator provided by the American Pregnancy Organization. Although this is a common way for women to predict their ovulation and their menses, this method does not determine specific hormone levels, which may affect accuracy of results on sexually dimorphic cognitive tasks. Hormonal assays, using blood or urine samples, would be the most accurate way to determine hormone levels during cognitive testing and would be recommended for future research.

A second limitation to consider with the split-half form of the cognitive assessment is the range of points that the participants could gain. For example, the maximum number of points that a woman could earn on the Picture Recognition split-half subtest was 29 or 30 depending on the form. With the average woman scoring 26.19 points during the menstrual phase and 26.39 points during the ovulation phase, most women did not reach a ceiling (a series of incorrect items in a row, suggesting the participant has demonstrated maximum ability level) on the subtest. Thus, it is difficult to determine if women’s abilities truly fluctuated without enough items to
assess their maximum ability level. Use of another commonly used, widely-accepted cognitive assessment based on CHC factors created specifically to make important decisions about adults’ cognitive ability would be recommended in order to further assess the participants’ maximum ability level. However, such a cognitive assessment may not be available at this time.

Implications

Despite the limitations of this study, its findings should be considered plausible for several reasons. One such reason is that this study used a reliable and valid cognitive measure, which is commonly used and widely-accepted. The WJ III COG is based on the latest empirical research regarding cognitive ability (i.e., CHC Theory). One may theorize that this study did not produce similar results to previous studies, because this was the only study that actually measured cognitive ability. Along with this theory, cognitive ability is considered a constant, which should not change over time. Thus, this study supported this theory of cognition. It is possible that previous studies may have actually been using assessments that measured something more closely related to achievement level or academic skills, which are more likely to fluctuate.

Additionally, it is suggested that future research consider replicating this study with achievement testing to determine if hormonal fluctuations actually affect academic skills, since these are fluid and may be more likely to be directly affected by slight changes in brain chemistry. Related, it is also plausible that despite monthly hormonal fluctuations, a majority of female brain development has occurred by college age. Thus, cognitive ability should already be a constant.

In conclusion, results of this study suggest performance on sexually dimorphic cognitive tasks during different phases of a woman’s menstrual cycle do not differ significantly.
Therefore, this research adds confidence that hormone levels do not need to be accounted for during cognitive assessment, which is vital information for fields which use cognitive information to make important decisions in the lives of women.

Summary

This study sought to investigate the effect of hormonal fluctuations on sexually dimorphic cognitive tasks throughout the menstrual cycle using improved study design. More specifically, this study compared performance on cognitive tasks deemed sexually dimorphic, during the menstrual phase and the ovulation phase, using a commonly used, widely-accepted, empirically-supported cognitive assessment measure (WJ III COG).

Overall, the data from this study did not verify the hypotheses that hormonal fluctuations caused by a woman’s menstrual cycle have a direct effect on a woman’s performance on sexually dimorphic cognitive tasks. Thus, women did not perform better on tasks that men typically perform better on during their menstrual phase, when progesterone and estrogen were lowest, nor did women perform better on tasks that women typically perform better on during their ovulation phase, when estrogen is highest.

Although this study faced several limitations, such as sample size, it is suggested that these findings may be plausible given the research design, especially in regard to the cognitive evaluation used.

In sum, the findings of this study provides some assurance to cognitive evaluators that hormone levels may not need to be accounted for during cognitive assessments. This may also provide assurance to those who use cognitive assessment information to make important decisions about women’s lives based on this information.
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*Headache*, p. 1181-1189.


doi:10.1111/1467-8721.ep10769964


Figure 1. CHC Theory

Source: Flanagan & Harrison, 2005, p.69
**Figure 2.** Descriptions of CHC Theory Broad Abilities (Stratum II)

<table>
<thead>
<tr>
<th>Broad Abilities</th>
<th>Descriptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid intelligence (Gf)</td>
<td>The use of mental operations, inductive reasoning, and deductive reasoning to solve problems.</td>
</tr>
<tr>
<td>Quantitative Knowledge (Gq)</td>
<td>The breadth of acquired declarative and procedural quantitative knowledge.</td>
</tr>
<tr>
<td>Crystallized Intelligence/Comprehension Knowledge (Gc)</td>
<td>The breadth of acquired knowledge of language, information and concepts.</td>
</tr>
<tr>
<td>Reading/Writing (Grw)</td>
<td>The wealth of acquired store of declarative and procedural skills for reading and writing.</td>
</tr>
<tr>
<td>Short Term Memory (Gsm)</td>
<td>The ability to maintain awareness of information in the immediate situation.</td>
</tr>
<tr>
<td>Visual Processing/Visual-Spatial Thinking (Gv)</td>
<td>The ability to store, retrieve, and transform visual images.</td>
</tr>
<tr>
<td>Auditory Processing (Ga)</td>
<td>The ability to cognitively control awareness and comprehension of auditory information.</td>
</tr>
<tr>
<td>Long-term Storage and Retrieval (Glr)</td>
<td>The ability to store and retrieve information in long-term memory fluently.</td>
</tr>
<tr>
<td>Processing Speed (Gs)</td>
<td>The ability to perform easy tasks automatically and fluently.</td>
</tr>
<tr>
<td>Decision Speed/Reaction Time (Gt)</td>
<td>The ability to make decisions about or react quickly to a simple stimulus.</td>
</tr>
</tbody>
</table>

*Source: Mather & Jaffe, 2002*
Figure 3. Tests from the WJ III COG administered to participants

<table>
<thead>
<tr>
<th>CHC Factor</th>
<th>Test</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystallized Intelligence/Comprehension Knowledge (Gc)</td>
<td>Test 1: Verbal Comprehension*</td>
<td>Measures lexical knowledge and language development through naming objects, naming antonyms and synonyms and completing verbal analogies</td>
</tr>
<tr>
<td></td>
<td>Test 11: General Information*</td>
<td>Measures general verbal information through identification of where objects can be found and what people can do with the objects</td>
</tr>
<tr>
<td>Visual Processing/Visual-Spatial Thinking (Gv)</td>
<td>Test 3: Spatial Relations</td>
<td>Measures visualizations and perceptual speed through identifying the subset of pieces needed to complete a shape</td>
</tr>
<tr>
<td></td>
<td>Test 13: Picture Recognition</td>
<td>Measures visual memory through identification of previously presented pictures from a field of pictures including distracting pictures</td>
</tr>
<tr>
<td>Processing Speed (Gs)</td>
<td>Test 6: Visual Matching**</td>
<td>Measures perceptual speed and scanning through rapidly locating and circling identical numbers from a defined set of numbers</td>
</tr>
<tr>
<td></td>
<td>Test 16: Decision Speed**</td>
<td>Measures semantic processing speed through identification and circling two most conceptually similar pictures in a row</td>
</tr>
</tbody>
</table>

* Favors males
** Favors females

Note: Tests 3 and 13 have not been found to be sexually dimorphic on the WJ III COG, yet this CHC factor has been found to favor males on other cognitive tests.
**Figure 4.** WJ III COG: Split-half subtests, form 1 and form 2

<table>
<thead>
<tr>
<th>Subtest</th>
<th>Form 1 Items</th>
<th>Form 2 Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A - Picture Vocabulary</td>
<td>6, 8, 10, 12, 14, 16, 18, 20, 22</td>
<td>7, 9, 11, 13, 15, 17, 19, 21, 23</td>
</tr>
<tr>
<td><strong>Verbal Comprehension</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1B - Synonyms</td>
<td>1, 3, 5, 6, 9, 11, 13, 15</td>
<td>2, 4, 6, 8, 10, 12, 16</td>
</tr>
<tr>
<td>1C - Antonyms</td>
<td>5, 7, 8, 10, 13, 15, 17</td>
<td>4, 6, 8, 10, 12, 14, 16, 18</td>
</tr>
<tr>
<td>1D - Verbal Analogies</td>
<td>1, 3, 5, 6, 9, 11, 13, 15</td>
<td>2, 4, 6, 8, 10, 12, 14</td>
</tr>
<tr>
<td><strong>Possible Points</strong></td>
<td>32</td>
<td>31</td>
</tr>
<tr>
<td><strong>Possible Points</strong></td>
<td>40</td>
<td>41</td>
</tr>
<tr>
<td>Visual Matching</td>
<td>1-60</td>
<td>1-60</td>
</tr>
<tr>
<td>Time recorded</td>
<td>180 seconds (max)</td>
<td>180 seconds (max)</td>
</tr>
<tr>
<td><strong>Possible points</strong></td>
<td>Rate = # of correct items/time</td>
<td>Rate = # of correct items/time</td>
</tr>
<tr>
<td></td>
<td>recorded (seconds) x 60</td>
<td>recorded (seconds) x 60</td>
</tr>
<tr>
<td>General Information</td>
<td>2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26</td>
<td>1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25</td>
</tr>
<tr>
<td>11A - Where</td>
<td>1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21</td>
<td>2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22</td>
</tr>
<tr>
<td><strong>Possible Points</strong></td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td><strong>Possible Points</strong></td>
<td>29</td>
<td>30</td>
</tr>
<tr>
<td>Decision Speed</td>
<td>1-40</td>
<td>1-40</td>
</tr>
<tr>
<td>Time recorded</td>
<td>180 seconds (max)</td>
<td>180 seconds (max)</td>
</tr>
<tr>
<td><strong>Possible points</strong></td>
<td>Rate = # of correct items/time</td>
<td>Rate = # of correct items/time</td>
</tr>
<tr>
<td></td>
<td>recorded (seconds) x 60</td>
<td>recorded (seconds) x 60</td>
</tr>
<tr>
<td><strong>Total Possible Points</strong></td>
<td>125 + rates</td>
<td>126 + rates</td>
</tr>
</tbody>
</table>
Table 1

*Menstrual-ovulation phase raw score/rate for cognitive tasks*

<table>
<thead>
<tr>
<th>Broad CHC Abilities</th>
<th></th>
<th>Menstrual Phase</th>
<th>Ovulation Phase</th>
<th>M-O</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crystallized Intelligence/ Comprehension Knowledge (Gc)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal Comprehension</td>
<td>$M$: 22.92</td>
<td>$M$: 22.96</td>
<td>-0.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD: 3.018</td>
<td>SD: 3.673</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Information</td>
<td>$M$: 16.22</td>
<td>$M$: 16.53</td>
<td>-0.31</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD: 2.948</td>
<td>SD: 3.112</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Processing Speed (Gs)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Matching</td>
<td>$M$: 17.97</td>
<td>$M$: 18.03</td>
<td>-0.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD: 1.424</td>
<td>SD: 2.077</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision Speed</td>
<td>$M$: 14.97</td>
<td>$M$: 14.83</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD: 2.580</td>
<td>SD: 2.118</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Visual Processing/Visual-Spatial Thinking (Gv)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial Relations</td>
<td>$M$: 36.36</td>
<td>$M$: 35.81</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD: 2.929</td>
<td>SD: 3.640</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picture Recognition</td>
<td>$M$: 26.19</td>
<td>$M$: 26.39</td>
<td>-0.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD: 1.770</td>
<td>SD: 2.406</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n = 36

Note. M-O: menstrual phase minus ovulation phase score.
Table 2

*Processing Speed: First trial scores vs. Second trial scores*

<table>
<thead>
<tr>
<th>Subtests</th>
<th>First Trial</th>
<th>Second Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Matching</td>
<td>$M$: 17.58</td>
<td>$M$: 18.42</td>
</tr>
<tr>
<td></td>
<td>SD: 1.44</td>
<td>SD: 1.98</td>
</tr>
<tr>
<td>Decision Speed</td>
<td>$M$: 14.22</td>
<td>$M$: 15.58</td>
</tr>
<tr>
<td></td>
<td>SD: 2.23</td>
<td>SD: 2.29</td>
</tr>
</tbody>
</table>

$n = 36$
Table 3

*Processing Speed: First trial menstrual phase scores vs. First trial ovulation phase scores*

<table>
<thead>
<tr>
<th>Subtests</th>
<th>First Trial Menstrual Phase</th>
<th>First Trial Ovulation Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Matching</td>
<td>( M: -1.07 )</td>
<td>( M: -0.67 )</td>
</tr>
<tr>
<td></td>
<td>SD: 2.28</td>
<td>SD: 1.35</td>
</tr>
<tr>
<td>Decision Speed</td>
<td>( M: -1.40 )</td>
<td>( M: -1.43 )</td>
</tr>
<tr>
<td></td>
<td>SD: 3.00</td>
<td>SD: 2.38</td>
</tr>
</tbody>
</table>

\( n = 36 \)

Note. \( M \) equals mean change score (first trial minus second trial).
Appendix A

**Researcher’s Oral Directions for Questionnaire**

You have chosen to complete a three page questionnaire. You may be selected to participate in a study based on the information you provide. Please answer all questions fully and honestly. When you complete your questionnaire, please provide the researcher with your name. Do not write your name on the questionnaire. The ID number provided on the questionnaire will allow the researcher to identify who the questionnaire belongs to.

If the information provided in your questionnaire matches the criteria of the study, you will be contacted in order to set up a meeting date and time. Meeting dates and times will be important for you to commit to due to the nature of the study. You should plan to meet with the researcher for approximately one hour. After the first meeting, the researcher will contact you to set up a second meeting date and time. Once again, this meeting will last approximately one hour. Once all participants have completed the study, the researcher will meet with the group one more time to explain the nature of the study and answer any questions.

If the information provided in your questionnaire does not match the criteria of the study, you will be contacted in order to be informed that you will not be able to be involved in this study.

The researcher you work with, as well as myself, will only be able to provide limited information about the nature of the study. A letter explaining the nature of the study will be sent to you by mail once the data has been collected.

Do you have any questions about the information I just explained? Do you have any questions about the questionnaire?
When you are finished with your questionnaire, please return it directly to me and tell me your name. Thank you for your participation.
Appendix B

Research Questionnaire
(Note: Items marked with an * served as distracter items)

ID #_________________________________    DOB:________________________
Age: _______________    Year in College (i.e., Freshman)________________________
Height: _______________   Weight: _______________   Ethnicity:______________________

Are you diagnosed with a disability (Yes or No)? If yes, what is the name of the disability?
________________________________________________________________________________

Current Information:

*Do you exercise (Yes or No)? If yes, how many hours have you exercised in the past week?  
____

*Past Medical History

Illnesses:                                      Date Discovered

Yes_____ No_____ High blood pressure           _____________________________
Yes_____ No_____ Diabetes                     _____________________________
Yes_____ No_____ Heart Problems               _____________________________
Yes_____ No_____ Cancer                       _____________________________
Yes_____ No_____ Stroke                       _____________________________
Yes_____ No_____ Blood clots                  _____________________________

Current Information:

*Did you eat breakfast today (Yes or No)?

Current Medications:

<table>
<thead>
<tr>
<th>Name</th>
<th>Frequency Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Current Information:

*Do you have a pet (Yes or No)?  *If yes, list type of pet(s)

______________________________________________________________________________

*Allergies:

<table>
<thead>
<tr>
<th>Medication/Substance</th>
<th>Reaction/Symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Current Information:

*Do you watch TV (Yes or No)?

*If yes, how many hours have you watched in the past week?__

OB-GYN History:

Age at first menstrual period? ____________
How many pregnancies have you had? ____________
How many children have you given birth to? ____________
Your age at first delivery? ____________
Start date of last menstrual period? ____________
Do you take an oral contraceptive? (Yes or No) ____________

(List Type)

Do you use another form of hormonal contraception? (Yes or No) ____________

(List Type)

Average number of days between periods? ____________
(first day of one period to first day of the next period)

Have you ever been diagnosed with PMDD (Premenstrual Dysphoric Disorder)? (Yes or No)

Current Information:

*Do you use a social internet network (facebook, myspace, eharmony, etc.) (Yes or No)?

*If yes, how many hours have you used the social network in the past week?__
*Social History*

Marital Status  ____ Never married  ____ Married  ____ Divorced  ____ Widowed

Do you currently smoke cigarettes?  ____ Yes  ____ No

Have you smoked cigarettes in the past?  ____ Yes  ____ No

Do you drink alcohol?  ____ Yes  ____ No

Current Information:

*Do you talk on the phone (Yes or No)?*

If yes, how many hours have you talked on the phone in the past week?  ____

*Opinion-Based Questions: (Circle the answer that best matches your opinion)*

Where would you rather live?  Miami, Florida  or  Minneapolis, Minnesota

Who would you rather meet?  Oprah Winfrey  or  David Letterman

Which scent do you prefer?  Gasoline  or  Asphalt

*I feel… (check all that apply at this moment in time)*

____ Anxious  ____ Relaxed  ____ Energetic  ____ Content/Happy

____ Irritated  ____ Goofy  ____ Comfortable  ____ Tired

____ Lucky  ____ Sad  ____ Pretty  ____ Sick

____ Out-of-it  ____ Stressed  ____ Generous  ____ Lovable

____ Fat  ____ Hopeful  ____ Smart  ____ Angry

____ Calm  ____ Creepy  ____ Ugly  ____ Humorous

Thank you! 😊
Appendix C

Researcher’s Directions Individual Meeting

“My name is _______________________. I am the researcher who contacted you to set up this meeting. I will be explaining some information to you about today’s meeting.

First, I would like to say thank you for participating. You have been selected to take part in a study based on the information you provided on the questionnaire. You will be meeting with me at least two times, for approximately 1 hour each time. Your next meeting will take place in approximately two weeks. The information you provide will be kept confidential; only the researchers involved in this study will have access to it. You have been given an ID number that will be used throughout the study for record purposes. I may not be able to answer all of your questions at this point in this study. If I cannot answer your question, I will let you know that I am unable to do so.

Before we begin the study, I will read you the following directions. I will be giving you another questionnaire to fill out with the same ID number on it as the first questionnaire you completed. This questionnaire will be very similar to the first questionnaire you completed. Please fill out the entire questionnaire. It is especially important to know of any changes that have occurred since the first questionnaire was completed.

Once you have finished filling out the questionnaire, please return it to me directly. We will move on to the next part of the study after your questionnaire is complete. Do you have any questions?

Before you begin, please state your name so that I may ensure you are receiving the questionnaire corresponding to your ID number.”
Allow participant to state their name. Double check that the ID number on the questionnaire corresponds with the appropriate name. Once the participant receives the correct questionnaire, say:

“You may begin”.

Collect the questionnaire directly from the participant once it is complete. File the questionnaire safely in your questionnaire accordion file, without looking at the answers. Check off that the questionnaire has been completed.

“Next, you will be given a series of tasks to complete. Each task will have directions that I will read to you. Please try your best. Are you ready?”

Read the opening for the Woodcock-Johnson Test of Cognitive Abilities III test and follow the directions for the subtests you will be completing.
Appendix D

Meeting Questionnaire
(Note: Items marked with an * served as distracter items)

ID #: _______________ Date: _______________

Updated Medical Information:

Are you taking any new medications (Yes or No)? If yes, please list below:

Type of Medication _____________________________, Frequency Taken ______________
Type of Medication _____________________________, Frequency Taken ______________

*Do you have any new allergies (Yes or No)? If yes, please list below:

Medication/substance ____________________________, Type of Reaction ________________
Medication/substance ____________________________, Type of Reaction ________________

Are you taking any new oral/hormonal contraceptives (Yes or No)? If yes, please list below:

Oral/Hormonal Contraceptive: _________________________, Frequency Taken __________

Did you stop taking any oral/hormonal contraceptive since the previous questionnaire? (Yes or No)

Are you currently pregnant (Yes or No)?

Date of last period: ________________________________

*Updated Social History:

Marital status _____ Never Married _____ Married _____ Divorced _____ Widowed
Do you currently smoke cigarettes (Yes or No)?
Do you drink alcohol (Yes or No)?
*Current Information:*

Do you exercise (Yes or No)?
   *If yes, how many hours have you exercised in the past week? ______

Did you eat breakfast today (Yes or No)

Do you talk on the phone (Yes or No)?
   *If yes, how many hours have you talked on the phone in the past week? ______

Do you use a social internet network (facebook, myspace, charmony, etc.) (Yes or No)?
   *If yes, how many hours have you used the social network in the past week? ______

Do you watch TV (Yes or No)?
   *If yes, how many hours have you watched in the past week? ______

*I feel… (check all that apply at this moment in time)*

_____ Anxious   _____ Relaxed   _____ Energetic   _____ Content/Happy

_____ Irritated   _____ Goofy   _____ Comfortable   _____ Tired

_____ Lucky   _____ Sad   _____ Pretty   _____ Sick

_____ Out-of-it   _____ Stressed   _____ Generous   _____ Lovable

_____ Fat   _____ Hopeful   _____ Smart   _____ Angry

_____ Calm   _____ Creepy   _____ Ugly   _____ Humorous

Thank you! 😊
THE EFFECT OF HORMONAL FLUCTUATIONS

Lanora J. Duell

EDUCATION

Alfred University, Alfred, NY
Doctor of Psychology in School Psychology
APA Accredited Program, NASP Approved
Certificate of Advanced Study in School Psychology
Master of Arts in School Psychology
Keuka College, Keuka Park, NY
Bachelor of Science in Unified Childhood/Special Education
Emphasis: American Sign Language Minor: Psychology

CERTIFICATIONS

Students with Disabilities (Grades 1-6), Initial Certificate
Childhood Education (Grades 1-6), Initial Certificate
School Psychologist, Internship Certificate
School Psychologist, Provisional Certificate

EXPERIENCE

September 2011-Present
Binghamton City School District, School Psychologist / CSE Chair

September 2010-August 2011
Cortland Junior High School, School Psychologist / CSE Chair
Cortland, NY

July 2009-June 2010
Handicapped Children’s Association, Doctoral School Psychology Intern
Johnson City, NY

CONFERENCE PRESENTATIONS


PUBLICATIONS


HONORS AND AWARDS

Alfred University: Lea R. Powell Fellowship Award (2008)
Keuka College: Outstanding Student Teacher of the Year (2006), Mentor of the Year (2006), Dean’s List, National Dean’s List, Chi Beta Phi Scientific Honor Society (Treasurer), Cross Country Heart Award (2003), Record Time Women’s Cross Country (2003), Frances H. Smith Honor Society (Treasurer), New York State Teacher’s Scholarship, “Pay it Forward” Scholarship, Leadership Scholarship, Phillip E. Totsi Scholarship, George R. Merrick Scholarship