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Cognitive performance of pregnant and postpartum women with and without major depression

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Cognitive Performance of Pregnant and Postpartum Women With and Without Major Depression

A dissertation submitted in partial satisfaction of the requirements of the degree Doctor of Philosophy

in

Clinical Psychology

by

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2010
The Dissertation of Sara Nowakowski is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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Chair

University of California, San Diego

San Diego State University

2010
DEDICATION

I would like to dedicate this manuscript to my husband, John. Without your love and support I would have never made it through the past five years of graduate school. From moving cross country with me several times, attending boring professional functions, to proofing so many of my papers and manuscripts (including this one), you truly deserve an honorary degree! Thank you for everything. You mean more to me than words can express.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature Page</td>
<td>iii</td>
</tr>
<tr>
<td>Dedication</td>
<td>iv</td>
</tr>
<tr>
<td>Table of Contents</td>
<td>v</td>
</tr>
<tr>
<td>List of Tables</td>
<td>vii</td>
</tr>
<tr>
<td>List of Figures</td>
<td>viii</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>ix</td>
</tr>
<tr>
<td>Curriculum Vitae</td>
<td>x</td>
</tr>
<tr>
<td>Abstract</td>
<td>xx</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Perinatal Depression</td>
<td>1</td>
</tr>
<tr>
<td>Postpartum Depression</td>
<td>2</td>
</tr>
<tr>
<td>Neurocognitive Functioning in Major Depression</td>
<td>4</td>
</tr>
<tr>
<td>Neurocognitive Functioning in Pregnancy</td>
<td>5</td>
</tr>
<tr>
<td>Neurocognitive Functioning in the Postpartum Period</td>
<td>6</td>
</tr>
<tr>
<td>Memory Functioning in Maternal Depression</td>
<td>7</td>
</tr>
<tr>
<td>Memory Functioning in Sleep</td>
<td>9</td>
</tr>
<tr>
<td>Significance and Long-Term Impact</td>
<td>11</td>
</tr>
<tr>
<td>Specific Aims and Hypotheses</td>
<td>12</td>
</tr>
<tr>
<td>Methods</td>
<td>15</td>
</tr>
<tr>
<td>Participants</td>
<td>15</td>
</tr>
<tr>
<td>Procedures</td>
<td>16</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Measures</td>
<td>18</td>
</tr>
<tr>
<td>Data Analytic Plan</td>
<td>22</td>
</tr>
<tr>
<td>Results</td>
<td>24</td>
</tr>
<tr>
<td>Preliminary Analyses</td>
<td>24</td>
</tr>
<tr>
<td>Covariates</td>
<td>24</td>
</tr>
<tr>
<td>Mood Measures</td>
<td>25</td>
</tr>
<tr>
<td>Neuropsychological Measure</td>
<td>25</td>
</tr>
<tr>
<td>Sleep Measures</td>
<td>26</td>
</tr>
<tr>
<td>Correlations</td>
<td>28</td>
</tr>
<tr>
<td>Discussion</td>
<td>30</td>
</tr>
<tr>
<td>Summary of Findings</td>
<td>30</td>
</tr>
<tr>
<td>Implications for Daily Living</td>
<td>33</td>
</tr>
<tr>
<td>Treatment Implications</td>
<td>33</td>
</tr>
<tr>
<td>Possible Strategies to Ameliorate Memory Deficits</td>
<td>34</td>
</tr>
<tr>
<td>Strengths and Limitations</td>
<td>35</td>
</tr>
<tr>
<td>Future Directions</td>
<td>36</td>
</tr>
<tr>
<td>Potential Moderating Effects of Hormones on Memory Functioning</td>
<td>37</td>
</tr>
<tr>
<td>Summary</td>
<td>38</td>
</tr>
<tr>
<td>Appendix</td>
<td>40</td>
</tr>
<tr>
<td>References</td>
<td>57</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 1. Demographic variables................................................................. 49
Table 2. Study Timeline............................................................................. 50
Table 3. Measures....................................................................................... 51
Table 4. Group means and standard deviations for mood measures at time of intake. 52
Table 5. Group means and standard deviations for mood measures at time of memory testing.................................................................................. 53
Table 6. Group means and standard deviations for memory performance .......... 54
Table 7. Group means and standard deviations for sleep measures............... 55
LIST OF FIGURES

Figure 1. Cognitive deficits found in the literature and proposed hypothesis……… 40
Figure 2. Mean (± SE) of Hamilton Depression Rating Scale…………………… 41
Figure 3. Mean (± SE) of California Verbal Learning Test Learning Trial……… 42
Figure 4. Mean (± SE) of California Verbal Learning Test Long Delay Free Recall. 43
Figure 5. Mean (± SE) of California Verbal Learning Test Semantic Clustering….. 44
Figure 6. Mean (± SE) of Pittsburgh Sleep Quality Index…………………………. 45
Figure 7. Mean (± SE) of Number of Awakenings on Sleep Diary………………… 46
Figure 8. Mean (± SE) of Multidimensional Fatigue Inventory…………………… 47
Figure 9. Scatterplot of Hamilton Depression Rating Scale and Pittsburgh Sleep
Quality……………………………………………………………………………………… 48
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2001  Alpha Chi National Honor Society (top 10% of all majors)
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RESEARCH EXPERIENCE

2009-Present  Brown University, EP Bradley Sleep and Chronobiology Research Laboratory
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Responsibilities include assisting with collection and management of data, data analysis and manuscript preparation for a prospective study examining sleep, mood, and genetic vulnerability in a sample of adolescents transitioning to college.

2004-09 University of California, San Diego Chronobiology and Mood Disorders Laboratory
Graduate Research Associate
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Responsibilities include conducting intake and structured clinical interviews (SCIDs), mood assessments using Hamilton Rating Scale for Depression (HRSD), neuropsychological assessments, managing and analyzing data, supervising undergraduate research assistants, ad hoc co-reviews, and grant and manuscript preparation.

2002-04 University of Rochester Sleep and Neurophysiology Laboratory
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2001-02 University of Rochester Sleep and Neurophysiology Laboratory
Clinical Technologist specializing in polysomnography
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2001-02 State University of New York at Brockport College
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Alpert Medical School at Brown University  
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University of California, San Diego and Veterans Affairs San Diego Healthcare System  
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2002, 03  Behavioral Sleep Medicine
2003  Archives of General Psychiatry
2003, 06  Journal of Affective Disorders
2005  Psychoneuroendocrinology
2006, 08  Journal of American Medical Association (JAMA)
2006  Journal of Fertility and Sterility
2007  Journal of Women’s Health
2007  The Lancet
2007, 08, 09  Journal of Sleep Research
2008  Chronobiology International
2009  American Journal of Physiology

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2009  Brown University Training Committee
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2008  Sleep Research Society Trainee Member-At-Large Elect, Trainee Educ and Advisory Committee
2007  Sleep Research Society Trainee Subcommittee to Trainee Education and Advisory Committee
2006-08  Sleep Research Society Communications Committee, Trainee Representative
2007  APPIC conference, San Diego - Student Volunteer
2007  SDSU/UCSD Joint Doctoral Program Selection Committee
2005-08  SDSU/UCSD JDP Interview & Host Graduate Student Applicants
2005  SDSU Undergraduate Research Symposium - Judge

PROFESSIONAL SOCIETY MEMBERSHIPS

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PUBLICATIONS

Manuscripts:


therapy on sleep continuity in patients with primary insomnia. Sleep, 27(4), 715-725.


Book Chapters:


Published Abstracts:


pregnant and postpartum depression. *Archives of Women’s Mental Health, 10, XII.*


(*) Oral Conference Presentation (n = 5); (#) Poster-only Presentation (n = 6)
Keenan and colleagues (1998) have demonstrated that episodic memory is
diminished during pregnancy and returns to baseline in the postpartum period. Given that
memory deficits may occur in major depression, possible memory deficits during
pregnancy could be exacerbated by major depression. The present study examined
memory performance in 37 pregnant women, 14 of whom met clinical criteria for a Major Depressive Episode (MDE) as defined in the Diagnostic and Statistical Manual 4th Edition (DSM-IV), and 23 normal control (NC) pregnant women who had no current or prior history of depression. Additionally, postpartum groups consisted of 21 postpartum women, 11 of whom met clinical criteria for a MDE, and 10 NC postpartum women. The study utilized a 2 x 2 Multivariate Analysis of Variance design to compare memory performance and sleep of pregnant and postpartum women with and without major depression. The study demonstrated that pregnancy and major depression were both associated with poorer performance in a task involving verbal learning and memory. Specifically, on the California Verbal Learning Test (CVLT), pregnant women learned significantly fewer words from trials one through five; recalled significantly fewer words on trial one, short delay free and cued recall, and long delay free and cued recall; and utilized a semantic clustering strategy significantly fewer than postpartum women. Depressed patients learned significantly fewer words from trials one through five, recalled significantly fewer words on CVLT long delay free recall, and utilized a semantic clustering strategy significantly fewer than NC women. No alterations in outcomes of the above analyses were found when age, education, weeks pregnant/postpartum, or circadian preference were applied as covariates. The present results are consistent with previous investigations of memory functioning of major depressive disorder and healthy pregnant and postpartum women. That is, pregnant and depressed women exhibited poorer performance in tasks involving verbal learning and memory compared with postpartum and NC women.
INTRODUCTION

In the early 20th century, Bleuler introduced the notion of “endocrine depression,” postulating a relationship between the endocrine system and psychiatric diseases. In the late 1970’s higher rates of depression were noted in women as compared with men (Weissman & Klerman, 1977) and these results have since been replicated (Kessler, McGonagle, Swartz, Blazer, & Nelson, 1993; Weissman et al., 1996). According to the Women’s Health Organization and World’s Bank Global Burden of Disease, depression is the most common disease worldwide in women (Murray & Lopez, 1996). Weissman and colleagues (1993) found that women are particularly vulnerable to depression during times of reproductive hormonal change.

Perinatal Pregnancy

Pregnancy is a period of great reproductive hormone fluctuation (Bloch, 2003; Halbreich, 2000; Parry et al., 2003; Zonana, 2005). Historically, pregnancy was thought to safeguard against mental illness. However, there is increasing evidence to challenge this notion, and to suggest that depressed mood is common during pregnancy (Evans, Heron, Francomb, Oke, & Golding, 2001; Johanson, Chapman, Murray, Johnson, & Cox, 2000), with estimates indicating 10-20% of women experience depression during pregnancy (Gotlib, Whiffen, Mount, Milne, & Cordy, 1989; Marcus, 2009; Marcus, Barry, Flynn, Tandon, & Greden, 2001). Gotlib and colleagues (1989) were among the first to point out a possible continuum of depression through pregnancy into the postpartum period. Despite their observation, research during the past 25 years has focused on postpartum depression, rendering
pregnancy-related depression a secondary issue. While Diagnostic and Statistical Manual – Fourth Edition (DSM-IV; American Psychiatric Association, 1994) recognizes postpartum onset mood disorders, it does not make reference to depression during pregnancy. The present study characterizes pregnancy-related depression, focusing on memory functioning that could potentially impact a pregnant woman’s ability to care for herself and her fetus.

Postpartum Depression

Negative mood and mild-to-moderate depression are common in the postpartum period (Cohen & Altshuler, 1997; Dalton, 1996; Diket & Nolan, 1997; Kendell, Chalmers, & Platz, 1987; Nott, Franklin, Armitage, & Gelder, 1976; O'Hara, 1986). Under a mandate from Congress, the NIH Office of Research has targeted postpartum depression as an area for increased research on women’s health. It is also a priority area for World Health Organization and American Psychiatric Association (APA). The incidence of postpartum depression has been reported from 8% to 23% (Cooper & Murray, 1997; O'Hara, Neunaber, & Zekoski, 1984). Inadequate treatment of depression may have severe consequences for the mother, her child, the family and society (Parry, 2003). Untreated depression puts women at risk for the sequelae of increased severity of affective illness (i.e., the depression may become chronic, recurrent, and/or refractory; Cooper & Murray, 1997). Evidence is now accruing that postpartum depression also can adversely affect the neurocognitive and emotional development of children whose mothers were depressed after giving birth (Beck, 1998; Goodman & Gotlib, 1999; Murray, 1992; Murray et al., 1999). Exposure to mothers suffering from postpartum depression, in the early months after birth may have lingering effects on children’s
psychological adjustment and intellectual development (Goodman & Gotlib, 1999; Halligan, Murray, Martins, & Cooper, 2007; Murray, Cooper, & Hipwell, 2003; Murray, Halligan, Adams, Patterson, & Goodyer, 2006; Murray, Woolgar, Cooper, & Hipwell, 2001; Weissman et al., 2006). In addition, it has been demonstrated that persons with MDD and maternal depression have significantly higher levels of disability than those with any of the disorders, causing a greater public health burden (Gureje, Ademola, & Olley, 2008), and greater workplace costs (Kessler et al., 1999; Webb et al., 2008).

Postpartum depression is defined as a moderate-to-severe mood disorder comparable to a major depressive episode in the DSM-IV (American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, 1994). The criteria for major depression include (a) depressed mood or diminished interest or pleasure and (b) at least four of the following symptoms: weight loss/gain or appetite increase/decrease, insomnia/hypersomnia, psychomotor agitation/retardation, fatigue, neurocognitive impairment, inappropriate guilt/feelings of worthlessness, and suicidal ideation. The criteria specify including only affective episodes whose onset is within four weeks postpartum, which is in contrast to the criteria specified by the Marcé Society, an international organization for the study of mental illness related to childbearing that includes episodes occurring within a year postpartum. Most epidemiologic studies have not used the strict criteria of onset within 4 weeks, as stipulated by the DSM-IV (American Psychiatric Association, 1994). The inconsistencies in the time frame used for diagnosing postpartum depression make the literature difficult to interpret. Several published reports suggest the highest risk for onset of postpartum depression is during 3-4 months postpartum (Cooper & Murray, 1997; O'Hara et al., 1984). Postpartum
Depression is often characterized as an irritable, severely depressed mood and the most common symptoms reported by new mothers include crying spells, insomnia, agitation, irritability, and confusion (Sugawara, Sakamoto, Kitamura, Toda, & Shima, 1999). In DSM-II (American Psychiatric Association, 1968) postpartum depression was noted as a separate diagnostic category. Some researchers hold the position that postpartum depression has a biological basis, which distinguishes it from Major Depressive Disorder (MDD; Steiner, 1990).

**Neurocognitive Functioning in Major Depression**

Diminished ability to think or concentrate and psychomotor slowing are identified as symptoms of major depressive disorder in the DSM-IV (American Psychiatric Association, 1994). Women with major depression often report a subjective sense of altered neurocognitive functioning; decreased concentration, motor inefficiency, forgetfulness, and indecisiveness are among the most frequent complaints. MDD is associated with objective neurocognitive deficits in attention (Mialet, Pope, & Yurgelun-Todd, 1996), psychomotor speed (Sobin & Sackeim, 1997), memory (Burt, Zembar, & Niederehe, 1995; Cohen, Weingartner, Smallberg, Pickar, & Murphy, 1982; Golinkoff & Sweeney, 1989; Ilsley, Moffoot, & O’Carroll, 1995), sustained attention (Cornblatt, Lenzenweger, & Erlenmeyer-Kimling, 1989) and executive functioning (Merriam, Thase, Haas, Keshavan, & Sweeney, 1999; Sweeney, Strojwas, Mann, & Thase, 1998). Cassens, Wolfe, and Zola (1990) reviewed literature from 1975 to 1990 and found a scattered pattern of dysfunction with impairments in memory, visuo-spatial and visuo-motor skills in patients with major depression. A more recent and stringent meta-analysis conducted by Veiel (1997) documents a global-diffuse impairment of executive functioning.
Neurocognitive Functioning in Pregnancy

Interest in the effects of a variety of reproductive states on brain functioning has dramatically increased in recent years. Several anecdotal reports can be found in the literature specifying “maternal amnesic syndrome” or “benign encephalopathy of pregnancy” (Baildam, 1991; Welch, 1991). Similar neurocognitive difficulties are also reported in a number of more systematic studies that have examined the subjective experience of neurocognitive change during and after pregnancy (Brindle, Brown, Brown, Griffith, & Turner, 1991; Casey, Huntsdale, Angus, & Janes, 1999; Crawley, Dennison, & Carter, 2003; Janes, Casey, Huntsdale, & Angus, 1999; Jarrahi-Zadeh, Kane, Van de Castlf, Lachenbruch, & Ewing, 1969; McDowall & Moriarty, 2000; Parsons & Redman, 1991; Poser, Kassirer, & Peyser, 1986; Sharp, Brindle, Brown, & Turner, 1993). Forgetfulness, reading difficulties, confusion, absent-mindedness, disorientation, distractibility, poor concentration, cognitive slowing, and word finding difficulties are among the subjective complaints, with poor memory being the greatest complaint across studies. In addition to these neurocognitive changes, Parsons and Redman (1991) found women reported poor co-ordination resulting in significantly more accidents around the home (dropping/spilling things, minor burns, etc.) during their pregnancies. With few exceptions, studies that examined subjective reports of neurocognitive change during pregnancy suggest a substantial proportion of women experience some degree of neurocognitive disturbance with estimates ranging from 50-80%.

Despite subjective reports, there are no systematic data on objective measures of neurocognitive functioning during pregnancy. The majority of studies report decreased
performance on neurocognitive tasks during pregnancy (Brindle et al., 1991; Buckwater, 2001; de Groot, Hornstra, Roozendaal, & Jolles, 2003; de Groot, Vuurman, Hornstra, & Jolles, 2006; Eidelman, Hoffmann, & Kaitz, 1993; Sharp et al., 1993), but some have demonstrated no effect of pregnancy (Casey et al., 1999; Crawley et al., 2003; Janes et al., 1999; McDowall & Moriarty, 2000; Morris, Toms, Easthope, & Biddulph, 1998) or even positive effects on some neurocognitive functions (Christensen, 1999; Schneider, 1989). Methodological limitations, such as limited measures of neurocognitive domains and lack of standardized measures hinder the interpretation and integration of findings. Discrepant findings in neurocognitive performance may also be due to differences in stage of pregnancy, subjects investigated, mood, hormones, and other variables.

**Neurocognitive Functioning in the Postpartum Period**

Neurocognitive impairments may extend beyond pregnancy into the postpartum period (Bailldam, 1991; Jarrahi-Zadeh et al., 1969; Welch, 1991). The effect of parturition on mental state and function is not fully understood. Surveys of new mothers have noted that many women report confusion, forgetfulness, and “fogginess” in the immediate postpartum period (Robinson, 1987; Stein, 1980). These anecdotal reports have been corroborated by studies examining subjective neurocognitive impairment (Casey et al., 1999; Janes et al., 1999; Jarrahi-Zadeh et al., 1969; Kane, Harman, Keeler, & Ewing, 1968; Swain, O'Hara, Starr, & Gorman, 1997). However, not all investigators reported impairments in the postpartum period (Harris, 1996), and measures have generally only extended to a few days or weeks postpartum. Objective studies of neurocognitive function have again yielded contradictory results. Robinson (1987) documented poor conceptual functioning on the eighth postpartum day; and Treadway, Kane, Jarrahi-
Zadeh, and Lipton (1969) noted poor functioning on the Trailmaking test 3 days after delivery. The findings from other studies support neurocognitive deficits during the postpartum period (Buckwalter, Buckwalter, Bluestein, & Stanczyk, 2001; Eidelman et al., 1993). In contrast, other investigators have failed to document deficits in neurocognitive functioning (Freedman, Redlich, Eron, & Jackson, 1952; Jarrahi-Zadeh et al., 1969; Rofe & Algom, 1985; Swain et al., 1997; Yalom, Lunde, Moos, & Hamburg, 1968). In a longitudinal study of explicit memory, Keenan and colleagues (1998) found a pregnancy-related decline in memory in the third trimester and improvement in memory function postpartum. In general, cognition during pregnancy has received more attention than the postpartum period, and the few studies that have continued investigation beyond pregnancy have not systematically examined the time course of neurocognitive effects. Some studies do not extend very far beyond parturition, measuring performance up to three days (Eidelman et al., 1993; Jarrahi-Zadeh et al., 1969), four weeks (Harris, 1996), six weeks postpartum (Buckwalter et al., 2001), while other studies combine postpartum and pregnancy data (Casey et al., 1999; Janes et al., 1999). A strength of the present study is the ability to examine memory functioning in women during pregnancy and the postpartum period cross-sectionally, which allowed us to make comparisons across these two periods (albeit not longitudinally).

Memory Functioning in Maternal Depression

Depressed mood experienced by some women during pregnancy and the postpartum period may impact memory or other cognitive processes. Depressed mood may be a moderator of memory deficits found during pregnancy and postpartum; however, few studies on memory functioning in pregnancy and postpartum have
simultaneously evaluated mood (Buckwalter et al., 2001; Casey et al., 1999; Treadway et al., 1969). Buckwalter and colleagues (1999) examined memory functioning of 19 women during their last 2 months of pregnancy and 2 months after delivery. When compared with performance in the postpartum period, women displayed more impairment of verbal memory and reported greater mood disturbance during pregnancy. However, depressed mood did not appear to explain memory deficits. It is noteworthy that Buckwater and colleagues sampled “healthy” pregnant women and measured depression using self-report instruments, such as the BDI and Profile of Mood States, not using Diagnostic and Statistical Manual (DSM) criteria. Mean BDI score was 10.2, indicating a minimally depressed mood. In another study by examining sleep, mood, and neurocognitive functioning in postpartum and non-postpartum women, Swain and colleagues (1997) observed few differences in multiple assessments of neurocognitive functioning. Swain et al., again, examined nonclinical postpartum women. Daily mood was measured using a visual analog scale. The authors concluded that new mothers differed on negative mood rating only during the first week, consistent with the time course of the “blues.” Self-reported mood predicted neurocognitive functioning for both postpartum mothers and non-postpartum controls. Thus, these studies suggest mood fluctuations may influence neurocognitive performance in healthy, non-clinically depressed women. In contrast, it remains largely unknown whether clinically diagnosable depression affects memory functioning in pregnancy and the postpartum period. It remains largely unknown whether women diagnosed with major depression during the perinatal and postpartum periods have diminished memory functioning. Therefore, the present study examined the effects of pregnancy and the postpartum period on mood and
memory functioning. According to previous literature, the overlap of impaired neurocognitive functioning among patients with major depressive disorder and among healthy pregnant and postpartum women are deficits found in episodic memory, with a predominance in verbal/semantic memory. No published studies have focused on memory of a major depressive episode diagnosed during pregnancy and/or the postpartum period. The present study will contribute to the larger literature by exploring the effects of perinatal and postpartum depression on verbal learning memory performance, and examine subjective sleep as a potential moderating variable. We expect to find deficits in verbal memory in pregnant and depressed women (see Figure 1).

Memory Functioning and Sleep

Discrepant findings in neurocognitive performance may also be due to differences in sleep. For example, Janes and colleagues (1999) found sleep disruption was a significant predictor of level of subjective memory complaints. The authors concluded that self-reports of memory change during pregnancy and postpartum were related to life changes such as changes in sleep pattern. Further, Naismith and colleagues (2009) found late insomnia in older people with major depression may be independently and aetiologically linked to neuropsychological performance, particularly verbal fluency and memory. The authors concluded that sleep and circadian disturbance may indicate underlying structural and neurochemical changes, may serve as a biomarker for ongoing cognitive decline, and may be a potentially modifiable risk factor.

In addition, daytime consequences of sleep disturbance and motherhood, such as fatigue, may contribute to diminished neurocognitive performance. Although individuals of all ages and both genders are at risk for developing fatigue, pregnant and postpartum
fatigue is particularly challenging, because of biological and hormonal changes and the
new mother has demanding life tasks to accomplish during this period of time.
Postpartum fatigue may impact postpartum maternal role attainment and may place a
woman at increased risk for postpartum depression (Corwin & Arbour, 2007). Fatigue is
an unrelenting condition that affects physical and mental health, and it has implications
for everyday activities, motivation, and social interactions. In order to examine sleep as
well as fatigue as a potential moderating variable, several subjective sleep and one fatigue
measure will be administered in the present study (see Measures).

Finally, there is a well-established diurnal variation found in depressed patients.
In DSM-IV one of the criteria for the melancholic subtype of depression is diurnal
variation of mood, with a pattern of being worse in the morning. Typical diurnal mood
variations with a morning low and afternoon high (evening type) have long been
considered a classical characteristic of endogenous depression or melancholia
(Wefelmeyer & Kuhs, 1996). However, diurnal variation is not specific to endogenous or
melancholic depression (Leibenluft & Wehr, 1992), and is not dependent of severity of
depression (Haug & Fahndrich, 1990). Moffoot et al. (1994) examined 20 melancholic
depressed patients and 20 NC subjects, matched for age and intelligence, on a battery of
neuropsychological tests administered at 08:00 and 20:00 and found that melancholics
performed significantly worse than NC on cognitive tests in the morning, but not in the
evening. Melancholic patients showed marked deficits in attention/concentration/working
memory, episodic memory, psychomotor speed, speed of recognition memory, and grip
strength in the morning. However, marked improvement of cognitive performance was
found in the evening along with improvement in mood. Similarly, tests of executive
function and verbal fluency (Porterfield, Cook, Deary, & Ebmeier, 1997) and sustained attention (Schmidt et al., 2009) are sensitive to homeostatic pressure and diurnal variation. Therefore, Horne-Östberg Morningness Eveningness Questionnaire (Horne & Ostberg, 1976) was administered in the present study to measure and control for circadian preference.

Significance and Long-Term Impact

Investigation of the effects of mood disorders during the pregnancy and postpartum periods, with the ultimate aim of developing new treatment strategies, is urgently needed, particularly given the limitation on the safe and effective treatment options documented in pregnant and lactating women. Selective serotonin reuptake inhibitor (SSRI) use during pregnancy incurs a low absolute risk for major malformations; however, other adverse outcomes have been reported. Wisner and colleagues (2009) investigated the impact of major depression versus antidepressant treatment on pregnancy and neonatal outcomes in 238 women. The authors found that infants exposed continuously to either SSRI or major depression were more likely to be born preterm (>20% rate) than were unexposed or partially exposed infants. However, in a prospective naturalistic investigation using longitudinal psychiatric assessments on a monthly basis across pregnancy, Cohen and colleagues (2006) found women who discontinued antidepressant medication relapsed significantly more frequently over the course of their pregnancies (68%) when compared with women who maintained their medication (21%). Furthermore, studies demonstrated failing to treat these disorders has disabling effects on the mother and family, and impairs the neurocognitive development of the child. The most serious consequence of untreated maternal depression is increased
mortality from suicide. For example, Appleby (1998) found severe post-partum psychiatric disorder is associated with a high rate of deaths from natural and unnatural causes, particularly suicide. The risk is especially high for women suffering from psychosis in the first postnatal year, when the suicide risk is increased 70% and infanticide 4%. Thus, new and expecting mothers and their doctors are faced with a difficult decision to risk harm of fetus/newborns by continuing medication to treat depression or to discontinue use and risk relapse of depression. At the present time, there is general consensus that untreated major depression outweighs the risk of effects of SSRI treatment on neonatal outcomes (Parry, 2009).

Clearly, maternal depression has deleterious effects on mother and child and requires unique treatment considerations. Potential teratologic effects of some pharmacotherapies or the mismatch of other therapies to symptoms of patients with pregnancy-related and postpartum depression complicates treatment. Research on the characteristics of maternal depression will aid in developing better therapy in the long-term. Identifying and delineating specific memory deficits in pregnant and postpartum women with major depression can serve as the first step towards augmenting treatment to enhance benefit. Tailoring treatment to level of memory may aid in comprehension and compliance of treatment.

Specific Aims and Hypotheses

**Aim 1:** Compare verbal learning and memory performance and subjective sleep quality of healthy pregnant and postpartum control women with pregnant and postpartum women with major depression.

**Hypothesis 1a:** Pregnant and postpartum depressed women will exhibit diminished
verbal learning and memory when compared with healthy control pregnant and postpartum women.

**Hypothesis 1b:** Pregnant and postpartum depressed women will report poorer subjective sleep quality (as measured by Pittsburgh Sleep Quality Index and sleep diaries) and greater fatigue (as measured by Multidimensional Fatigue Inventory) when compared with healthy control pregnant and postpartum women.

**Aim 2:** Investigate the association between depression severity and memory performance, and depression severity and sleep quality.

**Hypothesis 2a:** Depression severity and memory performance will be inversely correlated; i.e., as depression increases, memory performance decreases in all women.

**Hypothesis 2b:** Poor subjective sleep quality is expected to be associated with diminished mood, while improved sleep quality is expected to be associated with increased mood in all women.

**Aim 3:** Compare verbal learning and memory performance and subjective sleep quality in pregnant and postpartum women.

**Hypothesis 3a:** Based on findings by Keenan and colleagues (1998), pregnant (both healthy and depressed) women will display diminished verbal learning and memory performance compared with healthy and depressed postpartum women. The effects of depression status and child bearing status are expected to be additive, such that women who are both pregnant and clinically depressed will exhibit the greatest memory performance deficits and healthy postpartum women will display the smallest memory performance deficits.

**Hypothesis 3b:** Postpartum (both healthy and depressed) women will report poorer
subjective sleep quality (as measured by Pittsburgh Sleep Quality Index and sleep diaries) and greater fatigue (as measured by Multidimensional Fatigue Inventory) when compared with healthy and depressed pregnant women.
METHODS

Participants

Participants (N=62) of reproductive age (18-45 years) were recruited from the San Diego area. Four women were excluded from the study because they did not meet inclusion/exclusion criteria (2 women had other concurrent psychiatric disorders, one women had gestational diabetes, and one women was currently being treated with antidepressant medication). Of the remaining 58 women, 37 were pregnant women, 14 (mean age of 27.1 ± 5.4) of whom met clinical criteria for a MDE as defined in the *DSM-IV* and 23 who were normal control (NC) pregnant women (mean age of 28.1 ± 5.3), who had no current or prior history of depression. In 21 postpartum women, 11 met clinical criteria for a MDE as defined in the *DSM-IV* (mean age of 27.3 ± 3.3) and 10 were NC postpartum women (mean age of 28.4 ± 6.8) who had no current or prior history of depression. Groups were relatively balanced in terms of age, education, ethnicity, weeks pregnant/postpartum, and trimester (see Table 1).

Participants were recruited primarily from online advertisements placed on www.craigslist.org, flyers hung around the local community, at University of California, San Diego obstetrics and gynecology office and Outpatient Psychiatric Clinic, and from participants in Dr. Barbara Parry’s chronobiology of pregnancy and postpartum depression study. Abstinence from medication (including hormonal contraception in postpartum women and antidepressant medication in all women) was required for at least one month prior to the study.
Postpartum depression was determined by patient report during clinical interview, where depression must have been present at time of testing; and onset must have occurred within 1 month of delivery (by DSM-IV criteria). In addition, postpartum women were excluded if they delivered greater than 12 months prior to the study. Depression during pregnancy was determined by patient report during clinical interview, where depression must have been present at time of testing; and depression must have occurred during the pregnancy period. In order to rule out organic conditions or other factors that can influence cognition, individuals with a history of head injury involving loss of consciousness, significant learning problems, and/or learning disabilities were excluded from the study. A history of head injuries or learning difficulties was inquired about during the intake assessment in order to make the determination of possible exclusion. In addition, women with serious medical conditions (e.g., cancer, diabetes, thyroid disease), concurrent psychiatric diagnosis (except anxiety disorders), or who were imminently suicidal or in current need of hospitalization for treatment of depression were excluded from the study.

Procedures

All procedures conducted were approved by University of California, San Diego and San Diego State University Committees for Protection of Human Subjects, and participation in the study was voluntary. All information provided by each participant was strictly confidential, and each participant was informed that information was “de-identified” and not be shared outside of the laboratory, as documented in the consent form. Further, all data is stored under highly secure procedures, compliant with HIPPA
Since all information is confidential and is not collected as part of any clinical service, we did not share diagnostic information with any participants.

**Screening Phase.** All potential participants were evaluated via brief telephone screen interview in which interested participants were asked about inclusion/exclusion criteria. Participants were given the option for home or laboratory visits and the opportunity to reschedule missed appointments to ensure the completion of the protocol. After meeting initial screening criteria, a 1-3 hour interview was completed during which participants signed the informed consent form; and were provided information explaining the importance of the research, the safety of the protocol, confidentiality of the study and contact information for psychiatric assistance should it be needed. Additionally, psychiatric and medical symptoms were documented. The Structure Interview Guide for the Hamilton Depression Rating Scale (SIGH-SAD; Hamilton, 1967), Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), Beck Anxiety Inventory (BAI; Beck & Steer, 1990) and Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden, & Sagovsky, 1987) were administered to assess mood. The Multidimensional Fatigue Inventory (MFI) was also administered to assess fatigue at intake. Finally, a structured clinical interview for *DSM-IV* diagnoses (SCID-I/NP; First, Spitzer, Gibbon, & Williams, 1995) was used to obtain a complete psychiatric history from each potential subject, to determine whether she had the requisite symptoms to meet diagnostic criteria for major depressive episode (MDE), and to ensure that there is no concurrent Axis I diagnoses (see Diagnostic measures). A concurrent diagnosis of anxiety (with depression) did not preclude women from the study. Depressed patients (DP) were required to meet *DSM-IV* criteria for MDE and have a mean SIGH-SAD objective score
of ≥ 15 and BDI and EPDS subjective scores ≥ 10 during screening. NC women were excluded if they met DSM-IV criteria for MDE or if they scored ≥ 10 on the SIG-SAD, BDI, BAI, or EPDS. The following variables were also recorded: age, educational history, work status, handedness, number of weeks pregnant/postpartum, breast feeding status, and number of children. Participants were asked to complete a sleep diary for approximately one week, at home between screening and the experimental phase in order to track subjective sleep prospectively (see Measures).

Experimental Phase. Following screening and diagnostic classification, each participant completed a second visit approximately 1 week later to complete a 1.5 - 2 hour battery of neuropsychological tests consisting of measures of verbal learning and memory, psychomotor speed, verbal fluency, attention, and executive functioning/working memory that have been standardized and well-normed. Research assistants that were blind to subjects’ diagnoses administered neuropsychological tests. In addition, SIGH-SAD, BDI, BAI, EPDS, and MFI were administered both at the time of intake and at memory testing. See Table 2 for the study timeline.

Measures

Mood and Diagnostic measures. As part of screening of mood, participants were evaluated using several mood questionnaires.

*Hamilton Depression Rating Scale (HDRS).* HDRS is an objective 21-item scale assessing affective and physical depressive symptomology. Each item is rated on a scale ranging from either 0 to 2 or 0 to 4 with a maximum of 64 points (Hamilton, 1967).

*Addendum to Hamilton Depression Rating Scale.* As part of SIGH-SAD, HDRS addendum was implemented in order to assess atypical depressive symptoms (i.e. fatigue,
weight gain, social withdrawal, carbohydrate craving, and hypersomnia) with a maximum of 26 points. (Williams, Link, Rosenthal, Amira, & Terman, 1994)

_Hypomania Rating Scale._ The hypomania scale was used to rule out patients with mania, assessing expansive and irritable mood, decreased need for sleep, increased work and activities, activation, speech, flight of ideas, creativity, impulsive behavior, libido, or social activities. Each item is rated on a scale ranging from 0-2 to 0-5 with a maximum of 40 points (Rosenthal, 1986).

_Beck Depression Inventory (BDI)._ Subjective mood was assessed using the BDI, a 21-item scale with items ranging from 0-3 with a maximum of 63 points (Beck et al., 1961).

_Beck Anxiety Inventory (BAI)._ Subjective anxiety was assessed using the BAI, a 21-item scale with items ranging from 0-3 with a maximum of 63 points (Beck, Epstein, Brown, & Steer, 1988; Beck & Steer, 1990).

_Edinburgh Postnatal Depression Scale (EPDS)._ EPDS is a 10-item self-report mood scale designed to predict depression specifically in pregnant and postpartum women (Cox et al., 1987).

_Structured Clinical Interview of DSM-IV (SCID)._ The SCID-I/NP was used to diagnose DSM-IV Axis I disorders in persons not identified as psychiatric patients. Segal and colleagues (Segal, Hersen, & Van Hasselt, 1994) reported kappas from .70 to .93 for depressive disorders. Most investigators recommend using the SCID in lieu of clinical interviews (Shear et al., 2000). The SCID-I/NP is regarded among the most valid standardized instruments, and has often been used as the “gold standard” in evaluating
screening tools (Broadhead et al., 1995). In the present study the SCID-I/NP was used to evaluate lifetime Axis I psychiatric diagnosis in all subjects.

**Neuropsychological measure.** *California Verbal Learning Test (CVLT).* CVLT is a test designed to assess verbal learning and memory and has well-documented sensitivity and specificity (Delis, Kramer, Kaplan, & Ober, 1987). Participants are required to learn a 16-item list of shopping items, administered over five trials. Participants are then asked to learn and recall a distractor list. Subsequent to the distractor list, they are asked to recall the original list and recall words by category. Following a 20-minute delay period, participants are asked to recall these words, recall items by category, and recognize the words from a list including distracters. The CVLT yields information concerning strategies employed in encoding verbal stimuli, rapidity of verbal learning, spontaneous and cued recall and recognition. Verbal memory factors included in analyses were number of items recalled after the first and fifth presentation of the list, short-term and long-term cued and free recall, perseveration errors, and the degree to which items are semantically clustered upon recall.

**Sleep measures.** To evaluate the impact of sleep and circadian preference on memory performance, participants were asked to complete several sleep questionnaires.

*Pittsburgh Sleep Quality Index (PSQI).* The PSQI is a standardized self-rated questionnaire developed to assist in measuring retrospective global sleep quality over a one-month period. The 24-item questionnaire generates seven component scores, ranging from subscale scores 0 to 3: sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications and daytime dysfunction. The addition of these seven components yields a global score of subjective sleep quality. The
global score ranges from 0 to 21, and a higher score is indicative of poorer subjective
sleep quality. A score of > 5 identifies clinically significant sleep disturbance with 89.6%
sensitivity and 86.5% specificity (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989).

*Sleep diary.* The sleep diary was created in-house based on other validated sleep
diaries (Monk et al., 1994), and was used to measure prospective sleep. Women were
asked to complete the sleep diary upon rising to provide an estimate of lights out, sleep
latency, rise time, time in bed, quality of sleep, number of nocturnal awakenings, wake
after sleep onset, and total sleep time each night; and nap time each day for one week
prior to memory testing. Using a ratio of total sleep time to time in bed provided a
calculation for subjective sleep efficiency. Conventional sleep assessment procedures,
such as sleep diaries, can complement depression scales by providing additional
information about specific aspects of sleep in depression (Manber et al., 2005).

*Horne-Östberg Morningness-Eveningness Questionnaire (MEQ).* The MEQ is a
self-report instrument that contains 19 questions aimed at determining when during the
daily temporal span the respondent's maximum propensity to be active lies. Most
questions are preferential, in the sense that the respondent is asked to indicate when, for
example, he/she would prefer to wake up or start sleep, rather than when he/she actually
does. Questions are multiple choice, with each answer being assigned a value. Their sum
gives a score ranging from 16 to 86, with lower values corresponding to evening types
(Horne & Ostberg, 1976).

*Multidimensional Fatigue Inventory (MFI).* A 20-item self-report instrument
designed to measure fatigue, the MFI measures five dimensions independently: general
fatigue, physical fatigue, mental fatigue, reduced motivation and reduced activity. There
are four items in each dimension. The score on each item ranges from 1 (no fatigue) to 5 (very fatigued). The score in each dimension ranges from 4 to 20. Total possible scores range from 20 (no fatigue) to 100 (very fatigued). The instrument was found to have good internal consistency, with an average Cronbach's alpha coefficient of 0.84 and construct validity (Schneider, 1998; Smets, 1995).

**Data Analytic Plan**

**Examination of Covariates.** Demographics and sleep variables were analyzed for group differences using Analysis of Variance (ANOVA). If significant group differences are found at a p-value of .10, variables were added as covariates in the analyses below.

**Outcome Measure.** The CVLT is a neuropsychological measure that is standardized, and well normed (Heaton, 2004). The CVLT was scored using CVLT manual and electronic scoring software. Standardized scores were normed for sex, age and African American ethnicity.

**Aim 1 & 3.** Memory data was analyzed using a 2 x 2 Multivariate Analysis of Variance (MANOVA), where the categorical independent variables (IV) was diagnosis (DP vs. NC) and reproductive status (pregnant vs. postpartum) and the continuous dependent variables (DV) were scores of CVLT and subjective sleep measures (PSQI, sleep diaries, and MFI). Wilks’ criterion (Λ) was used to examine the omnibus test statistics. If overall main effects or the interaction were significant for the omnibus MANOVA, univariate ANOVAs were subsequently examined.

Main effects are expected for mood and child bearing status, where DP and pregnant women will exhibit diminished verbal learning and memory compared with NC and postpartum women. An interaction between child bearing status and depression
status will also be examined. An interaction is not expected to occur. In addition, main effects are expected for mood and child bearing status, where DP and postpartum women will exhibit diminished subjective sleep quality and greater fatigue when compared to NC and pregnant women.

**Aim 2.** To examine the relationship between measures of mood (i.e., HDRS, atypical items, BDI, BAI, and EPDS scores at time of memory testing) and memory performance Pearson Bivariate Correlations were conducted. A negative association between mood and memory performance was expected for all subjects. That is, as depression increases, memory performance will decrease.

Additionally, in order to examine the association between subjective sleep (measured by PSQI) and mood (measured by HDRS, BDI, BAI, and EPDS), bivariate correlations were conducted. A positive association is expected for PSQI score and mood scores. That is, as PSQI increases (indicating poorer sleep quality), mood scores will increase (indicating greater severity of depressed mood and/or anxiety).

**Power Analysis.** To determine what sample size was necessary to detect significant group differences in memory performance, a power analysis was conducted using nQuery software. Medium effect sizes were extrapolated from studies examining memory functioning of healthy pregnant/postpartum women. The power is based on a one-sided test; since we hypothesized that the memory performance would be diminished in maternal depression. At power of 80%, a sample of 60 (i.e., 15 per group) was determined to be necessary to detect significant differences for aims one and three. Thus, the projected sample size was 15 for each subgroup. Due to time constraints of the study, goal for sample sizes were not met in all of the groups.
RESULTS

Preliminary Analyses

Variables were assessed for normality, homogeneity of variance, and linearity. Using an alpha level of .001 to evaluate homogeneity assumptions, Box's M test of homogeneity of covariance was non-significant ($p > .05$). Therefore, the assumption of homogeneity of covariance was met. Levene’s homogeneity of variance test was not statistically significant ($p > .05$). Therefore, the assumption of homogeneity of variance was met.

Covariates

A 2 x 2 ANOVA indicated that diagnostic groups (NC vs. DP) were equivalent in age $F(1,57) = 0.82, p = .317$, education $F(1,57) = 0.44, p = .834$, weeks pregnant or postpartum $F(1,57) = 0.01, p = .922$, circadian preference determined by Horne-Östberg (H-O) Morningness Evennessness Scale $F(1,57) = 1.73, p = .202$; on reproductive status (pregnant vs. postpartum) groups were also equivalent in age $F(1,57) = 1.54, p = .221$, education $F(1,57) = 0.24, p = .877$, weeks pregnant or postpartum $F(1,57) = 0.30, p = .587$, circadian preference determined by H-O score $F(1,56) = 0.05, p = .831$; and diagnosis x reproductive status interactions were not significant for age $F(1,57) = 2.69, p = .107$, education $F(1,57) = 0.19, p = .891$, weeks pregnant or postpartum, $F(1,57) = 0.13, p = .720$, or circadian preference determined by H-O score $F(1,56) = 1.42, p = .246$ (see Table 1).

Age, education, weeks pregnant/postpartum, H-O and MFI scores were used in subsequent analysis as covariates. With respect to these covariates in the statistical
tests, no alterations in outcomes of the analyses were found when age, education, weeks pregnant/postpartum, circadian preference, or fatigue were applied as covariates.

Mood Measures

The HDRS, HDRS atypical measure (SIGH-SAD), hypomania scale, BDI, BAI, and EPDS were administered during the intake visit and during the time of neuropsychological evaluation. A 2 x 2 MANOVA was conducted for mood measure (for scores at intake and time of memory testing). As expected, there were significant group differences (see Figure 2) for diagnosis on measures of both subjective and objective depression at the time of intake (see Table 4) and memory testing (see Table 5).

Neuropsychological Measure

The verbal memory domain consisted of one test (California Verbal Learning Test) with multiple subtests/variables. The 2 x 2 omnibus MANOVA revealed no overall significant main effects for diagnosis $F(7, 47) = 1.57, p = .176$, reproductive status $F(7,47) = 1.86, p = .105$, or diagnosis x reproductive status interaction $F(7, 47) = 0.46, p = .855$. Due to close trends for main effects, and for exploratory purposes, univariate analyses were examined (see Table 6).

Aim 1a. For diagnosis, NC women learned significantly more words than DP on CVLT trials one through five $F(1,53) = 4.06, p = .05 (m = 39.65$ vs. $31.90)$, recalled significantly more words on long delay free recall $F(1,53) = 5.86, p = .019 (m = -1.12$ vs. $-2.30)$, and exhibited a significantly greater amount of semantic clustering on the CVLT versus DP $F(1,53) = 5.87, p = .022 (m = -0.57$ vs. $-1.05)$ and a trend towards significance for fewer CVLT perseveration errors $F(1,53) = 2.89, p = .096 (m = -0.39$ vs. $0.11)$. 
Aim 3a. For reproductive status, postpartum women learned significantly more words than pregnant women on CVLT trials one through five \( F(1,53) = 5.61, p = .037 \) \((m = 39.71\) vs. 31.67\), and recalled significantly more words on short delay free recall \( F(1,53) = 6.00, p = .018 \) \((m = -0.71\) vs. -1.70\), short delay cued recall \( F(1,53) = 10.61, p = .002 \) \((m = -0.64\) vs. -1.67\), long delay free recall \( F(1,53) = 6.32, p = .016 \) \((m = -1.43\) vs. -2.78\), long delay cued recall \( F(1,53) = 5.31, p = .026 \) \((m = -1.07\) vs. -2.12\). In addition, postpartum women were also able to use semantic clustering strategy significantly more than pregnant women \( F(1,53) = 6.18, p = .017 \) \((m = -0.43\) vs. -0.91\). Of note, all group standardized scores were negative values (see Figures 3-5).

Sleep Measures

Pittsburgh Sleep Quality Index. To measure subjective sleep quality over the past month, PSQI was administered at the time of intake. A 2 x 2 MANOVA revealed a significant overall main effect for diagnosis \( F(7,48) = 6.91, p < .001 \) and reproductive status \( F(7,48) = 4.47, p = .002 \), however diagnosis x reproductive status interaction was not significant \( F(7,48) = 0.77, p = .615 \). Due to significant overall main effects, univariate analyses were also examined.

Aim 1b. For diagnosis, groups were significantly different for Index 1 – Sleep Quality \( (p = .030) \), Index 2 – Sleep Latency \( (p = .030) \), Index 5 – Sleep Disturbance \( (p < .001) \), Index 6 – Use of Sleep Medications \( (p = .030) \), Index 7 – Daytime Dysfunction \( (p = .004) \), and PSQI Global Score \( (p < .001) \). For all indices and the global score, DP scored significantly higher on the PSQI, indicating poorer subjective sleep quality.

Aim 3b. For reproductive status, there was a trend towards significance on group difference for Index 1 – Sleep Quality \( (p = .083) \), Index 3 – Sleep Duration \( (p = .072) \),
and significant group differences on Index 5 – Sleep Disturbance \((p = .009)\), Index 6 – Use of Sleep Medications \((p = .053)\). For all indices postpartum women scored significantly higher than pregnant women on the PSQI, indicating poorer subjective sleep quality (see Figure 6).

**Sleep Diary.** To measure prospective sleep, a sleep diary was administered the week between intake and memory testing. A 2 x 2 MANOVA was conducted for mean sleep diary variables (lights out, rise time, sleep latency, number of awakenings, wake after sleep onset, sleep efficiency, total sleep time, and time napping) and revealed no significant group differences. For exploratory purposes, sleep diary data for the night prior to memory testing was also examined. A 2 x 2 MANOVA revealed the overall main effects were not significant for diagnosis \(F(6, 49) = 0.71, p = .646\) or reproductive status \(F(6, 49) = 0.77, p = .604\); however, the omnibus diagnosis x reproductive status interaction was significant \(F(6, 49) = 5.72, p = .002\). Univariate interactions were examined and revealed significant diagnosis x reproductive interactions for lights out \(F(6, 49) = 5.10, p = .034\), rise time \(F(6, 49) = 5.36, p = .030\), and number of awakenings \(F(6, 49) = 6.79, p = .016\).

Analyses of simple effects showed a trend towards significance in DP (but not NC), where postpartum women attempted to go to sleep earlier, recorded as “lights out” on the sleep diary on the night prior to memory testing versus pregnant women \((21:06 \text{ vs. } 23:22 \text{ h, } p = .096)\). The difference between NC and DP was not significant for lights out for both pregnant \((p = .599)\) and postpartum women \((p = .223)\). The difference between pregnant and postpartum women was nonsignificant for rise time recorded on the sleep diary on the night prior to memory testing for both NC women \((p = .316)\) and DP \((p = \)
The difference between NC and DP was nonsignificant for rise time for both pregnant \( (p = .647) \) and postpartum women \( (p = .130) \). In NC (but not DP), postpartum women reported significantly more nocturnal awakenings on the night prior to memory testing versus pregnant woman \( (3.00 \text{ vs. } 0.91, p = .002) \). In pregnant (but not postpartum) women, DP versus NC reported significantly more nocturnal awakenings \( (2.25 \text{ vs. } 0.91, p = .022) \); see Figure 7.

**Multidimensional Fatigue Inventory.** Multidimensional Fatigue Inventory (MFI) was administered during the intake visit and at the time of memory testing to examine fatigue. A 2 x 2 ANOVA revealed a trend towards significance on level of fatigue as measured by MFI at the time of intake \( F(1,57) = 3.20, p = .085 \), where DP reported feeling more fatigued \( m=55.9 \) \( (10.20) \) versus NC women \( m=47.7 \) \( (9.66) \).

**Aim 1b.** A significant main effect for diagnosis was revealed for MFI at time of memory testing \( F(1,57) = 7.41, p = .011 \), where DP scored significantly higher on MFI (indicating feelings of greater fatigue) \( m=58.3 \) \( (3.20) \) versus NC women \( m=45.9 \) \( (3.25) \).

**Aim 3b.** Notably, no significant differences were found for the main effect of reproductive status \( F(1,57) = 0.92, p = .346 \) or the diagnosis x reproductive status interaction \( F(1,57) = 0.16, p = .694 \) for MFI at intake or at time of memory testing \( F(1,57) = 0.36, p = .556 \) and \( F(1,57) = 0.12, p = .271 \), respectively. See Table 7 for means and standard deviations of sleep measures (see Figure 8).

**Correlations**

**Mood and Memory Performance.** Pearson bivariate correlations were calculated for all subjects between measures of mood (i.e., HDRS, atypical items, hypomania, EPDS, BDI, and BAI scores) at time of testing and memory performance.
Aim 2a. A positive correlation was found between CVLT preservations and HDRS ($r = 0.39$, $p = .007$), hypomania scale ($r = 0.37$, $p = .011$), BDI ($r = 0.32$, $p = .038$), and BAI ($r = 0.30$, $p = .041$). As mood scores increased (indicating greater severity of depressed mood), women made more perseveration errors (i.e., perseverating on the same word when recalling CVLT items).

Sleep and Mood. Pearson bivariate correlations were calculated for all subjects between measures of mood (i.e., HDRS, atypical items, hypomania, EPDS, BDI, and BAI scores) at intake and time of testing and PSQI (7 indices + global score).

Aim 2b. As expected, a positive correlation was found on most mood and PSQI scores, ranging between $r = 0.30$, $p = .093$ to $r = 0.69$, $p < .001$. As mood scores increased (indicating greater severity of depressed mood), PSQI index and global scores increased (indicating poorer subjective sleep quality; see Figure 9).
DISCUSSION

The present study examined memory performance in pregnant and postpartum women with and without major depression to investigate whether depressed mood affects performance on short- and long-term verbal memory. Several investigators have demonstrated that cognition, and more specifically, verbal memory, is diminished during pregnancy (Brindle et al., 1991; de Groot et al., 2006) and, to a lesser degree, during the postpartum period (Buckwalter et al., 2001; Eidelman et al., 1993; Robinson, 1987). Given that memory deficits occur in major depression, major depression could exacerbate memory deficits during pregnancy. Therefore, we hypothesized both depressed and pregnant women would exhibit diminished verbal memory relative to normal control and postpartum women.

Summary of Findings

Overall, the results confirm this hypothesis and are consistent with previous investigations of memory functioning of major depressive disorder and healthy pregnant and postpartum women. That is, DP exhibited greater deficits in tasks involving verbal memory. In addition, pregnant women exhibited more deficits with respect to verbal memory versus postpartum women.

Verbal Learning and Memory. Depressed women learned significantly fewer words from trials one through five, recalled significantly fewer words on long delay free recall, made more perseveration errors, and utilized semantic clustering strategy less often when completing CVLT versus NC women. Several investigators have demonstrated that individuals with MDE exhibit varying degrees of cognitive
dysfunction (Cassens et al., 1990; Veiel, 1997). Specifically, individuals with MDE tend to exhibit a subcortical pattern of verbal memory performance characterized by impaired encoding and retrieval of information, and marked improvement on recognition trails (Dunbar & Lishman, 1984; Massman, Delis, Butters, Dupont, & Gillin, 1992). The results of the present study are consistent with deficits in memory found in MDD (Burt et al., 1995; R. M. Cohen et al., 1982; Golinkoff & Sweeney, 1989; Ilsley et al., 1995).

In addition, pregnant women learned significantly fewer words from trials one through five, recalled fewer words on CVLT immediately and after short- and long-delay, and also utilized semantic clustering strategy less often versus postpartum women. These results of reproductive status group differences support subjective complaints and objective findings of diminished memory during the pregnancy period (Brindle et al., 1991; Buckwalter et al., 2001; Buckwalter et al., 1999; de Groot et al., 2003; de Groot et al., 2006; Lurie, 2005; Sharp et al., 1993). Of note, a few previous studies found subjective complaints of memory, but failed to detect memory deficits when measuring objectively (Casey et al., 1999; Crawley et al., 2003; Janes et al., 1999; McDowall & Moriarty, 2000; Z. Schneider, 1989). These discrepant findings may be due to methodological limitations of previous studies, such as small sample size, different phases of pregnancy, limited measures of neurocognitive domains and lack of standardized measures, or failing to control for potential confounding variables.

Our findings of diminished performance of verbal memory in pregnancy compared to postpartum is consistent with a longitudinal study of explicit memory by Keenan and colleagues (1998), who found a pregnancy-related decline in memory in the third trimester and improvement in memory function postpartum in healthy women.
without depression. Our findings also were consistent with other investigators who found no performance decrements in the postpartum period (Freedman et al., 1952; Jarrahi-Zadeh et al., 1969; Rofe & Algom, 1985; Swain et al., 1997; Yalom et al., 1968). Of note, a few studies did find diminished performance in verbal learning and memory during the postpartum period (Buckwalter et al., 2001; Buckwalter et al., 1999; de Groot et al., 2006; Eidelman et al., 1993). These differences, may in part be explained by timing of testing during the postpartum period. That is, several investigators point out that these deficits in verbal memory in the postpartum period may be transient and only occur during the early motherhood (de Groot et al., 2006; Eidelman et al., 1993).

Sleep and Memory Performance. In order to examine the effects of subjective sleep on memory performance, we administered several measures of subjective sleep. When examining PSQI (a measure of subjective sleep quality over the past month), DP reported poorer sleep quality, longer sleep latency, and increased sleep disturbance, and daytime dysfunction versus NC women. In addition, when examining the sleep diary entry on the night prior to memory testing, in pregnant women, DP reported more awakenings. Fatigue was measured in the present study at time of intake and memory testing. We found depressed patients reported feeling more fatigued at intake and at time of memory testing versus NC women. Taken in total, these findings suggest that subjective sleep disturbance, poor sleep quality, and fatigue may be a moderating variable and may contribute to poor memory performance.

However, when reproductive status was examined for differences on the PSQI and sleep diary, postpartum women reported significantly poorer sleep quality and increased sleep disturbance, and awakenings than pregnant women. No significant group
differences were found between pregnant and postpartum women in terms of fatigue. Since postpartum women reported more sleep disturbance, poorer sleep quality, and similar fatigue levels; yet performed significantly better on verbal learning and memory compared with pregnant women, it appears that sleep may not greatly influence memory performance after all.

Implications for Daily Living

So what does this mean in terms of women completing tasks in their daily lives? Studies of major depressive disorder have shown that neurocognitive deficits impact daily living. Memory deficits in maternal depression may also translate into experience related deficits in “real world” functioning and jeopardize care for other children during the pregnancy and early postpartum period. For example, maternal depression may compromise consenting to medical procedures, understanding hospital discharge instructions, transmission of childcare technique instructions, and care for newborn and other children. Specifically, verbal memory deficits may impact the ability to remember medical appointments, medication administration, instructions during medical visits, and other errands and appointments that may occur. When women with maternal depression feel the burden of time constraints, they may make more errors when performing instrumental activities of daily living such as drops, spills, or other accidents in the home. Patients with medical and delivery complications, sick neonates, or low social support may be of greatest concern.

Treatment Implications

In addition, deficits in memory may cloud a new mother’s decision-making about treatment options. Deficits in verbal memory in pregnant women with clinical depression
might explain why previous experiences of therapy have not worked well and suggest alternative paths of treatment. For example, Taylor and colleagues (2006) found examining psychomotor speed helped identify a subgroup of depressed patients that were unresponsive to fluoxetine, suggesting that patients may be cognitively profiled to predict treatment response. Tailoring therapy to level of neurocognitive ability may aid in comprehension and compliance of treatment. It may be necessary to tailor existing therapy to memory ability by increasing repetition and check-ins, providing written handouts, or by having patients summarize more often; or it may be necessary to develop new strategies to aid treatment outcome, such as replacing cognitive therapy with more behavioral techniques or utilizing biological interventions (e.g., light treatment, wake therapy).

**Possible Strategies to Ameliorate Memory Deficits**

Memory deficits may be improved by treating the underlying depression. In addition, clinicians may employ specific techniques to sharpen existing memory and make new information more easily retainable. For example, trying to make new information more meaningful and relevant to the patient by personalizing it will aid in recall. In addition, there are certain organizational habits that patients can be taught in order to perform better, such as sticking to a routine; keeping important, frequently used belongings in the same place; using a calendar or electronic organizer to remember appointment and other important dates; using a daily planner to keep lists of things to do each day, phone calls, bills, errands, medication administration, etc.; using and updating an address book to remember names and phone numbers; and using repetition, grouping, and retracing strategies.
Strengths and Limitations

A strength and limitation of the study is the rich ethnic diversity of the sample. In this sample of 58 women, 25 were Caucasian (43%), 20 were Hispanic (34%), 9 were Asian (16%) and 4 were African American (7%). While ethnic diversity increases ability to generalize findings, it might be at the expense of internal validity. Previous studies have demonstrated that ethnicity may influence results of neurocognitive testing and results should be interpreted with caution. At first blush, the large sample of ethnic minorities would suggest interpreting these results with caution. However, results of memory testing were normed for sex, age, and ethnicity (in African Americans). It remains largely unknown what the effects of other ethnic origins (such as, Hispanic and Asian) have on memory performance. That said, ethnicity was sampled relatively equally across groups. Consequently, ethnicity may not be a confounding variable or influence study results. For percentage of ethnicity per group see Table 1.

In addition, to increase enrollment, women were given the option to test in their home environments. Therefore, the use of environmental setting could also be seen as both a strength and limitation. On one side, women were allowed to test in a setting that was more comfortable to them and represented a more “real world” setting, however, all variables outside the laboratory can not be controlled. Study personnel did their best to control the home testing environment, by ensuring a quiet testing area and flat space to work, and allowing breaks when needed. However, more often in the postpartum condition, women had new infants to care for simultaneously to memory testing. While this may be more representative of “real world” by forcing women to multitask and care for infants while completing memory tasks, it may have interfered with performance on
tests. This challenge further supports the findings that postpartum women performed significantly better versus pregnant women, despite the challenge of caring for an infant while completing testing. This finding may suggest that postpartum women have a strength in divided and selective attention, by utilizing these abilities to overcome challenges and perform relatively well on tasks. Despite these limitations, the present study provides an initial exploration into the mood, memory, and sleep in pregnant and postpartum women with and without major depression.

**Future Directions**

Although this study is limited by its cross-sectional design and we do not have data on pre-pregnancy baseline performance, it appears that memory performance may increase in the postpartum period and return to baseline/premorbid functioning (at least when compared to pregnant counterparts). Longitudinal studies examining memory performance prior to and during pregnancy through the postpartum period would be necessary to confirm this initial finding. It would also be useful to examine memory in non-pregnant/postpartum women with and without depression compared to those women experiencing maternal depression to explore effects of reproductive status and delineate major depression from maternal depression. Further, longitudinal studies examining the course of maternal depression after it remits would be useful to examine long-term effects of mood on memory functioning. Finally, the notion of subjective-objective discrepancies in depressed patients is not a new idea and can be found in the sleep literature as well (Argyropoulos et al., 2003; Tsuchiyama et al., 2003; Weiss et al. 1973). Tsuchiyama and colleagues (2003) examined 23 patients with MDD and found that patients tended to inaccurately estimate total sleep time when compared with objective
polysomnographic (PSG) measures of sleep. These misinterpretations were influenced by degree of objective sleep disturbance, severity of depression, age, and personality. Future studies examining objective sleep and daytime sleepiness using polysomnography, multiple sleep latency test, or actigraphy in conjunction with measuring memory performance might be able to determine more accurately sleep effects on memory performance in maternal depression. Although results only partially confirm that sleep is a moderating variable of mood – performance relationship, it is important to continue to explore this issue because of the potential of sleep disturbance as a modifiable risk factor for both depression and memory deficits.

Potential Moderating Effects of Hormones on Memory Functioning

Several investigators have found that ovarian hormones estrogen and progesterone contribute to the higher incidence of major depression (Abou-Saleh, Ghubash, Karim, Krymski, & Bhai, 1998; Asher et al., 1995; Parry et al., 2003). Estrogen receptors in the brain, could mediate estrogen-induced vasodilatation that could affect the blood supply of the brain. Estrogen receptors are located in areas of the brain involved with memory, e.g., cerebral cortex, basal forebrain, and hippocampus. When estrogen levels begin to decline with menopause, there is a decline in various cognitive functions in women, such as memory, attention and language (Ditkoff, Crary, Cristo, & Lobo, 1991; Joffe et al., 2006; Maki, 2002; Sherwin, 1994, 2006). Other research has examined neuropsychological performance across the menstrual cycle (Hampson, 1990; Keenan, Stern, Janowsky, & Pedersen, 1992; Phillips & Sherwin, 1992). Resnick, Perry, Parry, Mostofi, and Udell (1998) examined neurocognitive performance of 37 women with and without premenstrual dysphoric disorder (PMDD) and found psychomotor slowing in the
late luteal phase in women with PMDD compared with the early follicular phase.

Buckwalter and colleagues (1999) examined the effects of steroid hormones on cognition in 19 pregnant women followed 2 months postpartum. During pregnancy, higher levels of progesterone were associated with greater mood disturbances and higher levels of dehydroepiandrosterone with better mood. After delivery, testosterone was strongly and consistently associated with greater reported mood disturbances. However, no hormone consistently has been found to be related to memory performance during pregnancy. Buckwalter et al. conclude that peripartal memory deficit could not be explained by the dramatic rise in circulating steroid hormones during pregnancy. However, memory functioning may not be related to the absolute value of reproductive hormones. Rather, it may be the case that memory performance is associated with longitudinal changes in reproductive hormone levels during pregnancy or their interaction with stress.

While clinical manifestations can be very similar, there may be neurocognitive distinctions between MDD and reproductive mood disorders. The similarities and differences between memory performance and pathophysiological processes of major depression and depressed mood proximate to reproductive hormone change must still be clarified. Further studies examining reproductive hormones (such as estrogen, progestin, and prolactin) and neuroendocrine variables (such as cortisol and follicle stimulating hormone) known to influence memory, in conjunction with measuring memory performance of maternal depression would be useful to determine potential associations.

Summary

In sum, the results confirm hypotheses one and three, and are consistent with previous investigations that found pregnant women and patients with major depression
exhibit greater deficits in tasks involving verbal learning memory compared with normal control and postpartum women. As depressed mood increased, neurocognitive errors increased. Although women experienced diminished verbal learning and memory during pregnancy, these deficits diminished in the postpartum period. In addition, the effects of sleep disturbance did not influence memory performance. Although postpartum women reported greater sleep complaints, they exhibited increased performance on memory tasks when compared with pregnant women. Further studies examining objective sleep are needed to clarify this issue. Finally, longitudinal studies examining reproductive hormones and neurocognitive performance over the course of pregnancy and the postpartum period are needed to explore changing levels of reproductive hormones and their effects on memory when interacting with stress.
### APPENDIX

<table>
<thead>
<tr>
<th>Major Depressive Disorder</th>
<th>Pregnancy &amp; Postpartum</th>
<th>Maternal Depression</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>↓ Verbal memory</td>
<td>↓ Verbal memory</td>
<td>Unknown</td>
<td>↓ Verbal memory</td>
</tr>
<tr>
<td>↓ Working memory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>↓ Attention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>↓ Psychomotor speed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>↓ Executive function</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Cognitive deficits found in the literature and proposed hypothesis
Figure 2: Mean score (± SE) of Hamilton Depression Rating Scale (HDRS) of pregnant and postpartum women with and without major depression. Significant group differences were found for diagnosis, where depressed pregnant and postpartum women exhibited a higher score on HDRS.
Figure 3: Mean score (± SE) of California Verbal Learning Test Learning Trial (CVLT) 1-5 in pregnant and postpartum women with and without major depression. Significant group differences were found for diagnosis and reproductive status, where depressed and pregnant women learned fewer words on CVLT than normal control and postpartum women.
Figure 4: Mean (± SE) of California Verbal Learning Test (CVLT) Long Delay Free Recall (standardized score) in pregnant and postpartum women with and without major depression. Significant group differences were found for diagnosis and reproductive status, where depressed and pregnant women recalled fewer words than normal control and postpartum women.
Figure 5: Mean (± SE) of California Verbal Learning Test Semantic Clustering (standardized score) in pregnant and postpartum women with and without major depression. Significant group differences were found for diagnosis and reproductive status, where depressed and pregnant women utilized semantic clustering strategy less often than normal control and postpartum women.
Figure 6: Mean score (± SE) of Pittsburgh Sleep Quality Index (PSQI) in pregnant and postpartum women with and without major depression. Significant group differences were found for diagnosis and reproductive status, where depressed and postpartum women reported poorer sleep quality (indicated by higher score on PSQI) compared to normal control and pregnant women.
Figure 7: Mean (± SE) of Number of Awakenings on Sleep Diary on night prior to neurocognitive testing. Significant overall interaction and simple effects were found. In pregnant (but not postpartum) women, depressed patients reported more awakenings than normal women. In normal control (but not depressed) women, postpartum women reported more awakenings than pregnant women.
Figure 8: Mean score (± SE) of Multidimensional Fatigue Inventory (MFI) in pregnant and postpartum women with and without major depression. Significant group differences for diagnosis were found, where depressed women reported greater fatigue compared to normal control women.
Figure 9: Scatterplot of Hamilton Depression Rating Scale (HDRS) and Pittsburgh Sleep Quality Index (PSQI). A positive association was found. That is, as scores on HDRS increased (indicating greater depression), scores on PSQI increased (indicating poorer subjective sleep quality).
Table 1: Demographic variables for pregnant and postpartum women with and without major depression. Group means (standard deviations) or percentages where indicated.

<table>
<thead>
<tr>
<th></th>
<th>Pregnant NC (n=23)</th>
<th>Pregnant DP (n=14)</th>
<th>Postpartum NC (n=10)</th>
<th>Postpartum DP (n=11)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>28.1 (5.3)</td>
<td>27.1 (5.4)</td>
<td>27.3 (3.3)</td>
<td>28.4 (6.8)</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td>15 (2.7)</td>
<td>14 (3.1)</td>
<td>15 (2.5)</td>
<td>15 (1.8)</td>
</tr>
<tr>
<td><strong>Ethnicity (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>65</td>
<td>29</td>
<td>20</td>
<td>37</td>
</tr>
<tr>
<td>Hispanic</td>
<td>35</td>
<td>21</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>African American</td>
<td>0</td>
<td>21</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Asian</td>
<td>0</td>
<td>29</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td><strong>Weeks preg/pp</strong></td>
<td>24.9 (8.6)</td>
<td>24.8 (10.1)</td>
<td>23.9 (13.2)</td>
<td>22.2 (16.8)</td>
</tr>
<tr>
<td><strong>Trimester (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First (1-13 weeks)</td>
<td>20.8</td>
<td>25</td>
<td>28.6</td>
<td>33.3</td>
</tr>
<tr>
<td>Second (14-25 weeks)</td>
<td>29.2</td>
<td>25</td>
<td>14.3</td>
<td>33.3</td>
</tr>
<tr>
<td>Third (26+ weeks)</td>
<td>50</td>
<td>50</td>
<td>57.1</td>
<td>33.3</td>
</tr>
<tr>
<td>No. of children</td>
<td>0 (0.4)</td>
<td>1 (1.0)</td>
<td>2 (1.0)</td>
<td>2 (0.6)</td>
</tr>
</tbody>
</table>

Note. No significant group differences on any demographic variable p’s > .05
Table 2: Study Timeline

<table>
<thead>
<tr>
<th>Week</th>
<th>Appointment</th>
<th>Length</th>
<th>Data Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-week 1</td>
<td>Study Overview &amp; Initial Telephone Screen</td>
<td>20-30 mins</td>
<td>Inclusion/Exclusion criteria</td>
</tr>
<tr>
<td>Week 1</td>
<td>Intake</td>
<td>1-3 hours</td>
<td>Psychiatric &amp; medical history, present diagnoses, mood, sleep, psychosocial, reproductive variables</td>
</tr>
<tr>
<td></td>
<td>Informed consent</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SCID, questionnaires, sleep log between visits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2</td>
<td>Memory Testing + Mood measures</td>
<td>1.5 - 2 hrs</td>
<td>Memory performance, mood and fatigue variables</td>
</tr>
</tbody>
</table>
Table 3: Measures

<table>
<thead>
<tr>
<th>TEST</th>
<th>DOMAIN(S)</th>
<th>CUT-OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mood measures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hamilton Depression Rating Scale (HDRS)</td>
<td>Objective measure of depression</td>
<td>± 15</td>
</tr>
<tr>
<td>HDRS Addendum of SIGH-SAD</td>
<td>Atypical symptoms of depression</td>
<td>-</td>
</tr>
<tr>
<td>Hypomania Rating Scale</td>
<td>Mania symptoms</td>
<td>± 10</td>
</tr>
<tr>
<td>Beck Depression Inventory</td>
<td>Subjective depression</td>
<td>± 10</td>
</tr>
<tr>
<td>Beck Anxiety Inventory</td>
<td>Subjective anxiety</td>
<td>± 10</td>
</tr>
<tr>
<td>Edinburgh Postnatal Depression Scale</td>
<td>Subjective maternal depression</td>
<td>± 10</td>
</tr>
<tr>
<td><strong>Neuropsychological measure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>California Verbal Learning Test</td>
<td>Verbal learning and memory</td>
<td>± 2 S.D.’s</td>
</tr>
<tr>
<td><strong>Sleep measures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pittsburgh Sleep Quality Index</td>
<td>Global sleep quality</td>
<td>± 5</td>
</tr>
<tr>
<td>Sleep diary</td>
<td>Prospective subjective sleep</td>
<td>-</td>
</tr>
<tr>
<td>Multidimensional Fatigue Inventory</td>
<td>Fatigue</td>
<td>± 50</td>
</tr>
<tr>
<td>Horne-Östberg Questionnaire MEQ</td>
<td>Circadian preference</td>
<td>± 40</td>
</tr>
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</table>
Table 4: Group means and standard deviations for mood measures in pregnant and postpartum women with and without major depression at time of intake.

<table>
<thead>
<tr>
<th></th>
<th>Pregnant NC (n=23)</th>
<th>Pregnant DP (n=14)</th>
<th>Postpartum NC (n=10)</th>
<th>Postpartum DP (n=11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamilton Depression Rating Scale**</td>
<td>4.0 (2.8)</td>
<td>14.3 (5.2)</td>
<td>4.3 (3.7)</td>
<td>16.0 (3.1)</td>
</tr>
<tr>
<td>Hamilton Addendum (as part of SIGH-SAD)**</td>
<td>2.9 (1.6)</td>
<td>6.8 (2.1)</td>
<td>2.2 (1.5)</td>
<td>4.9 (3.2)</td>
</tr>
<tr>
<td>Hypomania Rating Scale*</td>
<td>1.3 (1.6)</td>
<td>2.2 (1.5)</td>
<td>1.2 (1.5)</td>
<td>4.1 (4.0)</td>
</tr>
<tr>
<td>Beck Depression Inventory**</td>
<td>5.9 (4.1)</td>
<td>15.5 (7.8)</td>
<td>4.0 (2.6)</td>
<td>20.9 (10.5)</td>
</tr>
<tr>
<td>Beck Anxiety Inventory**</td>
<td>6.6 (6.5)</td>
<td>15.2 (11.0)</td>
<td>2.4 (2.1)</td>
<td>14.1 (5.3)</td>
</tr>
<tr>
<td>Edinburgh Postnatal Depression Scale**</td>
<td>3.3 (2.4)</td>
<td>10.8 (4.0)</td>
<td>2.7 (2.3)</td>
<td>13.9 (2.3)</td>
</tr>
</tbody>
</table>

Note. * p < .01 and ** p < .001 for diagnosis (DP vs. NC)
Table 5: Group means and standard deviations for mood measures in pregnant and postpartum women with and without major depression at time of memory testing.

<table>
<thead>
<tr>
<th></th>
<th>Pregnant NC (n=23)</th>
<th>Pregnant DP (n=14)</th>
<th>Postpartum NC (n=10)</th>
<th>Postpartum DP (n=11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamilton Depression Rating Scale**</td>
<td>4.3 (3.5)</td>
<td>15.6 (5.7)</td>
<td>4.8 (4.1)</td>
<td>18.0 (8.5)</td>
</tr>
<tr>
<td>Hamilton Addendum (as part of SIGH-SAD)**</td>
<td>2.4 (2.3)</td>
<td>7.8 (2.9)</td>
<td>2.3 (1.8)</td>
<td>7.1 (2.8)</td>
</tr>
<tr>
<td>Hypomania Rating Scale**</td>
<td>1.2 (1.3)</td>
<td>3.5 (2.5)</td>
<td>1.0 (1.6)</td>
<td>4.0 (3.7)</td>
</tr>
<tr>
<td>Beck Depression Inventory**</td>
<td>4.6 (2.7)</td>
<td>15.1 (8.5)</td>
<td>1.8 (2.4)</td>
<td>16.5 (7.4)</td>
</tr>
<tr>
<td>Beck Anxiety Inventory**</td>
<td>3.4 (3.3)</td>
<td>13.9 (9.6)</td>
<td>2.8 (3.5)</td>
<td>12.3 (8.5)</td>
</tr>
<tr>
<td>Edinburgh Postnatal Depression Scale**</td>
<td>2.1 (2.9)</td>
<td>10.2 (4.1)</td>
<td>3.0 (1.8)</td>
<td>12.4 (5.3)</td>
</tr>
</tbody>
</table>

Note. ** p < .001 for diagnosis (DP vs. NC)
Table 6: Group means and standard deviations for memory performance in pregnant and postpartum women with and without major depression.

<table>
<thead>
<tr>
<th></th>
<th>Pregnant NC (n=23)</th>
<th>Pregnant DP (n=14)</th>
<th>Postpartum NC (n=10)</th>
<th>Postpartum DP (n=11)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Verbal Learning &amp; Memory</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLVT Learning T1-T5</td>
<td>33.5 (14.8)</td>
<td>27.5 (13.1)</td>
<td>45.8 (19.8)</td>
<td>36.3 (12.5)</td>
</tr>
<tr>
<td>CVLT Short-delay free recall</td>
<td>-1.5 (1.4)</td>
<td>-2.1 (1.0)</td>
<td>-0.6 (2.1)</td>
<td>-0.7 (1.2)</td>
</tr>
<tr>
<td>CVLT Short-delay cued recall</td>
<td>-1.5 (1.0)</td>
<td>-2.1 (1.0)</td>
<td>-0.4 (1.3)</td>
<td>-0.7 (1.3)</td>
</tr>
<tr>
<td>CVLT Long-delay free recall</td>
<td>-2.0 (1.5)</td>
<td>-3.4 (1.3)</td>
<td>-0.2 (1.7)</td>
<td>-1.2 (1.7)</td>
</tr>
<tr>
<td>CVLT Long-delay cued recall</td>
<td>-2.0 (1.7)</td>
<td>-2.4 (1.5)</td>
<td>-1.0 (1.2)</td>
<td>-1.1 (0.8)</td>
</tr>
<tr>
<td>CVLT Perseveration errors</td>
<td>-0.3 (1.3)</td>
<td>-0.1 (0.9)</td>
<td>-0.8 (0.4)</td>
<td>0.3 (1.4)</td>
</tr>
<tr>
<td>CVLT Semantic clustering</td>
<td>-0.7 (0.9)</td>
<td>-1.4 (0.5)</td>
<td>0.0 (1.2)</td>
<td>-0.7 (0.7)</td>
</tr>
</tbody>
</table>
Table 7: Group means and standard deviations for sleep measures in pregnant and postpartum women with and without major depression.

<table>
<thead>
<tr>
<th>Pittsburgh Sleep Quality Index (PSQI)</th>
<th>Pregnant NC (n=23)</th>
<th>Pregnant DP (n=14)</th>
<th>Postpartum NC (n=10)</th>
<th>Postpartum DP (n=11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index 1 – Sleep quality</td>
<td>0.4 (0.5)</td>
<td>1.3 (1.0)</td>
<td>1.2 (1.2)</td>
<td>1.8 (1.3)</td>
</tr>
<tr>
<td>Index 2 – Sleep latency</td>
<td>0.3 (0.5)</td>
<td>0.9 (0.8)</td>
<td>0.0 (0.0)</td>
<td>0.7 (0.5)</td>
</tr>
<tr>
<td>Index 3 – Sleep duration</td>
<td>0.5 (0.7)</td>
<td>0.2 (0.7)</td>
<td>0.5 (0.8)</td>
<td>1.3 (1.2)</td>
</tr>
<tr>
<td>Index 4 – Sleep efficiency</td>
<td>0.5 (0.5)</td>
<td>0.7 (0.9)</td>
<td>0.5 (0.5)</td>
<td>0.3 (0.8)</td>
</tr>
<tr>
<td>Index 5 – Sleep disturbance</td>
<td>1.4 (0.5)</td>
<td>2.1 (0.3)</td>
<td>1.0 (0.0)</td>
<td>1.7 (0.5)</td>
</tr>
<tr>
<td>Index 6 – Use of sleep medications</td>
<td>0.8 (0.5)</td>
<td>1.2 (0.4)</td>
<td>1.2 (0.4)</td>
<td>1.7 (1.0)</td>
</tr>
<tr>
<td>Index 7- Daytime dysfunction</td>
<td>0.3 (0.5)</td>
<td>1.4 (1.6)</td>
<td>0.2 (0.4)</td>
<td>1.8 (2.1)</td>
</tr>
<tr>
<td>PSQI Global Score</td>
<td>4.1 (2.1)</td>
<td>7.8 (2.3)</td>
<td>4.5 (1.5)</td>
<td>9.3 (5.3)</td>
</tr>
</tbody>
</table>

Sleep diary (night prior to testing)

| Lights out | 22:54h | 23:22h | 23:06h | 21:06h |
| Rise time  | 07:36h | 08:09h | 08:20h | 05:54h |
| Sleep latency | 20" (36) | 18" (14) | 12" (5) | 46" (63) |
Table 7: Group means and standard deviations for sleep measures in pregnant and postpartum women with and without major depression, Continued.

<table>
<thead>
<tr>
<th></th>
<th>Pregnant NC (n=23)</th>
<th>Pregnant DP (n=14)</th>
<th>Postpartum NC (n=10)</th>
<th>Postpartum DP (n=11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of awakenings</td>
<td>0.9 (0.9)</td>
<td>2.3 (1.5)</td>
<td>3.0 (1.2)</td>
<td>2.5 (1.3)</td>
</tr>
<tr>
<td>Wake after sleep onset</td>
<td>7m (13.2)</td>
<td>37m (64)</td>
<td>38m (24)</td>
<td>40m (31)</td>
</tr>
<tr>
<td>Total Sleep Time</td>
<td>8h 15m</td>
<td>7h 52m</td>
<td>8h 24m</td>
<td>7h 22m</td>
</tr>
<tr>
<td>Nap time</td>
<td>14m (40)</td>
<td>89m (63)</td>
<td>70m (97)</td>
<td>0m (0)</td>
</tr>
</tbody>
</table>

**Multidimensional Fatigue Inventory**

<p>| | | | | |</p>
<table>
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</thead>
<tbody>
<tr>
<td>MFI at Intake</td>
<td>45.4 (9.2)</td>
<td>57.0 (11.5)</td>
<td>51.8 (10.5)</td>
<td>57.7 (10.6)</td>
</tr>
<tr>
<td>MFI at NP testing</td>
<td>48.5 (12.5)</td>
<td>57.1 (11.4)</td>
<td>46.0 (6.0)</td>
<td>60.6 (14.2)</td>
</tr>
</tbody>
</table>

**Horne-Östberg Morningness Evenness Questionnaire**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>56.1 (10.0)</td>
<td>56.6 (6.0)</td>
<td>52.5 (10.6)</td>
<td>61.8 (7.0)</td>
<td></td>
</tr>
</tbody>
</table>
References


Massman, P. J., Delis, D. C., Butters, N., Dupont, R. M., & Gillin, J. C. (1992). The subcortical dysfunction hypothesis of memory deficits in depression:


