SPACE REPRESENTATION AND GENDER DIFFERENCES

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Abstract
Scientific literature highlighted gender differences in spatial orientation. In particular, men and women differ in terms of the navigational processes they use in daily life. Scientific literature highlighted that women use analytical strategies while men tend to use holistic strategies. According to classical studies, males show a net advantage at least in the two categories of mental rotation and spatial perception. Subsequently, brain-imaging studies have shown a difference between males and females in the activity of brain regions involved in spatial cognition tasks. What we can say with certainty is that, given the complex nature of the sub processes involved in what we call spatial cognition, the gender differences recorded by numerous scientific studies conducted in this field are closely related to specific measured abilities. The evidence that emerges with certainty from diverse studies is, however, that of a huge variety of strategies that differ according to sex, context, purpose to reach, education, age, and profession. In the study presented here, the gender and age-related tests show a significant sex-based difference in perspective-taking tasks, but there is no gender-based difference in the mental rotation task.

Key words: *perception, action, perspective-taking tasks, skill.*

Introduction

The present research project intended to investigate the relationship between gender difference, perspective taking skills and mental rotation skills. The hypothesis about the relationship between age and skills under investigation, gained in the study of the scientific literature, is that these skills are developed in a very extensive range, from 4/5 to 11/12 years of age, and covers, in fact, much of the first cycle of education.

In particular, if the skills of perspective taking begin to occur early as three years old, the ability of mental rotation, that allows to integrate the different perspectives into a coherent functional representation of space, fully manifests itself only at the turn of the ten / eleven years, confirming the view taken by Piaget and Inhelder in 1948 (Piaget & Inhelder, 1948). As for the difference between the genders, the assumption is that the different behavior between genders is not a variable that intervenes only during the acquisition of the skills being investigated, but that represents a structural difference, and persists into adulthood.

The project included the development from scratch of a non-invasive research tool (a videogame), designed to be meaningful to the target identified - that could make sense to the children, in the expression of Hughes (Hughes & Donaldson, 1979) - and to take advantage of the full potential of space representation offered by the new media and of the confidence that the current generation of primary school students shows to possess with such systems. "Numerous data in the literature provide evidence for gender differences in spatial orientation." (Lambrey & Berthoz, 2007).

Problem statement
Gender differences have been a popular topic in social sciences for many years. Regarding the specific field of spatial cognition, it should be specified that both common belief and scientific literature claim that men and women differ in spatial abilities. The 1974 seminal study by Maccoby & Jacklin (1974), in which spatial cognition was considered a unitary capacity in which males excelled in comparison to females, marrying well with common beliefs, gave rise to the commonplace of a supposed male greater ability which is feeding itself by metabolizing results from specific studies. A 1985 study by Linn and Petersen (Linn & Petersen, 1985)classified spatial tests, distinguishing the three categories of mental rotation, spatial perception, and spatial visualization. According to classical studies (Benton, Varney, & de Shamsher, 1978; Inhelder& Piaget, 1958; Shepard & Metzler, 1971) quoted in de Goede (de Goede, 2009), males show a net advantage at least in the two categories of mental rotation and spatial perception. Subsequently, brain-imaging studies have shown a difference between males and females in the activity of brain regions involved in spatial cognition tasks. "A brain imaging study by Grön, Wunderlich, Spitzer, Tomczak & Riepe(Grön, Wunderlich, Spitzer, Tomczak, & Riepe, 2000) have shown that males and females recruit different brain regions in navigation. They found that men primarily engaged the left hippocampal region. In women on the other hand the right parietal and right prefrontal areas were activated. These differences might reflect typical gender differences in navigational approaches, that is a strong reliance in females on landmarks and the usage of both landmarks and

geometry in males, which would in general provide males with an advantage in navigational tasks" (de Goede, 2009). Other studies have addressed the cognitive dimension of gender differences in spatial cognition, suggesting that these differences are related to coding strategies rather than differences in specific abilities. Schmitz (Schmitz, 1997) has suggested that different strategic preferences already develop in childhood; since boys, as compared to girls, tend to have a larger range of spatial experience, they would experience less spatial anxiety later on in live. Higher levels of anxiety would induce a stronger dependency on landmarks, which provides an explanation for the preference for this cue type in females (de Goede, 2009). The biological structure is fundamentally important, but its links with spatial perception are not of a mechanical nature. Studies involving gender differences have largely debated the link between the right and left hemispheres of the brain with linguistic and spatial functions in men and women. Clinical trials on patients with right hemisphere have not demonstrated.

However, a more devastating effect of such damage to the spatial performance of men than women, as it would have been easy to suppose in accordance with the assumption made earlier.The results of a Kimura study suggest that normal differences between men and women on line rotation and orientation activities should not be the result of different degrees of dependence on the right hemisphere. My laboratory has studied the ability of patients with damage to one hemisphere of the brain to visualize the rotation of certain objects. As expected, for both sexes, those with damage to the right hemisphere got lower scores on these tests than those with damage to the left hemisphere did. Also, as anticipated, women did not do as well as men on this test.

Damage to the right hemisphere, however, had no greater effect on men than on women(Kimura, 1992). According to Kimura, some other brain systems may be mediating the higher performance by men. Berthoz summarizes: ''There are anatomical and neuroendocrinal bases for gender differences […], but it is now accepted that, whatever the origin (nature or nurture) of these differences, men and women do not process spatial information, for instance, in the same way.'' According to Berthoz, women are more dependent on visual field for spatial orientation. They are statistically better in cognitive tasks that can be verbally mediated and in storing significant forms that can be called to recognize. Men and women do not react the same way to a sensory conflict.

These differences are not due to education, although it can of course have a great influence. They originate in anatomical differences in the brain, but also hormonal factors - estrogen changes for women and testosterone for men (Berthoz, 2013). For travel memory, women tend to adopt more egocentric and sequential strategies. Berthoz suggests that this is related to their preference for what can be verbally mediated. In other words, women prefer a verbal description of travel, which is of a sequential nature. This is probably due to the cerebral lateralization process. Men, on the other hand, prefer more allocentrics strategies. In general, males are statistically more efficient in mental rotation tasks, such as changing perspective by reading a map. Some studies point out that the mental representation of large environments in males contains more "metric" information in men than in women, while females relied more on information about the actual references in the environment during navigation. ''On the whole, variation between men and women tends to be smaller than deviations within each sex, but very large differences between the groups do exist—in men's high level of visual spatial targeting ability, for one'' (Kimura, 1992). The evidence that emerges with certainty from diverse studies is, however, that of a huge variety of strategies that differ according to sex, context, purpose to reach, education, age, and profession. Berthoz speaks, in this regard, of functional vicariance.

Methods

The project included the development from scratch of a non-invasive research tool (a videogame), designed to be meaningful to the target identified - that could make sense to the children, in the expression of Hughes (Hughes & Donaldson, 1979) - and to take advantage of the full potential of space representation offered by the new media and of the confidence that the current generation of primary school students shows to possess with such systems.

The videogame prototype realized requires the user to navigate in a three dimensional space through an avatar. User deals with three different tasks, two of which are designed to measure the skills of perspective taking, while the third task is calibrated on the ability of mental rotation.

The default point of view is a semi-subjective view with the camera following the avatar. The player has the option to select other views, going through semi-subjective, subjective and objective point of view. In the first task, the avatar of the player is located in a park and has in front of him two men.

A window in overlay shows the point of view of one of the two men. The player's task is to indicate which of the two men belong the views shown in the overlay window. The position of the avatar is fixed (the user can change your point of view, but cannot move the avatar in space), while the position of the elements on the scene is random, according to a predetermined pattern.

At each new attempt, the position of the two men in front of the avatar will be randomly assigned to the two person-placeholders and the location of objects that represent possible landmarks (tree, lamppost, bench) will be randomly assigned to the object-placeholders.

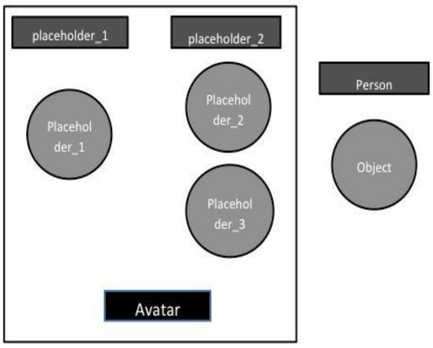

Figure 1. Position of the elements in the game space

In the second task the user has in front of him one. Two windows in overlay at the top of the screen show two points of view, one of which belongs to the individual in the scene. The user, in this case, must select the window that shows the point of view of the individual present in the park.

In the third task the user is dealing with "the invisible man". The player cannot see the man in the park but he can see, in the overlay window, what the invisible man is seeing. The park is divided into 6 zones. By moving the mouse, the player can select the area of the park in which he believes, based on what he sees in the window, he can find the invisible man.

Results

The game was tested between January and March 2015, with a group of 70 children, 35 males and 35 females, from the third, fourth and fifth primary school class and from a first secondary school class of the Istituto Comprensivo San Valentino Torio, in the province of Salerno.

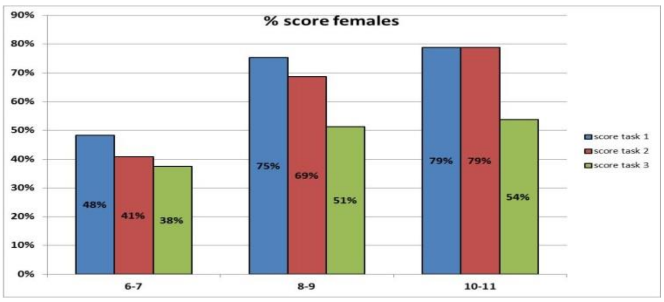

Figure 1.

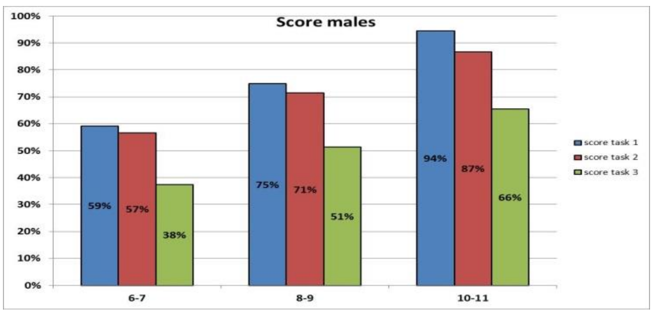

Figure 2.

Table 1.

% Score (females)			
	Age 6-7	Age 8-9	Age 10-11
Task 1	48%	75%	79%
Task 2	41%	69%	79%
Task 3	38%	51%	54%

Table 2.

% Score (males)			
	6-7	8-9	10-11
Task 1	59%	75%	94%
Task 2	57%	71%	87%
Task 3	38%	51%	66%

Table 3.

STATISTICS (females)				
Age (years)		6-7	8-9	10-11
Score task 1	Mean	4,8	7,5	7,9
	SD	0,6	0,9	0,8
Score task 2	Mean	4,1	6,9	7,9
	SD	0,5	1,7	1,4
Score task 3	Mean	3,8	5,1	5,4
	SD	0,9	1,3	0,9

Table 4.

STATISTICS (males)				
Age (years)		6-7	8-9	10-11
Score task 1	Mean	5,9	7,5	9,4
	SD	1,1	0,9	0,7
Score task 2	Mean	5,7	7,1	8,7
	SD	1,1	1,0	1,2
Score task 3	Mean	3,8	5,1	6,6
	SD	1,0	1,0	1,8

Each user performs 10 attempts for each task. The software records the beginning of each game, the user data (age and gender), and, during the game, time for each attempt and the result (success / failure) of the attempt. Group composition by age and sex, and the overall scores obtained for individual tasks are readable in Appendix A.

Relationship between gender difference and performance

In order to assess the impact of gender on the scores we conducted the following hypothesis tests. We conducted a T-Student test on scores obtained on at the task 1 by females and males. The results indicate the presence of a significant difference in the performance of the subjects relating to the factor examined (t [68]= 0.961, p = 0.048). We conducted a T-Student test on scores obtained on at the task 2 by females and males. The results indicate the presence of a significant difference in the performance of the subjects relating to the factor examined (t [68]=0.964, p = 0.044).

Discussion and conclusion

The tests conducted regarding the relationship between gender and age show a significant difference obtained in the first two tasks in relation to sex.

Success rates for the three tasks and sex seem to indicate a gradual improvement in performance in the three tasks in relation to the increase in age for both sexes. In this study, the gender -related tests show a significant sex-based difference perspective -taking tasks, but there is no gender-based difference in the mental rotation task. Success rates for three tasks seem to indicate a progressive improvement in performance in the three tasks in relation to increasing age for both sexes. What we can say with certainty is that, given the complex nature of the subprocesses involved in what we call spatial cognition, the gender differences recorded by numerous scientific studies conducted in this field are closely related to specific measured abilities. Moreover, given once again the peculiar nature of the field of study, the choice of instruments used for measurements is not at all neutral. The differences relate to paper-and-pencil test based studies compared to those that take into account the ecological variable and are based on tasks performed in real or virtual spaces.

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PROSTORNA ORIJENTACIJA I SPOLNE RAZLIKE

Sažetak
Znanstvena literatura je istaknula spolne razlike u prostornoj orijentaciji. Konkretno, muškarci i žene razlikuju se u smislu navigacijskih procesa koje koriste u svakodnevnom životu. Znanstvena literatura je naglasila da žene koriste analitičke strategije dok muškarci imaju tendenciju korištenja holističke strategije. Prema klasičnim studijama, muškarci pokazuju prednost barem u dvije kategorije: mentalnoj rotaciji i prostornojpercepciji. Nakon toga, studije slikag mozga pokazale su razliku između muškaraca i žena u aktivnosti regija mozga uključenih u prostorno-kognicijske zadatke. Ono što možemo sa sigurnošću reći je da, s obzirom na složenu prirodu sub procesa uključenih u ono što nazivamo prostornom spoznajom, spolne razlike zabilježene brojnim znanstvenim istraživanjima provedenim na ovom području usko su povezane s određenim mjerenim sposobnostima. Dokazi koji se sa sigurnošću pojavljuju iz različitih studija, međutim, predstavljaju golem niz strategija koje se razlikuju po spolu, kontekstu, cilju dostizanja, obrazovanja, dobi i zanimanju. U ovdje prikazanom istraživanju, testovi koji se odnose na spol i dob, pokazuju značajnu razliku u zadacima koji rade na perspektivi na temelju spola, ali nema razlike u odnosu na spol na mentalnoj rotaciji.

Ključne riječi: *percepcija, akcija, zadaće koje promiču perspektivu, vještina.*

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