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SEX DIFFERENCES IN THE VISUOSPATIAL SKETCHPAD IN SCHOLAR CHILDREN

DIFERENCIAS SEXUALES EN LA AGENDA VISO-ESPACIAL DE NIÑOS ESCOLARES

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Abstract

This paper studies sex differences in working memory related to the visuospatial sketchpad and its interaction with the central executive through performance of a dual task with different levels of difficulty. Fourteen boys and 14 girls between 9 and 10 years old performed a memory task (primary task) with 4 levels of difficulty corresponding to 4 memory load levels, and a Go/No-go task as a visuospatial stimuli processing task (secondary task). The results demonstrated that the increase in the difficulty level in the primary task makes subjects have fewer correct responses in the secondary task; however, this only affected males significantly. These results might be a consequence of the amount of resources given by the central executive to perform the tasks: more resources were given to accomplish the primary task than to the secondary task, affecting the performance of the second. One may concluded that the relations between the central executive (processing) and the visuospatial sketchpad (storage) seem to be determined by a higher resource demand required by the storage in the memory, to the detriment of the processing activities of the central executive.

Key words: Sex differences in children, visuospatial sketchpad.

Resumen

En la presente investigación se estudiaron las diferencias sexuales en la memoria de trabajo relacionadas con la agenda viso-espacial y la interacción ejecutivo central-agenda viso-espacial mediante una tarea dual con diferentes niveles de dificultad. Participaron 14 niñas y 14 niños con edades entre 9 y 10 años, quienes realizaron una tarea de almacenamiento (tarea primaria), con 4 niveles de carga en la memoria y una tarea *Go/No-Go* como tarea de procesamiento de estímulos viso-espaciales (tarea secundaria). Los resultados mostraron que a mayor nivel de carga en la tarea primaria, los sujetos tuvieron significativamente menos aciertos en la tarea secundaria, sin embargo esto afectó significativamente solo a los niños. Lo anterior pudo deberse a que el ejecutivo central destinó mayores recursos a la tarea primaria que a la secundaria lo que afectó el desempeño en ésta última. Se puede concluir que las relaciones entre el ejecutivo central (procesamiento) y la agenda viso-espacial (almacenamiento) parecen estar determinadas por una mayor demanda de recursos que exige el almacenamiento en la memoria, en detrimento de las actividades de procesamiento del ejecutivo central.

Palabras clave: Diferencias sexuales en niños, agenda viso-espacial.

Introduction

Working memory (WM) is a system of limited capacity, simultaneously responsible for processing and temporarily storing information (Baddeley, 1986). According to Baddeley's model (2000), WM has four subsystems. The central executive (CE), which controls the flow of assigned attention resources to process or store (by reviewing) information (Cowan, 2005; Engle, Kane, & Tuholski, 1999). This is to say, it is an attention control system capable of focusing and changing attention resources, but it does not have storage capacity (Baddeley, 2003). The phonological loop (PL), which retains and manipulates verbal material, is composed of two components: the phonological store and the articulatory rehearsal component; the first is a memory store that is able to retain information based on speech for a short period of time (for example, read words), and the second is responsible for two different functions: changing visual information into a speech-based code, and placing it into the phonological store and renewing the information at the phonological store, counteracting the decay process. The visuospatial sketchpad (VSSP) processes and stores visual and spatial information. The episodic buffer processes both verbal and visuospatial information. Of these components, the CE and the PL are the most studied; not so the VSSP and the episodic buffer.

The VSSP works in the recognition and manipulation of objects, in academic tasks and in the memory of places, in mathematical and scientific thinking (Delgado, & Prieto, 2004), in the representation and manipulation of visual information, in solving of visuospatial problems, and takes an important role in disciplines of knowledge such as engineering, architecture, physics, chemistry and surgery (Sorby, & Baartmans, 1996). Aside from participating in spatial orientation activities, the VSSP is fundamental in reading comprehension and mental calculation (Jones, & Morris, 1992). According to Logie (1995) and Pickering, Gathercole, Hall, & Lloyd (2001) the VSSP is divided into two subcomponents: visual cache that storages color an visual forms, and an inner scribe related to spatial information and movement; this information is reviewed at the visual cache and then is transferred to the CE to be processed.

According to WM definition, its capacity must be by measured employing tasks that simultaneously impose demands in the processing and storage of information (Alloway, & Archibald, 2008); this would demand resources both for the CE (processing) and for the corresponding store (visual and/or visuospatial). The way in which resources are distributed allows evaluating the relations between the CE and each of the other components. For example, in a verbal dual task, the execution of the subjects is less efficient when the primary task is more complex or insofar as the secondary task also involves verbal stimuli (Hunt, & Ellis, 1999). This may be due to the high level of demand made to the CE, since attention resources are limited and must be distributed to the execution of two tasks as well as interference causing the use of the same type of information on both tasks. However, the use of simple tasks in the WM studies is frequent (Jenkin, Myerson, Hale, & Fry 1999). ;Factors that influence the capacity of the cognitive functions like the WM include the age and sex. In this field, the investigations are oriented to the study of the differences between men and women, establishing contrasts between both in relation to verbal and visuospatial abilities. Some studies (Coluccia, & Louse, 2004; Kimura, 1996; Levine, Vasilyeva, Lourenco, Newcobe, & Huttenlocher, 2005) show that women perform better at verbal tasks and verbal articulation, learn to write and read more quickly, and demonstrate a greater capacity in perceptual speed and visual memory (both functions related with the left side of the brain), while men have a better performance at visuospatial tasks like spatial visualization (ability in the use of analytical strategies to manipulate spatial information), spatial perception (body orientation in the space), mental rotation of two- or three-dimensional figures, measuring speed and precision, form recognition, left-right discrimination, representation of two-dimensional objects into three-dimensional objects and unfolding visual forms into complete sets (functions related with the right side of the brain) (Gil-Verona, Macías, Pastor, Paz, Barbosa, Maniega et al., 2003; Goldberg, 2001).

In a study where a meta-analyses was made, Torres, Gomez-Hil, Vidal, Puig, Bogey, & Salamero (2006) also showed that women perform at higher levels in verbal fluency, perceptual speed, memory and verbal learning, and men perform better at visuospatial ability, math problem and visual memory. Additionally, in a more recent analysis of the literature, there was reported superior execution in men in some visuospatial tasks, such as object localization (Andreano, & Cahill, 2009). Other authors had observed these effects in experimental studies (Lawton, & Hatcher, 2005; Singh, & Mishra, 2004). In a study that evaluated age and sex in youth and the elderly during passive spatial tasks (discrimination and perceptual memory of the distance) and in active tasks such as mental rotation, higher performance was observed in men during the mental rotation task, while women performed more highly during the other tasks (Iachini, Ruggiero, Ruotolo, & Pizza, 2008). However, Harness, Jacot, Scherf, White, & Warnick (2008) showed than women perform better than men in verbal as well as visuospatial tasks.

In contrast to the previous studies, Feingold (1988) found that sex-based differences in verbal fluency and mathematical problem-solving are moderated or absent in some cases, while in visuospatial processing tasks the differences are very conspicuous, on account of which it may be supposed that the WM, and particularly the VSSP, is involved in these differences. Nonetheless, some studies deny the existence of sex-based differences in cognitive abilities. Hyde (2005) maintains that men and women are more cognitively similar than is reflected in studies on sex-based differences. Moreover Rahman, Bakare, & Serinsu (2011) show that these differences do not exist while Torres, Gomez-Gil, Vidal, Puig, & Salamero (2006) did not find differences in tasks that measure attention. In studies involving adolescents, there were no sex differences regarding recall of verbal stimuli (words) and image recall (Ionescu, 2008).

In the few studies that have directly approached WM related to sex, we found equally contradictory results. Iachini, Ruggeiro, Ruotolo, & Pizza (2008) found superior execution in women, relative to men, in the visuospatial WM measured through the Corsi's block task. Other studies have reported a better performance for men at WM tasks of arithmetic type (Lynn, & Irwing, 2008) and authors such as Torres, Gómez-Gil, Vidal, Puig Boget, & Salamero (2006) did not find differences at the WM tasks.

So, the lack of consistency is evident in studies about the sex differences in the various cognitive aspects that have been studied, including the WM. However, the results seem to show more evidence of differences between the subjects of different sex even if there is clarity missing.

Another possibility to understand the sex differences in visuospatial processing could be the study of results provided by investigations made in subjects of different ages, especially at early ages, since at these stages the role of experience could be less important than the natural biological mechanisms of every male or female subject.

Authors like Clements-Stephens, Rimrodt, & Cutting (2009) argue that studying the differences based on sex during the visuospatial processing in children and teens could provide evidence about the maturation of important regions involved in this type of processing, and also identify the development of the sex differences due to the use of strategies, which are in turn influenced by the experience. However, investigations conducted with children of different ages are very few so far.

Several investigations have shown that differences between men and women arise around preschool age or during the first primary school year. Levine, Huttenlocher, Taylor, & Langrock (1999) found that, on average, preschool-aged children are more precise than girls at tasks that measure precision in spatial transformations. They concluded that sex differences are present in spatial tasks since the 4 and half years old. However, Tzuriel, & Egozi (2010) suggest that the sex differences observed in children could be the consequence of other factors, such as training, since when men and women are trained in mental rotation tasks, there is no any difference observed between them.

As it happens in the adult case, the few studies that directly research the WM are not consistent either. Sánchez, Taballo, Marro, Sánchez, Yorio, & Segura (2009) carried out a study about de WM develop in children. They found that the performance improves with age, as in the case of recall and recognition of visuospatial patterns, although it is not clear if this improvement is the product of an increase in sketchpad capacity during infancy or changes in strategy that affect the amount of information that can be retained. In this study it was also observed that sex differences are present since childhood, because boys have a better performance than girls at visuospatial tasks. However, in a similar study, boys performed worse than girls; this result was interpreted as a cerebral immaturity in boys related to girls, between 6 and 10 years old (Vuaontela, Steenari, Carlson, Kolvisto, Fjälberg, & Aronen, 2003).

Some authors highlight that these differences could be caused by the spatial processes evaluated, among which the WM is emphasized (Iachini, Ruggiero, Ruotolo, & Pizza, 2008). Inside the so-called "spatial memory," one may distinguish to visuospatial WM, memory for object location, memory for routes and sequential spatial information (Kessels, De Haan, Kappelle, & Postma, 2001; Kesses, Postma, Kappelle, & De Haan, 2002; Postma, 2000; Postma, Jager, Kessels, Hans, Koppeschaar, & Van Hok, 2004). However, even in studies where the WM is mentioned as the principal object of study, its role is rarely well-specified. Additionally, there are no pure measures of this type of processing, because some images can be coded either semantically or phonologically (Pickering, 2001). For example, Palmer (2000) reported that children under 8 years codify the images visually, but after that age they tend to use phonological codification for its recall (see also Hitch, Halliday, Schaafstal, & Scharaagen, 1988). Some authors like Robert, & Savoie (2006) suggest that the lack of consensus in the studies about sex differences might be caused by the fact that many tasks that make either verbal or visuospatial demands in WM tasks only make storage demands explicit. These authors provide evidence that, in comparison with simple tasks, dual tasks are better at showing sex differences in the verbal and visuospatial WM (see also Cronoldi, & Vecchi, 2003) and conclude that women perform better than men when the task requires, besides storage, either a verbal or visuospatial process (Kaufman, 2007). In this context it has been observed that the sex differences in spatial orientation only emerge when the tasks require a high load of the visuospatial WM (Coluccia, & Louse, 2004). Thus, it seems that studies on the visuospatial WM in which dual tasks are used and in which high demands are made to memory load are those which present more consistent results in relation with sex differences in spatial ability.

The purpose of this paper was to compare the visuospatial WM in boys and girls of school age, using a dual task with different load in the VSSP store, aside from establishing how the CE and visuospatial interact in this type of tasks.

Method

Subjects

Fourteen girls ($\bar{x}$ = 9.7 years) and 14 boys ($\bar{x}$ = 9.6 years) participated, all of whom attend public schools in Mexico City. They were in the academic school grade corresponding to their age. All children voluntarily participated after an announcement was made in 2 schools. Children were selected with an intellectual coefficient ≥ 85 according to the WISC-R. They had a normal neurological and neuropsychological evaluation that was made by a neuropsychologist and a neurologist.

Task

The children performed a dual task with simultaneously demand of processing and storing visuospatial stimulus and 4 levels of memory load. At the beginning of each session, the instructions were shown on the computer screen. The experimental phase consisted of the execution of a primary and a secondary task (figure 1). At the primary task there were presented 3x4 cells matrices with a number of cells randomly filled according to the memory load level (figure 2) which were needed to be remembered by the subjects, while the secondary task consisted into a *Go/No-Go* visual task. The stimuli of which consisted this secondary task were arrows pointing to different directions. During the execution of the secondary task, subjects were instructed to "review in memory" the position of the filled cells of the given matrix in the primary task.

In the zero memory load (difficulty level 1), subjects only executed the secondary task, which consisted in a pseudo-random presentation of series of arrows in different direction (←→↑↙↓↖↗↘). The subjects were instructed to respond, as quick as possible, to the presentation of the target stimuli (↘) by clicking the left button of the mouse, while the other stimuli did not require any type of response. The duration of each stimulus was 100 ms and had an inter-stimuli interval of 1.8-2.2 seconds. A total of 360 stimuli were presented divided into 4 blocks, 18 target stimuli and 72 frequent stimuli per block with a duration of 3 minutes and 4 seconds.

In the next 3 levels (i.e., low memory load, medium memory load and high memory load) the subjects performed both tasks at the same time. In the primary task, each block begins with the presentation of a matrix during 10 seconds for storage in the memory. Immediately afterward began the secondary task, which consisted in the *Go/No-Go* task (in the same manner that they did in the zero load condition). After this task was done, the recall stage began, where three different matrices were randomly presented one at a time where the one that was presented in the primary task was or was not included. The subject had to respond by clicking the left button of the mouse when the matrix was identified and clicking the right button when the matrix was not included. The matrix presented at the start of each block was different in each of them. Thus, each level included the following order of phases: the storage demands (matrix), processing (execute the *Go/No-Go* task) and recall. In these 3 levels, the duration of each block was 3 minutes, 25 seconds.

The presentation of the matrices and the arrows was made in white with a black background on the center of the computer screen; the task has a total running time of 50 minutes, and was delivered by the STIM program (*NeuroScan*, 1995) on a computer.

Data analyses

To compare the performance of both sexes, and observe the differences between the memory load levels (level 1, 2, 3 and 4), the percentage of correct responses and reaction time on the secondary task, as well as the percentage of

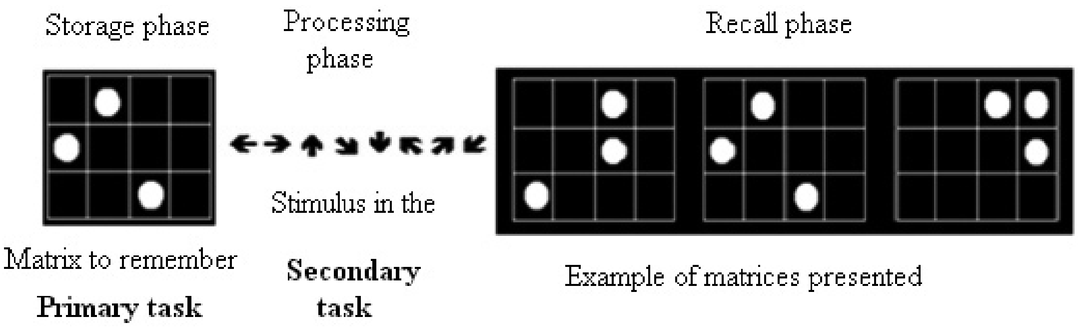

Figure 1. Sequence of events during the experimental session (dual task) for the low memory load condition. A trial started with the primary task which consisted in the presentation of a matrix (during 10 seconds). Subjects were asked to "keep in mind" (i.e., storage phase) the matrix presented. They continued with the secondary task (processing phase), in which the subject responded to the target stimuli presentation (enclosed in a box). After the secondary task, subjects were asked to identify between three matrices randomly presented one by one. One of them should be the one presented at beginning of the trial (Recall phase) and the children must press a button of mouse.

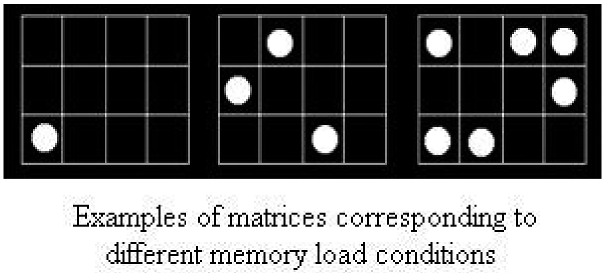

Figure 2. Samples of matrices presented at low memory load (left matrix), medium memory load (central matrix) and high memory load (right matrix), which consisted of presentation of 1, 3 and 6 points respectively and where the subjects have to remember their positions.

matrices-recalled in the primary task, were analyzed. At the secondary task, the percentage of correct responses and the average of the reaction times for each trial block were obtained, and the blocks for each load level were averaged. For the primary task, matrix-recalled was measured by obtaining the percentage of correctly-remembered matrices in each level (because each level consisted of 4 blocks and in each block a new matrix to remember was presented, a total of 4 matrices was presented per level). Before statistical analysis, the percentages were transformed using ARCSIN [SQRT (percentage/100)] to reach an approximation to the normal distribution. A series of ANOVAs was made with two factors: Sex (girls and boys) as an inter-subject factor and Memory load level (1, 2, 3 and 4) as an intra-subject factor, for the percentage of correct recall and percentage of correct responses as well as for reaction times. When there were two or more degrees of freedom at the numerator, the Greenhouse-Geisser correction was applied. Post hoc multiple tests were carried out by the Tukey test when necessary.

Results

SECONDARY TASK

As it is shown on Table 1, the main effect of the Memory load level was statically significant. On Figure 3 and table 2, it is shown that as the level in the Memory load increased, i.e. as the matrices had a larger number of filled cells, the subjects had fewer correct responses in the secondary task, although in the level 4, with higher load, the number correct responses slightly increased. However, the post hoc analyses only showed significant differences between the percentages obtained at the zero memory load versus low memory load ($p < .001$), versus medium memory load ($p < .001$) and versus high memory load ($p < .001$). Thus since the level in which the visuospatial load started to increase, the performance at the secondary tasks significantly decreased.

Table 1

Results of ANOVA using the percentage of correct responses (transformed values) from the secondary task

Effect	F	d. f.	P	Epsilon
Sex	1.1	1, 26	.3	---
ML	10.5	1.8, 47.9	.000007	.6
Sex x ML	3.1	1.8, 47.9	.03	.6

d.f.= degree of freedom, ML= Memory load

Table 2.

Means and Standard deviations of percentage of correct responses in the secondary task

	Memory load									
	1		2		3		4		Total	
Sex	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	x	S.D.
Girls	72	18	60	24	58	25	57	25	62	23
Boys	76	13	44	18	42	16	51	22	53	17
Total	74	16	52	22	50	22	54	23	----	----

$\bar{x}$ = Mean, S.D.= Standard Deviation, Total = All subjects across memory load conditions

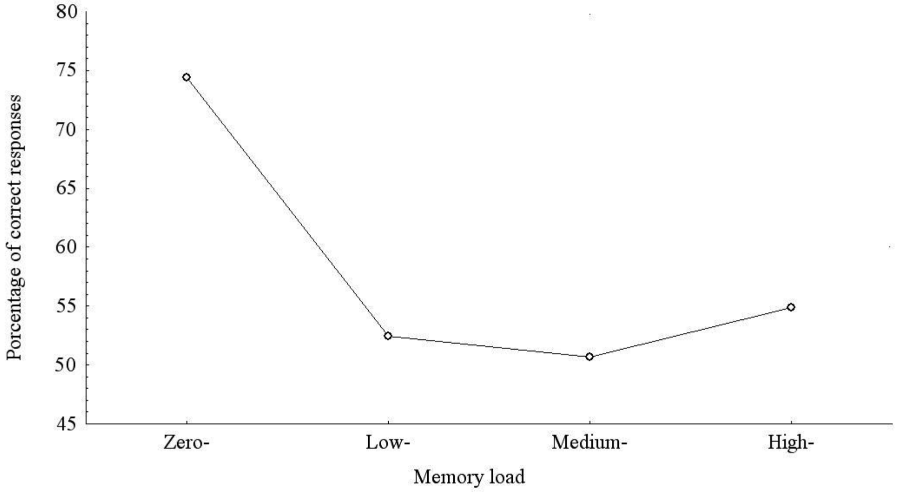

Figure 3. Effect of memory load (primary task) on the percentage of correct responses of the secondary task for all children. Notice the dramatic decrease in the percentage of correct responses in the low memory load.

Although the main effect of the Sex was not statically significant, there was a significant Sex by Memory load level interaction (see tables 1 and 2 and figure 4). In the low memory load level, boys and girls had similar performance, but when the memory load increased, in the medium memory load level for example, the number of correct responses decreased in both groups, but in the girls the decrease was moderate while in the boys, it was more severe. In accordance to the post hoc analyses, these sex differences were significant in the low memory load (p = .01) and in the medium memory load (p = .004). Likewise, the between group post hoc comparisons (boys versus girls) showed that in the boys the number of correct responses significantly decreased as the Memory load level increased (table 2).This was observed in the comparisons of the zero memory load level versus low memory load level (p < .001), versus medium memory load level (p<.001) and versus high memory load level (p<.001). On the other hand, in the girls, the differences in the percentage of correct responses related with the Memory load level were not significant.

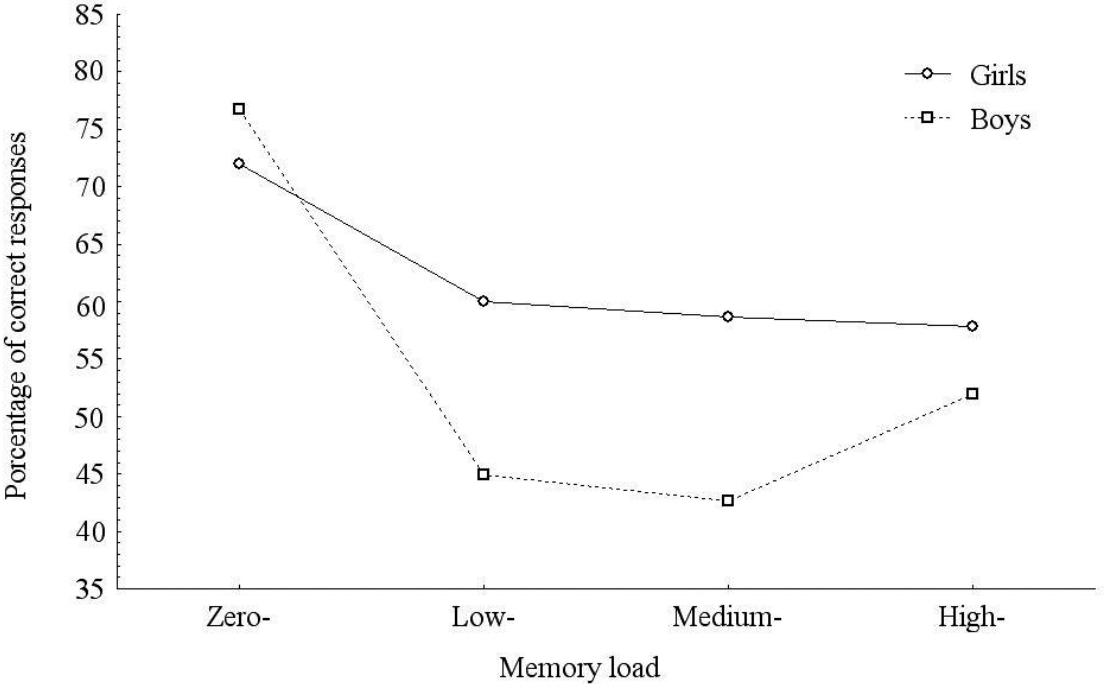

Figure 4. Effect of memory load (primary task) on the percentage of correct responses of the secondary task by boys and girls. It can be observed the lowest percentage of correct responses for low and medium memory load conditions in the group of boys.

The analysis of the reaction times related to the Memory load level, in the secondary task, did not show significant differences between groups (table 3). However, there was a marginal difference in the main effect of the Memory load level. As Table 4 shows, in boys and girls there was a tendency of increasing the reaction times as the Memory load level decreased.

Table 3.
Results of ANOVA using reaction times from the secondary task

Effect	F	d. f.	p	Epsilon
Sex	1.1	1, 26	.3	---
ML	2.3	2.2, 56.5	.09	.7
Sex x ML	1.3	3, 78	.3	.7

d.f.= degree of freedom, ML= Memory load

Table 4.
Means and Standard deviations of Reaction times for the secondary task

	Memory load									
	1		2		3		4		Total	
Sex	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Girls	565.9	79.3	594.5	66.2	575.8	65.6	579.6	66.5	578.9	69.4
Boys	571.8	39.3	592.1	63.2	615.2	27.5	608.3	53.6	596.9	45.9
Total	568.9	61.4	593.3	63.5	595.5	53.3	593.9	61	---	---

$\bar{x}$ = Mean, S.D.= Standard Deviation, Total = All subjects across memory load conditions

Primary Task

As table 5 shows, in the primary task (memorization of matrices), there were no significant main effects or interactions. On table 6 one may notice that both groups remembered between 80% and 90% of the presented matrices, independently of the memory load level.

Table 5.
Results of ANOVA using the percentage of correct responses (transformed values) from the primary task

Effect	F	d. f.	p	Epsilon
Sex	.8	1, 26	.4	---
ML	1.6	1.9, 48.8	.2	.9
Sex x ML	.3	1.9, 48.8	.7	.9

d.f.= degree of freedom, ML= Memory load

Table 6.
Means and Standard deviations of percentage of correct responses in the primary task (recall)

	Memory load							
	2		3		4		Total	
Sex	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Girls	80	22	92	11	82	20	85	18
Boys	85	25	92	11	87	18	88	18
Total	83	23	92	11	84	19	---	---

$\bar{x}$= Mean, S.D.= Standard Deviation, Total = All subjects across 3 levels of memory load conditions

Discussion

Although the principal goal of this paper was the study of sex differences in the visuospatial processing, we will discuss the general results and then bring these findings into context with sex-related differences.

Processing and storing of information in the VSSP need attentional resources (supplied by the CE). These resources are limited but flexible, since they can be used in active way (categorize, take decisions, etc.) or in a passive way like it happens in the PL. This paper showed that the subjects maintained a uniform recall of the matrices independently of the memory load in the VSSP. However, memory load significantly affected the performance in the secondary task, showing that the CE was seriously affected in relation to the matrix complexity. This could be caused by the CE allocated more resources to the primary task and the resources designated to the secondary task were insufficient, and then the performance in the secondary task was severally affected. This effect may have been aggravated by the fact that in the primary and secondary tasks, the stimuli were visuospatial (Hunt, & Ellis 1999). Thus, we can observe that the relations between the CE (processing) and the VSSP (storage) seem to be determined by a huge demand of resources that require the storage in the memory, having in consequence a deficient CE.

In relation to the sex, in both groups were observed a similar performance in the recall and storage stages. However, it is clear that in the secondary task the boys were the most affected (Sex x Memory load interaction). This indicates that the boys had less correct responses in the secondary task as the memory load increased. Vuontela et al. (2003) and Levine et al. (1999) also observed that boys performed worse than girls in WM spatial tasks, but these authors do not specify how the different components of the WM interact. In accordance with our interpretation, the boys allocated less resources to the processing stage (secondary task) and more to the storage phase, while the girls allocated a sufficient amount of resources to have a similar performance as the boys. This allowed the girls rely on more resources than the boys in the processing stage having better performance than them (probably in terms of better strategy). Perhaps these different strategies are what Logie, & Pearson (1997) and Tzuriel, & Egozi (2010) refer to the differences in the visuospatial ability may depend on differences in the processing strategies affecting the amount of information that can be retained and processed simultaneously.

In the literature there are others factors mentioned that could influence the presence of sex differences such as the transformation of visuospatial information into phonological codes in infants older than 8 years (Palmer, 2000; Pickering, 2001). It is possible that the girls of this sample transformed the visual items into phonological codes (for example, finding similarities in the configuration of the matrix with some letter or figure).

Other possibility could be that independently of strategies, the demands for codification storage require more attentional resources from boys than from girls, which could impede the correct information processing. This could result in more errors in the secondary task for the boys. These differences may be observed only after an increase in the memory load. Thus, it seems that sex differences can only be observed from the tasks that test high WM storage demands. This agrees with the ideas expressed by Coluccia, & Louse (2004), who assure that the differences in spatial orientation only arise when the tasks require a high memory load of the visuospatial processing.

Based on the results of this study, we can affirm that the lack of uniformity in the difficulty level of the tasks used in previous investigations could be a factor that explains why in some studies there have not been observed sex-based differences either in the children or adults.

These results also show that the dual task used in this study was useful in differentiating between individuals of different sex. The fact that it involved a dual task where VSSP load was varied, gathered the necessary conditions to test this WM system, confirming the statements of Robert, & Savoie (2006), Cornoldi, & Vecchi (2003) and Kaufman (2007). However, it is important to mention that the task could not discriminate between the memory load differences, so it is important to pay attention to this factor.

The studies about visuospatial abilities, frequently found better performance in men, which shows the possible influence of the gonadal hormones in their performances. Some authors have proposed that these differences are related to the hemispheric specialization to which gonadal hormones contribute since birth (Gil Verona et al., 2003).

Contrary to these observations, in the present study, the girls performed better than the boys, what make us suppose that it is not until the adolescence that sexual difference begins to be expressed until it reaches its adult form, when hormonal development has finished. So, the hormonal factor could interact with the experience to solve paradigms of dual type that were used to study the WM.

Data on this paper showed higher performance for girls in visuospatial WM. Robert, & Savoi (2006) and Kaufman (2007) observed a similar trend between adult men and women, using a very similar task as this study. However, it is necessary to emphasize that this study used a small sample, which limits the generalization of the findings.

Conclusions

In this paper, it is clear that girls showed a better performance than boys in their processing abilities, in situations where the amount of load of visuospatial storage was increased. The memory load level in the tasks that measures the visuospatial WM capacity is an important factor in differentiating the performance between girls and boys in the visuospatial ability.

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