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# Cognitive Functioning During Pregnancy: A Controlled Investigation Using Psychometric Testing

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**Abstract**

We report the results of prospective psychometric testing of a group of pregnant women and a comparison with non-pregnant controls. The tests utilised to assess cognitive function were the Selective Reminding Test, the Stroop Test and the Cognitive Failures Questionnaire. In addition, the Profile of Mood State was administered. The pregnant subjects were tested in the third trimester and re-tested in the eighth post-partum week. An average interval of eleven weeks separated the 2 test administrations. The controls were tested and re-tested after a similar interval. On the Stroop and Selective Reminding tests, both groups significantly improved by very similar amounts on the second testing, suggesting that improvement was an artefact of practice effects on the tests rather than a reflection of impaired cognition during pregnancy. However, on some memory indices, the experimental group's performance (both antenatally *and* postnatally) was significantly inferior to that of the non-pregnant controls. Performance on the two objective tests appeared unrelated to subjective symptomatology or day-to-day cognitive failure. Possible explanations of the findings are discussed and the methodology is critically evaluated.

**Zusammenfassung**

Wir berichten über die Ergebnisse einer prospektiven psychometrischen Testuntersuchung einer Gruppe schwangerer Frauen im Vergleich mit einer Kontrollgruppe von Nichtschwangeren. Die zur

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Prüfung der kognitiven Funktionen verwandten Teste waren der "Selective Reminding Test", der "Stroop Test" und das "Cognitive Failures Questionnaire". Zusätzlich wurde ein Stimmungsprofil erhoben. Die Schwangeren wurden im dritten Trimester getestet und 8 Wochen nach der Geburt wurde die Testuntersuchung wiederholt. Ein mittlerer Abstand von 11 Wochen trennte die beiden Testuntersuchungen. Bei der Kontrollgruppe wurde die Testung in einem ähnlichen Abstand wiederholt. Beim "Stroop Test" und dem "Selective Reminding Test" zeigten beide Gruppen bei der zweiten Untersuchung signifikant bessere Ergebnisse in einem sehr ähnlichen Ausmaß, woraus folgt, daß dies eher ein Artefakt der Untersuchungsdurchführung war als ein Hinweis auf herabgesetzte kognitive Funktionen während der Schwangerschaft. Doch war das Ergebnis der Gruppe der Schwangeren bei einzelnen Gedächtnisfunktionen vor und nach der Geburt signifikant geringer als das der nichtschwangeren Kontrollgruppe. Das Testergebnis scheint unabhängig von den subjektiven Beschwerden oder der Tagesform zu sein. Mögliche Erklärungen für diese Ergebnisse und die methodologischen Gesichtspunkte werden diskutiert.

## Introduction

The possibility that pregnancy may result in alterations in women's cognitive function has received little attention in the literature. Since the 1930's, several anecdotal accounts, mainly from psychoanalysts, have appeared which describe alterations in both the "process" and "content" of thinking. Condon [1] has recently reviewed this literature which suggests that such changes appear to typically commence in the second trimester and remit at approximately three weeks postnatally. These writers suggest that the alteration in the *process* of thinking involves a diminution of the logical, evaluative aspects of cognition and an increase in the more intuitive, less rational modes. Simultaneously, *content* of thought is said to undergo an upsurge of "more primitive" fantasy material.

### *Previous Empirical Studies of Cognition in Pregnancy*

The first systematic attempt to explore this phenomenon was that of Jarrahi-Zadeh et al. [2]. These investigators administered a battery of psychological tests to a group of 86 women in the third trimester of pregnancy and retested the women on the third day postnatally. The same battery of tests was administered to a matched group of 21 non-pregnant control women on *one occasion only*. The authors concluded that women, *both* during pregnancy and the immediate postpartum period, perform less well on cognitive tests than non-pregnant/non-postpartum controls. They found that the degree of impairment was directly related to the level of psychological symptomatology in pregnancy and the immediate postnatal period.

This study could be criticised on at least two grounds. First, the third postpartum day is almost certainly too early to establish any postpartum steady state

level, and in addition is potentially complicated by the occurrence of the three day blues which would be expected in 50% of the sample [3]. Second, cognitive testing was performed twice on the experimental group but only once on the control group and consequently no estimate of the possible influence of practice effects on the test could be obtained, i.e. the trend towards improvement in the postpartum period may simply be an artefact of the women having performed the same tests on one occasion already.

Poser et al. [4] documented the self-reports of 51 professional pregnant women's alterations in cognitive function as the subjects recalled them *retrospectively*, often a considerable time after their actual pregnancies. The investigators reported that 81% of the women reported increased forgetfulness, 51% impaired concentration and 29% increased "confusion". These symptoms appeared unrelated to obstetric or demographic variables. The study suffers from major short-comings in terms of a large degree of retrospectivity and also the failure to use instruments of proven reliability and validity.

In 1987, Condon [5] reported that 48% of a sample of 165 randomly selected women in the third trimester of pregnancy believed that their memory and concentration were impaired *relative to their recollection* of their pre-pregnant level of function. Sixteen percent of the total sample rated this impairment as severe.

In a second investigation Condon and Ball [6] surveyed 90 expectant couples in the third trimester of pregnancy using a 17 item self-report questionnaire which focused on *subjectively experienced* alterations in cognitive function. Each woman's partner independently completed a similar inventory of any changes in her cognitive function which he had observed. Approximately 50% of these women subjectively reported psychological changes corresponding to a decline in cognitive functioning. Approximately one quarter of these (viz 10% of the total sample) rated such changes as "very marked". Statistically significant changes were reported on 13 of the 17 items. There was a highly significant correlation between the woman's self-report and the report of her partner. A very high intercorrelation existed between the 17 items suggesting that, for example, if a woman reported impairment of memory, she would very likely also report impaired concentration, judgement, grasp, problem-solving etc. As was the case in Poser et al.'s [4] study, demographic variables were unrelated to the questionnaire scores.

### *Empirical Studies of Cognition in Relation to the Menstrual Cycle*

In constrast to the paucity of data on cognition during pregnancy, there is a substantial (but controversial) literature on cognitive alterations during the menstrual cycle. The hormonal changes during this cycle are minuscule in magnitude relative to those occuring over the course of normal pregnancy [7]. If indeed such hormonal fluctuations are relevant to cognition, it is curious that cognitive alterations in pregnancy have received relatively so little attention. The suggestion that gonadal steroids influence brain function is supported by at least two lines of evidence. First, Becker et al. [8] have demonstrated EEG changes related to oestrogen fluctuations over the course of the menstrual cycle. Second, Altemus et al. [9] have demonstrated alterations in dichotic listening in women over the course of the menstrual cycle.

The conflicting literature on cognition and the menstrual cycle has been extensively reviewed by Sommer [10,11] and more recently by Logue and Moos [12]. Only two observations from this literature will be briefly reviewed here. Both being particularly relevant to the question of cognitive changes in pregnancy. First, there is increasing recent evidence that specific cognitive abilities may be linked to specific hormones. This is a complex and controversial area, however there is some evidence that oestrogen (possibly via MAO inhibition facilitating synaptic transmission) may enhance performance on repetitive automatic tasks. Conversely, oestrogen my impair performance on tasks requiring a delayed response or perceptual restructuring [13]. Progesterone appears to antagonise these effects of oestrogen [14]. Little is known of the possible effects of prolactin on mood or cognition [15]. Finally, androgens may selectively enhance spatial abilities [16]. This enhancement of spatial abilities appears to be antagonised by oestrogen [17].

More recently, the possibility that endogenous opioids may play a role has been considered. It is known that beta-endorphin reaches very high levels in late pregnancy, however the effect of such substances on cognition is unknown.

The second observation of relevance from the menstrual literature is that there is considerable evidence, that women's *subjective* reports of cognitive impairment premenstrually usually fail to be substantiated in objective laboratory tests or by measurements of function in the workplace [10,11].

Logue and Moos [12] sum up the current situation vis-a-vis the presence of many one-off findings but a dearth of replicated findings. They state:

*"It is tempting to link these findings (on cognition and the menstrual cycle) to changes in hormonal levels, but the results presently available are not sufficient to support any specific hypothesis."*

Clearly, this statement is equally applicable to the findings to date on cognition during pregnancy. The present prospective study aims to examine differences in cognitive function between late pregnancy and 8 weeks postpartum employing a more rigorous methodology which includes testing and retesting non-pregnant control subjects to allow for the effects of practice on tests of cognition.

## Methodology

Thirty-eight women, who met the inclusion criteria of the study, were randomly recruited from patients attending a routine antenatal clinic at a general hospital. The inclusion criteria were that the woman was in the third trimester of pregnancy, suffered no major psychiatric illnesses or complications of pregnancy and was living with a male partner. The latter criterion was dictated by the need to utilise partner reports. Both primiparous and mulitiparous women were included. The study was prospective in design, the 38 women being tested on one occasion during the third trimester and re-tested in the eighth postpartum week, i. e. on average 11 weeks later. This interval is sufficiently long for hormonal changes associated with parturition and breast-feeding to have reached steady state.

On both occasions the women were assessed on four measures:

1. The Profile of Mood States (POMS).
   This instrument [18] is a well-validated measure of subjective mood state and provides scores on six sub-scales, viz tension, depression, anger, vigour, fatigue and confusion.
2. The Cognitive Failures Questionnaire (CFQ).
   This questionnaire [19] measures self-reported failures in perception, memory and motor function which occur in the course of routine day-to-day activities. A truncated version has also been published for completion by the subject's partner and this was also utilised in the present investigation.
3. Selective Reminding Tests (SRT).
   Buschke's Selective Reminding Procedure [20,21] was used to evaluate auditory-verbal learning ability. In contrast to the conventional methods for assessment of list learning, the examiner presents on each trial only those words that the subject failed to recall on the previous trial. This procedure allows measurement of both storage and retrieval parameters yielding scores on each trial for:
   i) Total number of words recalled over all ten trials ("total recall")
   ii) Total words consistently retrieved from long term storage over all ten trails ("longterm retrieval")
   iii) Total number of words entered into longterm storage over all ten trails ("longterm storage")

   In the present study, the word list used antenatally comprised the names of fifteen animals presented over a maximum of ten trials. In the postnatal condition fifteen articles of clothing were used.
4. The Stroop Test.
   This is a reliable and well-validated instrument [22] consisting of three tasks. The first task requires that the subject reads a series of colour names printed in black ink. The second task requires the subject to identify a series of coloured bars. In the third task, the subject is required to name the ink colour used to print the names of colours, where the actual colour of the ink differs from the colour name. Each subject is given 45 seconds to read/name as many items as possible in each of the three conditions. Whilst the first two conditons provide relatively pure measures of reading and colour naming speed, the third condition, because of the conflict between word and colour, measures the ease with which subjects can resist interference by a distracting stimulus.

The Stroop Test and the SRT were administered under standard conditions by a psychologist trained in their use.

A non-pregnant control group of 15 women was recruited from mothers of children attending a nearby pre-school. The control group approximately matched the experimental group in age and socio-economic status. To control for practice effects on the tests, this group was also tested on two occasions eleven weeks apart using both the Stroop and SRT administered by the same psychologist.

The main hypotheses of the study were tested using two-way analysis of variance with repeated measures on time of testing (within seconds) and experimental condition (pregnant versus control) between groups. The dependent variables were the Stroop and SRT scores. The null hypothesis (i.e. that there is no difference between the experimental and control groups in terms of changes in cognitive scores between initial and repeated testing) predicts that the interaction effect between time and group will be non-significant.

## Results

### *Sample Characteristics*

The characteristics of the 38 pregnant women are presented in Table 1. Thus, the majority were Australian women in their middle to late twenties with at least one child. There is a reasonable spread with regard to socio-economic status.

**Table 1.** Demographic characteristics of pregnant women (n = 38)

| | |
|---|---|
| Age (S.D.) | 27.3 (4.7) |
| Nationality (%) | |
| Australian | 67 |
| U.K. | 24 |
| Other | 9 |
| Primigravidas (%) | 21 |
| With one or more children (%) | 64 |
| Social class* | |
| Professional | 18 |
| Semi-professional | 43 |
| Skilled | 7 |
| Semi-skilled | 4 |
| Unskilled | 28 |
| Mean gestation in weeks (S.D.) | 34.9 (3.6) |
| Employed (%) | 12.1 |

* As determined both the woman's level of education and occupational status.

### *Influence of Demographic Variables and Parity*

None of the demographic variables nor parity were significantly related to performance on the SRT memory test either antenatally or postnatally.

In the case of the Stroop test, only social class exerted a significant effect. On both test occasions, higher social class predicted better performance on "word" and "colour" but not on "colour-word". Pearson correlations were approximately 0.4 with two-tail significance of 0.04.

*Influence of Pregnancy on Cognitive Performance*

The means and standard deviations of the Stroop and SRT scores obtained by the experimental and control groups are presented in Table 2. Higher scores denote better performance on both tests and hence it can be seen that *both* groups improved on all measures when re-tested as compared with initial testing.

**Table 2.** Means and standard deviations of scores on the Stroop and SRT tests

| | Exp. group (n = 38) | | Control group (n = 15) | |
|---|---|---|---|---|
| | Antenatal | Postnatal | Initial test | Retest at 11 weeks |
| Stroop Colour / Word Test* | | | | |
| Word | 100.1 (15.5) | 110.5 (16.0) | 107.4 (15.3) | 110.1 (12.1) |
| Colour | 81.3 (16.0) | 88.6 (17.4) | 81.3 (12.2) | 85.7 (11.7) |
| Colour-Word | 50.1 (11.1) | 55.1 (13.0) | 48.1 (13.5) | 53.0 (11.0) |
| Selective Reminding Test# | | | | |
| Total recall | 97 (14) | 111 (13) | 108 (15) | 119 (16) |
| Longterm retrieval | 61 (14) | 72 (23) | 75 (21) | 88 (20) |
| Longterm storage | 119 (18) | 125 (14) | 120 (18) | 125 (16) |

* Units are words read / colours named in 45 seconds.
\# Units are total words over 10 trials.

The results of the two-way MANOVA with repeated measures are summarised in Table 3 for the Stroop colour-word scores and the three SRT indices. The main findings which emerge are:

1. *Both* the experimental and control groups demonstrate highly significant improvement on *all* cognitive measures on re-testing ($p < .001$ on all measures). These are represented by the "within groups (time)" effects in Table 3.
2. In terms of the *degree* of improvement on re-testing, there is *no* significant difference between the experimental group and the controls. See "interaction" (groups × time) effects in Table 3.
3. On two of the SRT indices, viz total recall and longterm retrieval (but not on the Stroop or longterm storage the performance of the experimental group is significantly inferior to that of the controls on *both* testing occasions. See "between groups" effects in Table 3.

In summary, the significant improvement which pregnant women demonstrate when re-tested at eight weeks postpartum is no different from that shown by non-pregnant controls tested eleven weeks apart. However, the performance of the pregnant group on two of the SRT indices is less proficient than that of the controls and continues to remain so even at eight weeks postpartum.

**Table 3.** Results of 2-way repeated-measures analysis of variance

| Source | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| Stroop Colour-Word | | | | | |
| Between groups | 92.3 | 1 | 92.3 | 0.37 | 0.544 |
| Error | 12635.0 | 51 | 248.0 | | |
| Within groups (time)* | 536.0 | 1 | 536.0 | 11.42 | 0.001 |
| Interaction | 0.1 | 1 | 0.1 | 0.00 | 0.968 |
| Error | 2394.0 | 51 | 47 | | |
| SRT: Total recall | | | | | |
| Between groups* | 2173 | 1 | 2173 | 7.28 | 0.009 |
| Error | 15220 | 51 | 298 | | |
| Within groups (time)* | 3407 | 1 | 3407 | 31.80 | 0.000 |
| Interaction | 59 | 1 | 59 | 0.55 | 0.462 |
| Error | 5456 | 51 | 107 | | |
| SRT: Longtime retrieval | | | | | |
| Between groups* | 4546 | 1 | 4546 | 9.03 | 0.004 |
| Error | 25669 | 51 | 503 | | |
| Within groups (time)* | 3028 | 1 | 3028 | 12.95 | 0.001 |
| Interaction | 8 | 1 | 8 | 0.03 | 0.856 |
| Error | 11924 | 51 | 234 | | |
| SRT: Longterm storage | | | | | |
| Between groups | 480 | 1 | 480 | 1.27 | 0.265 |
| Error | 18887 | 50 | 378 | | |
| Within groups (time)* | 1752 | 1 | 1752 | 11.8 | 0.001 |
| Interaction | 318 | 1 | 318 | 2.15 | 0.149 |
| Error | 7397 | 50 | 148 | | |

* Denotes significance at $p < 0.01$ level.

### *Relationship Between Stroop and SRT Scores*

There were very significant correlations between the three Stroop measures and also between the three SRT measures ($p < .001$ in all cases). However, none of the Stroop measures significantly correlated with any of the SRT indices. Thus, the two tests appeared to measure quite distinct abilities relating to speed of information processing versus memory.

### *POMS Scores and Their Relationship to Cognitive Functioning*

As shown in Table 4, the experimental group exhibited decreased levels of psychological symptoms on all six POMS sub-scales in the postpartum period as compared to the third trimester. These decreases achieved statistical significance on the global score and on all sub-scales except anger.

Both antenatally and postnatally, POMS scores failed to have any significant association with performance on either the Stroop or the SRT. Likewise, *differ-*

**Table 4.** Results on profile of mood states and cognitive failures questionnaire for the experimental group

| | Antenatal mean (S.D.) | Postnatal mean (S.D.) | t (paired) | p (2 tail) |
|---|---|---|---|---|
| POMS scores | | | | |
| Tension | 14.5 (7.7) | 10.6 (6.5) | 2.7 | 0.01 |
| Depression | 12.6 (9.8) | 9.3 (8.1) | 2.1 | 0.04 |
| Anger | 10.1 (7.5) | 9.6 (8.1) | 0.3 | NS |
| Vigour (reverse scored) | 11.1 (6.1) | 14.7 (7.0) | 2.8 | 0.01 |
| Fatigue | 15.7 (6.5) | 11.8 (6.2) | 3.4 | 0.002 |
| Confusion | 10.6 (5.6) | 7.2 (3.9) | 3.8 | 0.001 |
| Global score | 52.3 (33.9) | 33.7 (29.0) | 3.2 | 0.003 |
| Cognitive failures questionnaire scores | | | | |
| Self-report (total) | 67.9 (16.5) | 63.5 (15.2) | 1.74 | 0.09 |

*ences* between antenatal and postnatal POMS scores were not correlated with *differences* in scores on either of the cognitive tests.

### *Cognitive Failures Questionnaire (CFQ) Scores and Their Relationship to Objective Cognitive Measures*

As shown in Table 4, women reported more episodes of cognitive failure in the third trimester as compared with eight weeks postpartum, however the difference failed to reach statistical significance.

The antenatal partner-report cognitive failure scores were very significantly correlated with the women's own self-report ratings (Pearson correlation = 0.55, $p = .001$) which lends validity to the self-report findings.

Both antenatally and postnatally, CFQ scores failed to predict performance on either the Stroop or the SRT. Likewise, differences between antenatal and postnatal CFQ scores were uncorrelated with differences on either of the cognitive test scores.

There were very significant correlations between POMS and CFQ scores (Table 5). Thus, high levels of symptomatology on the POMS strongly predicted high levels of subjective cognitive failure in both the antenatal and postnatal periods. Likewise, changes in POMS scores (between antenatal and postnatal testing) were strongly correlated with changes in CFQ scores.

## Discussion

### *Critique of Methodology*

The original sample of 38 pregnant women may be considered free from any obvious sample bias and there were no drop-outs between the initial and subsequent testing in either the experimental or control group.

**Table 5.** Correlations between POMS and CFQ scores antenatally and postnatally

| | CFQ scores | |
|---|---|---|
| | Antenatal | Postnatal |
| Antenatal or postnatal POMS | | |
| Tension | 0.56* (.000) | 0.64 (.000) |
| Depression | 0.46 (.003) | 0.37 (.02) |
| Anger | 0.23 (NS) | 0.23 (NS) |
| Vigour | −0.27 (NS) | −0.34 (.04) |
| Fatigue | 0.39 (.01) | 0.48 (.004) |
| Confusion | 0.73 (.000) | 0.55 (.001) |
| Global | 0.55 (.000) | 0.47 (.005) |

* Pearson correlation (1 tail significance).

The Stroop Test and SRT provide sensitive measures of cognitive impairment and were administered on both occasions in a standardized setting by the same psychologist trained in their use. No ceiling effects were encountered on either test. The POMS and CFQ have also been widely used and well-validated. The high correlation between CFQ scores and partner-reports of cognitive failure lend validity to the self-report CFQ data.

Although all the women were in the third trimester, they were at different gestations (mean = 34.9 weeks, S.D. = 3.6 weeks). The influence of gestation on cognitive performance was explored and found to be non-significant. However, this variation in gestation does result in varying intervals between testing and re-testing. In future studies a more uniform gestation may be desirable so that controls and experimental subjects are re-tested after exactly the same interval.

The original purpose of the control group was to enable an estimate to be made of the importance of practice effects. The control group was approximately matched for age and social class. In retrospect, as will be discussed below, more comprehensive matching (e.g. for intellectual ability) would have been desirable. The relatively small size of both the experimental and control groups limits the power of the study. Nevertheless, as will be discussed further below, those findings which failed to reach statistical significance also failed to exhibit trends of a kind which one might suspect would become significant in a sample of larger size.

*The Assessment of "Performance"*

As pointed out by Broadbent [19,23], "performance" is a complex construct, the assessment of which is difficult and the determinants of which are multiple and complex. First, performance usually comprises a number of separate components. For example, problem-solving involves choice, as well as implementation, of a strategy. Second, ability is necessary but not sufficient for performance, cognitive errors, slips and failures occur on a day-to-day basis despite apparent in-

tact capability. Third, the effect of effort is a potential confounding variable, i.e. individuals may bolster their test performance by trying harder[24]. Fourth, improvement in performance on a test administered more than once may be an artefact of practice. These kinds of complexities may account for the frequent failure of an individual's laboratory test results to correlate with his/ her subjective account of cognitive failure or even partner-reports of apparent day-to-day cognitive difficulties. Likewise, it may be hazardous to generalise from laboratory tests to performance in other situations such as the workplace.

The relationship between performance and stress is also complex in that at higher stress levels performance declines on most tasks yet lower levels of stress (or arousal) may also be detrimental to performance as exemplified by the well-known Yerkes-Dodson Law[25].

### *The Influence of Pregnancy on Cognition*

The two main findings from this study may be summarised as follows:

1. Inspection of Table 2 reveals that on *all* Stroop and SRT indices, the magnitude of the "improvements" in performance which occur on re-testing are very similar in the control and experimental groups. This is strongly suggestive of such improvements being simply an artefact of practice effects on the test. The latter, in addition to actual learning of technique, may embrace reduced anxiety due to greater familiarity with the test and its administrator. The near identical magnitude of the improvements in both groups makes it unlikely that a Type II error has occured (i.e. that real differences may exist which have failed to attain statistical significance due to the small sample size).

   In other words, on the objective measures there is no evidence that pregnancy per se results in impaired cognitive performance as compared with two months postpartum.
2. On two of the three SRT indices (but on none of the Stroop ones), the experimental groups performance during the third trimester *and* at eight weeks postpartum was significantly inferior to that of the non-pregnant controls.

Finding 1) above would lead to the conclusion that pregnancy has no effect on cognition. In contrast, finding 2) would suggest that pregnant women may have memory impairment. There are several ways of reconciling these two findings, however the study design does not enable a definitive conclusion to be reached regarding memory.

The first possible explanation is based on the fact that the control group was not matched for variables such as intellectual ability and hence it is possible that their superior memory performance reflected real differences in such traits between the groups. Under this assumption, the conclusion reached would be that pregnancy has no effect on either Stroop or SRT performance. The findings that CFQ scores showed no significance changes between the third trimester and eight weeks postpartum lends further support to this formulation.

A second possibility is that the significant difference between the SRT scores of the experimental and control groups does indeed reflect impaired memory in late pregnancy. The failure of the pregnant subjects memory scores to improve (more than controls) on re-testing at eight weeks could then be explained in one of two ways:

Either:

> Real memory impairment exists in the third trimester and is *still* present at eight weeks. Possibly the effects of hormonal changes in late pregnancy give way to those associated with breast feeding and both exert influences on cognition. Alternatively, the psychological stresses of late pregnancy give way to those associated with infant care. Thus, both biological and psychological influences may continue to exert detrimental influences.

or:

> Real memory impairment occurs in the third trimester but the pregnant women make greater *effort* and hence boost their (downgraded) memory function to a higher level. Factors underlying such effort may include a subjective awareness of cognitive impairment [6], higher psychological stress levels as suggested by the POMS scores during pregnancy or the demand characteristics of the test situation. At eight weeks postpartum, stress is significantly less (Table 4) and a similar level of performance can be achieved without additional effort. Clearly, measuring and controlling for the possible effects of effort presents formidable difficulties in studies of this kind.

Even if the differences in SRT scores (Table 2) between the two groups do indeed reflect a real impairment associated with pregnancy, the *pratical* significance of this degree of impairment remains moot and may well be minimal.

The highly significant correlation, both antenatally and postnatally, between CFQ and POMS scores (Table 5) strongly suggests that day-to-day cognitive failures are stress-related. This notion gains further support from the finding that postnatal POMS scores dropped significantly and this was associated with a trend (albeit not statistically significant) towards improvement in CFQ scores. Unfortunately, the CFQ was not administered to the non-pregnant controls and no normative data has been published in a comparable group. Hence, no conclusions concerning the effect of pregnancy per se on CFQ scores can be drawn.

The fact that scores on two *objective* tests of cognition did not reflect the postnatal decrease in psychological stress (on POMS scores) could be explained in a number of ways. Possibly additional effort, at least for a short period, can negate the effects of stress. Alternatively, if real cognitive deficits exist in pregnancy they may be mediated by biological mechanisms unrelated to subjective psychological stress.

The only previous "controlled" study of cognition and pregnancy re-tested the women at only three days postpartum and did not re-test the controls at all [2]. Hence, there is, as yet, no literature with which to compare the present findings.

As summarised in the introduction, previous research has consistently shown that pregnant women subjectively report substantial impaired cognition relative

to their non-pregnant state. The present findings fail to provide conclusive *objective* evidence of such deterioration. The introduction also highlighted the fact that a similar situation pertains in the research findings regarding premenstrual cognitive impairment, viz women often report it, yet it tends to elude demonstration by objective testing. Possibly, the tests are too insensitive or are inappropriate for tapping the subjective experience. Alternatively, additional effort generated by the formal test situation may bolster performance. Finally, it is possible that some women consciously or unconsciously embrace a stereotype of cognitive dysfunction premenstrually or during pregnancy. Obviously further research is required to elucidate the inconsistencies between subjective reports and objective test findings, both premenstrually and during pregnancy.

## Conclusions

The present findings do not permit definitive conclusions to be reached about whether or not pregnant women are subject to cognitive dysfunction. The most parsimonious explanation of the findings (and that favoured by the authors) is that pregnant women's *objective* cognitive functioning, at least as measured by these two tests, is similar to that of non-pregnant women. Nevertheless, the possibility that the findings do reflect a real memory impairment in late pregnancy, persisting through the early postnatal months, cannot be excluded; nor can the possibility that real cognitive deficits exist during pregnancy which are masked by women exerting greater effort in formal test situations.

The present findings provide no clear evidence that pregnant women's performance in the work environment is likely to be impaired as a result of the pregnancy state.

Clearly, further research into this important issue is required. A prospective study of a group of women *about to become* pregnant would be the methodology of choice, but logistically is very difficult to implement. In attempting to replicate the present study, greater attention should be paid to matching the two groups on IQ and also to assessing psychological stress levels and cognitive failures in the control group as well as the experimental group. Ideally, the control group should be tested in the follicular phase of their menstrual cycle. Finally, larger group size and a more comprehensive neuropsychological test battery would be desirable. The latter should desirably include incidental learning tasks to eliminate the effect of effort, and better approximate real-life learning situations.

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