Journal of Behavior, Health & Social Issues vol. 4 num. 2 Pp. 91-102 NOV-2012 / ABR-2013
DOI: 10.5460/jbhsi.v4.2.34110

CREATIVE THINKING AND ITS RELATION TO THE MENSTRUAL CYCLE

EL PENSAMIENTO CREATIVO Y SU RELACIÓN CON EL CICLO MENSTRUAL

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Received: July 13, 2012
Reviewed: September 24, 2012
Accepted: September 30, 2012

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Acknowledgments: Partially financed by the Dirección General de Apoyo al Personal Académico, UNAM, Project no. IN-2284092. The authors wish to thank Paul Kersey for the translation of the manuscript. Send correspondence to: Yolanda del Río Portilla, Phd., Laboratorio de Sueño y Coordinación de Psicofisiología, Facultad de Psicología, Universidad Nacional Autónoma de México, México, D. F., Av. Universidad 3004, Col. Copilco Universidad, Delegación Coyoacán, C.P. 04510, Distrito Federal, México E-mail: iyrp@unam.mx, phone: 52-(555)6222251.

Abstract

Creativity, understood as a cerebral function that generates products that are both novel and practical, is one factor that allows us to better adapt to our environment. Sexual hormones, meanwhile, have effects on the central nervous system that can modify it, either temporarily or permanently. It has been shown that these two aspects are interrelated in women, as cerebral activity varies with the phases of the menstrual cycle; for example, in performance on memory-related tasks. Thus, the objective of this research was to determine whether changes in verbal and figural creativity occur during the three phases of the cycle: menstrual, follicular and luteal. The study evaluated 28 healthy women and 10 healthy men, all 18-to-25-year-old undergraduate students. Creativity was measured using the scales from the verbal and figural sections of the Torrance Test of Creative Thinking (TTCT), Forms A and B (counterbalanced), in three sessions programmed to coincide with the three phases of the female subjects' menstrual cycles. Also, the women filled out the Menstrual Distress Questionnaire (MDQ). For the male participants, the three applications were timed to coincide with the phases of the women's cycles. Though no significant differences were observed in verbal and figural creative thinking among the phases of the menstrual cycle, significant gender differences were seen, as men achieved higher scores than women on some aspects of figural creativity when

the latter were in the follicular and luteal phases. The study concludes that differences in the levels of sexual hormones between men and women influence performance on creativity tasks, and that figural creativity proved to be more sensitive to hormonal change. Finally, the factors of Intellectual Quotient (IQ) (evaluated by the WAIS test), and verbal and spatial abilities (assessed using the DAT test), were not found to have any effect on creativity.
Keywords: Creative thinking, menstrual cycle, verbal creativity, figural creativity.

Resumen

La creatividad entendida como una función cerebral que genera productos nuevos y prácticos, es un factor que nos permite adaptarnos mejor al ambiente. Las hormonas sexuales, por otro lado, tienen ejercen influencia sobre el sistema nervioso central que puede modificarlo de manera temporal o permanente. Se ha demostrado que estos dos aspectos están relacionados en las mujeres, ya que la actividad cerebral varía con las fases del ciclo menstrual; por ejemplo en las ejecucioes en tareas relacionadas a la memoria. El objetivo de esta investigación fue determinar si ocurrían cambios en la creatividad verbal y figural durante las tres fases del ciclo: menstrual, folicular y luteal. El estudio evaluó a 28 mujeres sanas y a 10 hombres sanos, todos ellos alumnos de licenciatura con edades entre 18 y 25. La creatividad se midió empleando las secciones verbales y figurales de la Prueba de pensamiento creativo de Torrance (PPCT), formas A y B (contrabalanceadas), en tres sesiones programadas para que coincidieran con las tres fases de los ciclos menstruales en las participantes. También las mujeres contestaron el cuestionario de distrés menstrual (CDM). Para los hombres participantes, las tres aplicaciones se programaron para que coincidieran con las fases de los ciclos de las mujeres. A pesar de que no se observaron diferencias significativas en el pensamiento creativo verbal, ni el figural ente las fases del ciclo menstrual, se registraron diferencias significativas por género, ya que los hombres alcanzaron puntajes mas elevados que las mujeres en algunos aspectos de creatividad figural cuando ellas atravesaron las fases folicular y luteal. El estudio concluye que las diferencias en los niveles de las hormonas sexuales entre hombres y mujeres afectaron la ejecución en las tareas de creatividad, y que la creatividad figural fue mas sensitiva al cambio hormonal. Finalmente ni el coeficiente intelectual (CI) evaluado mediante la prueba WAIS, ni las habilidades verbales y espaciales valoradas mediante la prueba DAT, tuvieron efectos sobre la creatividad.
Palabras clave: Pensamiento creativo, ciclo menstrual, creatividad verbal, creatividad figurativa.

Introduction

Creativity is defined as the cerebral function that associates, analyzes and interprets acquired knowledge in order to generate new ideas that benefit an individual or community (Escobar and Gómez-González, 2006). Its two defining characteristics are the ability to produce works that are both novel (i.e., original, unanticipated) and practical (i.e., useful, having characteristics that relate to adaptive tasks) (Dietrich, 2004).

Guilford's (1977) work on the nature of creative thinking suggests an association between creativity and divergent thinking, a concept he defines as the creation of new, logical options based on the production of a matrix of alternative information that operates by modifying the contents of memory in order to satisfy some specific criterion. But Guilford also proposes a second type of thinking, called convergent. In contrast to the divergent form, convergent thinking creates information based on other, existing data, and entails recovering elements (ideas, objects) from memory to satisfy a set of requirements.

Attempts have been made to establish a possible relation between intelligence and creativity. Ferrando et al. (2005), for example, described "threshold theory", which postulates that when IQ falls below a certain limit, creativity is also limited; whereas when IQ is above this cut-off, creativity becomes a dimension virtually independent of it. In this view, intelligence relates to creativity as a necessary, but insufficient, condition for it.

A similar controversy emerged from inquiries into differences between men and women regarding creativity. Razumnikova (2004) has stated that the two genders show distinct hemispherical organization during creative thought, based on findings of gender-related differences in electroencephalographic patterns recorded while women and men were resolving a creativity task. Those variations were attributed to interhemispheric cooperation and the existence of sexual differences in attentional processes. Jönsson and Carlsson (2000) found that individuals with both feminine and masculine traits (measured by the Bem Sex Role Inventory) may be more creative than those who are strongly typified by sex. This seems reasonable if we assume that people with access to both abilities (male and female) could manifest greater strategy diversification when faced with a problem. Finally, Gutiérrez (2006) writes that empirical results suggest that neither sex enjoys an advantage when it comes to considerations of creative potential.

Two important points from previous reports on sexual differences in behavior and cognitive processes are, first, that they emerge because neural substrates are organized by hormones in the early developmental phases of the maternal breast; and, second, that in later phases –puberty, for example– they are activated by hormones and produce marked changes in brain structure (Moir and Jessel, 1994; Sherwin, 2003). Obviously, these pre- and post-partum hormonal changes play a significant role in sexual dimorphism; that is, the set of morphological, biochemical, physiological and behavioral characteristics that differentiate men from women (Colom and Jayme, 2004).

Finally, hormones are known to participate in several basic behaviors like eating, drinking, biological rhythms and stress in all organisms (Rosenzweig, Breedlove and Watson, 2005).

With respect to cognitive abilities, studies have shown that women excel on verbal tasks, activities that require attention to detail, sequential tasks, verbal fluency, perceptive dexterity, verbal memory, and fine motor abilities, which are often called "typical feminine abilities". Men, in contrast, tend to do better on tasks of a quantitative nature, such as those involving mathematical reasoning and visuospatial abilities: the "typical masculine abilities" (Nelson, 1996).

On a related topic, research on women has described lower performance on tests of verbal ability during the menstrual phase of their cycle (though they are typically still more proficient than men), but better results on tests of visuospatial ability (where men typically surpass them). This stage of the cycle is characterized by relatively low levels of estrogen and progesterone. In contrast, during the phases marked by high hormone levels, the opposite occurs (Sherwin, 2003). Also, studies of EEG coherence in women have shown higher interhemispheric correlation in recordings of cerebral activity in the follicular phase (Solís-Ortiz, Ramos, Arce, Guevara and Corsi-Cabrera, 1994). A study that evaluated activities that demand the participation of prefrontal areas using the Wisconsin Card-Sorting Task found better performance in the early luteal phase when progesterone levels are at their highest, and during menstruation, results that were associated with a decrease in the potential of the alpha band in the EEGs recorded. That work sustained that cerebral activity was indeed modified by the phase of the women's menstrual cycle (Solís-Ortiz and Corsi-Cabrera, 2008).

Hausmann et al. (2000) found significant differences in spatial ability (measured by the Mental Rotation Test), with higher scores attained during menstruation and lower ones in the mid-luteal phase. They concluded that during the menstrual cycle concentrations of estradiol (a hormone of the estrogen group) negatively affect the modulation of spatial cognition.

Other evidence suggests that estrogens positively influence performance on cognitive tests deemed typically female, as demonstrated by Rosenberg and Park's 2002 study, which found an influence of this hormone on verbal working memory. Their article showed an increase in working memory at the midpoint of the cycle compared to the initial and final phases; changes that coincided with the levels of estrogen secreted by the body during the cycle.

Studies based on the Guilford battery of divergent thinking (1967), which records semantic and figural abilities as well as aspects of flexibility and fluidity, confirm a clear improvement in the functioning of divergent thinking in the ovulatory period, compared to the menstrual or luteal phases. Similarly, measurements of motor perseverance showed fewer stereotypical reactions, while functioning on tests of convergent thinking in relation to problem-solving was not modulated by the menstrual phase, as shown by the women in the control group who took contraceptives (Krug, Stamm, Pietrowsky, Fehm and Born, 1994). These results suggest that in the ovulatory phase, typified by a peak in estrogen levels, the strength of cognitive and motor habits decreases, an alteration that may improve behavioral flexibility in social interaction, and influence the choice of sexual partners.

In a later study, Krug et al. (2003) observed a marked increase in divergent thinking during the ovulatory period that paralleled a similarly notable increase in the dimensional complexity of electroencephalographic activity, which is thought to correlate with the number of cortical neuronal assemblies that are activated simultaneously as the basis of the flow of cognitive representations. This suggests that an increase in EEG complexity during the ovulatory period could predispose cortical networks towards greater creative thinking.

As this brief summary shows, little is yet known with certainty about the participation of sexual hormones in creativity. Hence, our research focused on the relation between creative thinking and the phases of the menstrual cycle, using one of the instruments most often employed to study verbal and figural creative thinking. The study was also designed to discern differences between men and women, due to variations in the important hormonal base that forms before birth and is reinforced in adulthood. Finally, it sought to determine whether intelligence and spatial and verbal abilities influence greater creative performance.

Method

Participants

Subjects were 28 women and 10 men, aged 18-to-25, all healthy, righthanded students in the first or second year of an undergraduate program in psychology. An initial interview was held to confirm that they were not consuming alcohol or drugs or suffering from any psychiatric disorder, such as depression or anxiety. All participants scored in the 90-119 range on the IQ test (WAIS, 1981), with average IQs of 111.1 for men, and 106.14 for women. Women attained average verbal and spatial ability scores of 70.22 and 61.21, respectively; while the corresponding averages for men were 63.92 and 69.72, according to the Verbal and Spatial sub-scales of Form V of the Differential Aptitudes Test (DAT) (Bennett, Seashore and Wesman, 1982).

All female participants had regular menstrual cycles (28 days ±2), and none presented severe or extreme pre-menstrual disorders (as determined by the Menstrual Distress Questionnaire, MDQ) (Ramirez de Lara et al., 1972). None of them had received any type of hormonal therapy in the previous 3 months.

Materials

In order to ascertain whether verbal and spatial abilities are related to creativity, subjects' scores on these two capacities were obtained using Form V of the DAT (Bennett et al., 1982). All scores were tabulated following the norms established for the Mexican population (Villegas and Varela, 2006).

Participants' creative thinking was assessed using the two scales of the Torrance Test of Creative Thinking (TTCT): figural (TTCT-F, Spanish version) (Torrance, 1998, 2008), and verbal (TTCT-V, English version) (Torrance, 1990, 2008). Both the equivalent A and B forms were applied. To score, the Torrance test uses the properties proposed by Guilford:

- Fluidity: the fertility of ideas or reactions generated in response to a situation, stressing the quantitative aspect; i.e., the relevance of responses is more important than their quality.
- Flexibility: identified as the qualitative aspect of creativity; i.e., the ability to adapt, redefine, reinterpret or adopt new tactics to reach a solution.
- Originality: alludes to the minimum frequency of a response in a given population; i.e., the solution generated must be unique or distinct

from earlier ones.

- Elaboration: the degree of development reflected in the ideas produced, corroborated by the richness and complexity of performance on assigned tasks.

The following properties are added specifically for the figural scale:

- Abstraction of titles: the ability to synthesize topics and organize thought processes; i.e., to capture the essence of implied information.
- Resistance to premature closure: measures a person's ability to remain open (delay closure) long enough to make the mental leap required for original ideas.

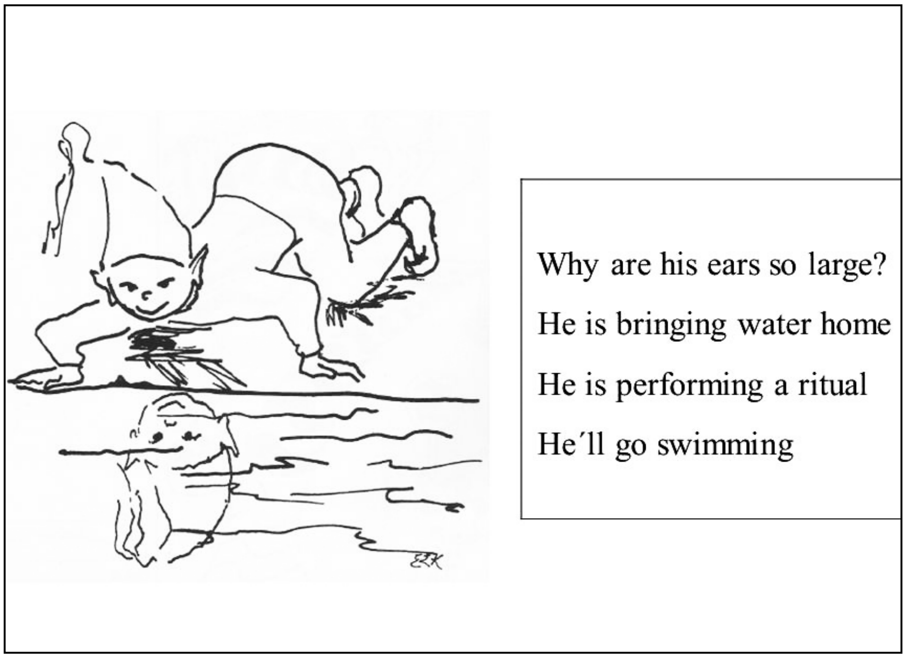

Figure 1. Examples of items from the TTCT-V (a) and TTCT-F (b).

a) Activity 2. TERMINATION OF DRAWINGS
By adding some lines to the incomplete figures on this page and the next, you can draw some interesting objects or pictures. Again, try to think of an object or picture that nobody else would. Try to tell a story that is as complete and interesting as possible. Continue to add new ideas to your first one to tell a story that is absorbing and exciting. Create an interesting title for each picture and write it in the box next to each drawing.

b) Activities 1-3. ASK-AND-GUESS
The first three activities are based on the drawing below. They give you a chance to see how good you are at asking questions to find out things that you don´t know, and in making guesses about possible causes and consequences of happenings. Look at the picture. What is happening? What can you tell for sure? What do you need to know to understand what is happening? What caused it to happen? What will the result be?

Procedure

Phase 1: Instrument validity

As no Spanish version of the TTCT-V was available, the original English-language content was translated, and then validated by judges. Expert psychologists in the field of creativity were asked to assess whether the translated version of the questions adequately represented the constructs, and if they were phrased in language suitable for Mexican subjects. The results of this analysis are shown in Table 1.

Table 1
Analysis of content validity according to the judges of the verbal scales of the Torrance Test, forms A and B (Torrance, 1990)

Item	Level of agreement among judges	Overall score for the item
TTCT-V form A		
Activity 1 to 3 Ask and Guess	0.73	73%
Activity 1 Asking	0.91	92%
Activity 2 Guessing causes	0.88	88%
Activity 3 Guessing consequences	0.91	92%
Activity 4 Product improvement	0.75	75%
Activity 5 Unusual uses (Cardboard Boxes)	0.95	95%
Activity 7 Just suppose	0.8	80%
TTCT-V form B		
Activity 1 to 3 Ask and Guess	0.73	73%
Activity 1 Asking	0.95	95%
Activity 2 Guessing causes	0.91	92%
Activity 3 Guessing consequences	0.91	92%
Activity 4 Product improvement	0.75	75%
Activity 5 Unusual uses (Tin cans)	0.98	98%
Activity 7 Just suppose	0.8	80%
Total global score (forms A and B): 87%		

To ascertain whether this instrument made understanding the instructions and/or applying the test difficult, an exploratory trial with the TTCT-V and TTCT-F scales was done with 2 men and 6 women who were representative of the study population. No problems were encountered with the instructions or application.

Phase 2: Experimental
The objective of this research was to identify whether hormonal changes associated with the menstrual cycle modify creativity in women with regular cycles. Creativity was evaluated using the A and B forms of the TTCT- V and TTCT-F tests, counterbalanced in three sessions programmed during: (1) the menstrual phase (days 2-to-5 of menstrual bleeding); (2) the follicular phase (days 12-18); and, (3) the luteal phase (8-5 days before the ensuing period), following Pocock and Richards (2002).

For the control group of men, creativity was evaluated at three moments timed to coincide with the phases of the women's cycle (i.e., a 7-to-15-day interval between applications).

Data analysis

To analyze the differences in creativity among the phases of the menstrual cycle, a repeated measures ANOVA was used, while differences in creativity between men and women were compared by a Mann-Whitney U test. To determine if intelligence levels and verbal and spatial ability are related to creativity, a Pearson's correlation was applied, set at a level of $\alpha=0.05$. All analyses were performed using the SPSS statistical package, Version 17 (IBM Corp.). To explore whether normal-to-brilliant IQ levels (NB-IQ) influenced the results of the creativity tests, an additional, gender-independent, analysis was also conducted.

Results

The analysis of the differences in IQ and verbal and spatial ability between men and women showed variations only with respect to verbal IQ ($p = 0.005$) and total IQ ($p = 0.017$), where men had higher scores.

A correlation was used to determine if there was a relation between creativity and the IQ and verbal and spatial abilities tests applied, but none was found; indicating that the IQ and verbal and spatial abilities tests have no influence on creative thinking but, rather, correspond to a type of convergent thinking.

Differences in creativity during the menstrual cycle

The TTCT-V and TTCT-F scores obtained during the phases of the menstrual cycle (menstrual, follicular, luteal), did not reveal any significant differences. The comparison of the verbal and figural scales showed that the latter was higher ($p = 0.001$) in all three phases of the cycle.
Results for the men showed no differences in the three applications performed, though there was a modification in the type of creativity, as their TTCT-F scores were higher than their verbal scores in all applications ($p = 0.001$).

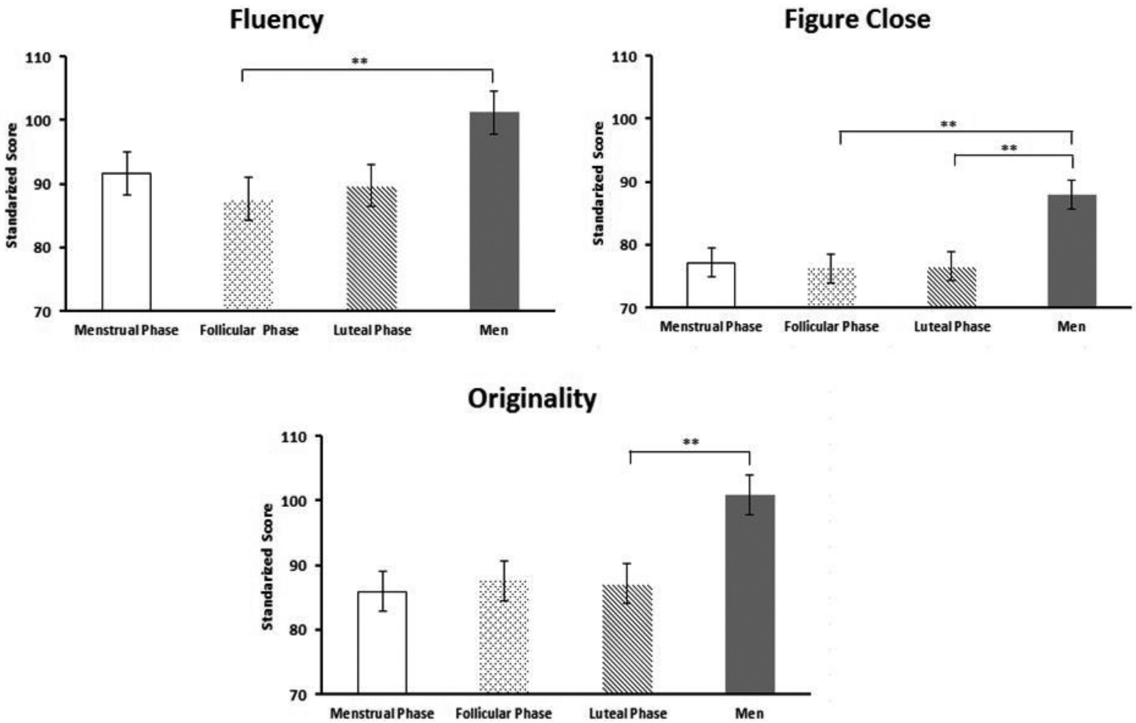

Figure 2. Standard TTCT-F values for fluidity, originality and closure from women in the different phases of the menstrual cycle (menstrual, follicular, luteal) compared to men. Asterisks indicate significant sexual differences (**p<0.01).

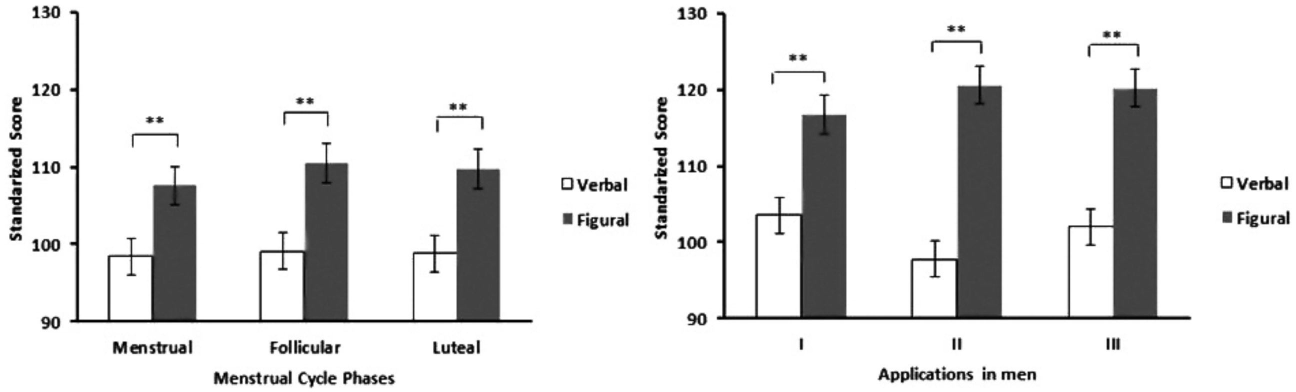

Figure 3. Standard TTCT-V and TTCT-F values according to applications following the phases of the menstrual cycle in women, and applications in men. Asterisks indicate significant differences between the type of creativity in the phases of the menstrual cycle and the applications (**p<0.001).

Differences in creativity between men and women
With respect to the effect of gender regardless of the phase of the women's menstrual cycle, no significant differences in TTCT- V were found, while on the TTCT-F men attained higher scores ($p = 0.031$).

Turning to the effect of gender and its relation to the phases of the cycle, no differences were observed when results from the menstrual phase were compared to the scores of the male group. In the follicular phase, significant differences were seen on the figural scale, with men scoring higher on fluidity ($p = 0.007$) and closure ($p = 0.01$). The Creativity Index (CI) reflected a tendency towards higher scores ($p = 0.052$). In comparison to the women's results to the luteal phase, men achieved higher scores for originality ($p = 0.003$), and closure ($p = 0.01$), and showed a tendency towards higher scores for CI ($p = 0.051$) on the TTCT-F instrument.

No significant differences were seen in relation to the effect of gender on verbal and spatial abilities.

In order to determine a possible relation between intelligence and creativity, the subjects with normal-to-brilliant IQ levels (NB-IQ) were separated as follows: 7 men and 8 women with average IQs of 113.86 and 122.38, respectively, but the performances observed were consonant with the results from the sample as a whole.

Discussion

The literature contains reports that circulating levels of sexual hormones in the different phases of the menstrual cycle affect cognitive functions, including memory and learning (Sherwin, 2003). The aim of the present study was to ascertain whether hormonal variations also tend to produce changes in creative thinking.

In this work, comparisons of scores for creative thinking in the three phases of the menstrual cycle revealed no significant differences. This finding does not concord with descriptions in the literature that report higher scores on the flexibility and fluidity scales of Guilford's Creativity Tests during the pre-ovulatory period when estrogen levels are high (Krug et al., 1994; Krug et al., 2003). Damasio (2001) also reported higher scores for flexibility and fluidity on these tests in the pre-ovulatory phase, and a marked improvement in the dimensional complexity of electroencephalographic activity that affected working memory, an element postulated as a critical transition zone for creative thinking.

We infer that the absence of changes in the creativity scores among the phases of the menstrual cycle may be attributable to the creativity test employed, which may not have been sufficiently sensitive to detect the variations that might have existed. Moreover, though we found differences when comparing some of the means between the two study groups, the variability encountered tended to be very high, suggesting the possibility that statistically significant differences might be identified in a study with a larger sample size.

When the differences between the types of verbal and figural creativity were analyzed in relation to the phases of the menstrual cycle, scores for figural creativity were high during the menstrual phase (characterized by low estrogen and progesterone levels), but those for verbal creativity were low. This finding does agree with existing reports which show that in this phase of their cycle women have poor execution on verbal tasks but improved performance on visuospatial ones (Sherwin, 2003; Simic and Santini, 2012). However, the present study also detected differences that favored figural creativity during the follicular and luteal phases, another result that contrasts with findings from earlier studies that have reported higher verbal abilities during these phases. For example, in Protopopescu et al.'s study (2005), a go/no-go task showed that responses to verbal stimuli in the orbitofrontal cortex are greater when the valence is negative than when it is neutral or positive during the luteal phase compared to the menstrual phase. In our study, one possible explanation of the increase in figural creativity in the luteal phase could involve the effects of lateralization on visual function. On this issue, Weis et al.'s work (2011) on functional changes in cerebral asymmetry during the phases of the menstrual cycle found a decrease in the advantage of the right hemisphere in visuospatial activities during the luteal phase.

With respect to gender differences, significant variation between men and women was found, regardless of the latter's menstrual status, with men scoring higher on the figural scale. This result coincides with many reports in the literature that have found higher visuospatial abilities among men (Gooren and Kruijver, 2002; Hampson, 1995; Moir and Jessel, 1994; Nelson, 1996).

In relation to the phases of the menstrual cycle, the only differences observed on the figural scale occurred with women in the follicular (fluidity and closure) and luteal phases (closure and originality), when estrogen and progesterone levels are elevated. Men attained higher scores than women, a result that also coincides with a large body of earlier literature that indicates greater visuospatial abilities in males (Gooren and Kruijver, 2002; Hampson, 1995). However, it was clear that during the menstrual phase – when both female hormones are at their lowest levels– no significant differences between men and women existed. This suggests a sensitivity of hormones to figural creativity in the different phases of the cycle that produces a pattern of cognitive performance similar to that of men, as Dietrich et al. have reported (2004).

The present study also found that the differences between the sexes become more marked when the secretion of the predominant female hormones is higher, as several earlier studies have suggested (Gizewski et al., 2006; Hausmann et al., 2000). This may be due to the differential development of the brains of men and women in the pre-natal stage caused by hormonal flows that affect both behavioral and cognitive processes (Moir and Jessel, 1994; Nelson, 1996).

The differences in figural creativity seen in this study suggest a sensitivity of visual functions to hormonal changes, a finding corroborated at the cellular level by observations that the V1 cortex expresses to both the receptor and estrogens, as well as to the enzyme that synthesizes them (P450-aromatase), though in a heterogeneous, tissue-dependent manner (Jeong, Tremere, Burrows, Majewska and Pinaud, 2011). Another possible explanation is that verbal function may be relatively less sensitive to hormonal changes. Imaging studies indicate that interhemispheric inhibition in the visuospatial vias plays a very significant role in stimuli processing (Chakravarty, 2012: Huang et al., 2012).

Analysis of intelligence and creativity using a Pearson correlation failed to reveal any significant relation between these two factors (WAIS) (Ferrando et al, 2005), or with the verbal and spatial abilities measured by DAT, which would reflect a more convergent type of thinking.

The results obtained in this study suggest that creativity, like other cognitive processes, is modified by the menstrual cycle, as has been reported in studies based on EEGs in women, which show a higher interhemispheric correlation during the follicular phase while recording cerebral activity (Solís-Ortiz, Ramos, Arce, Guevara and Corsi-Cabrera, 1994).

Pursuant to the results observed in the present work, we can propose possible directions for further research; for example, applying creativity tests to women with low hormonal levels, such as those in menopause, or those undergoing hormonal replacement therapy. This would produce greater precision than measuring hormonal levels in men because progesterone and estradiol would be reduced. Also, brain activity could be recorded as an additional indicator of cerebral participation.

Conclusions

The principal objective of this work was to probe the influence of sexual hormones on higher cognitive processes, such as creative thinking, during the menstrual cycle. The results obtained allow us to affirm that sexual hormones do indeed play an important role in producing creative thinking, as evidenced by the sexual differences found, which showed that men score higher than women on the figural TTCT; a result that concords with earlier studies. Also, significant differences were observed only in figural creativity between women in the follicular and luteal phases of the menstrual cycle and in men's scores for fluidity, originality and closure on the TTCT. We therefore conclude that differences in hormone levels in women do affect the realization of creativity tasks, and that figural creativity is more sensitive to this hormonal change.

Finally, this study found that the factors of IQ and verbal and spatial abilities did not influence creative thinking.

As contributions of this research, we would emphasize the finding that sex hormones influence cognitive processes, such that they are affected by the activating capacity of hormones during the menstrual cycle; though evidence is incomplete (i.e., differences in all phases).

It is possible that increasing the size of n would result in a clearer demonstration of these trends, since it is known that the EEG technique revealed differences during the phases of the menstrual cycle (Solis-Ortiz, et al, 1994). Future studies might also consider including: 1) laboratory tests to measure serum hormone levels and thus identify more accurately the different phases of subjects' menstrual cycle; and, 2) study groups of women with different hormonal status, such as those in menopause, or ones using contraceptives.

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