THE BODY AND THE SPACE: AGE AND GENDER DIFFERENCES IN SPACE REPRESENTATION

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Abstract

The paper addresses the issue of the representation of space in the child, from Piaget to neurosciences, describing the reference systems competing in the representation of space and the Piagetian conceptual framework, and reporting the scientific debate on the "three mountains task" and the spatial theory of empathy. The experimental project intended to investigate the relationship between chronological age and perspective taking skills and mental rotation, and the relationship between gender difference and perspective taking skills and mental rotation. The hypothesis about the relationship between age and skills under investigation, gained in the study of the cited scientific literature, is that these skills are developed in an extended period, ranging from 5 to 11 years, and cover a good part the first cycle of education. In particular, if the perspective taking skills begin to appear as three years old, the mental rotation ability that allows to integrate 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). Regarding the difference between the genders, the assumption is that gender is not a variable that intervenes only on the age of acquisition of skills under investigation, but that represents a structural difference that persists into adulthood.

Key words: *space representation, perceptual egocentrism, empathy, perspective taking*

Introduction

The age range 6-7 years and 12-13 years is the period in which the child learns the change of point of view, in the literal sense, and, in a broad sense, realizes that the world can not be seen one way, that space can be manipulated, that it is possible to consider the thoughts and emotions of others. It is the age in which the capacity for empathy develops, understood as the ability to see the world through the eyes of others. The scientific debate on the relationship between perspective taking and spatial thinking has focused on two main factors, first, the age when the child leaves the perceptual egocentrism and acquires the ability to imagine different perspectives. The disagreement between positions is strong, and results in sometimes very distant assessments. If Piaget suggests a "window" of time between 6 and 11 years, other scholars, on the basis of different tests, have supported different theses, moving the threshold to five, four and even three years (Rochat).

In addition, the ability of perspective-taking, taken individually, do not seem sufficient to demonstrate the ability, in the child, to have a coherent representation of space, to allow handling of viewpoints (Frith& De Vignemont, 2005). Berthoz, in this regard, puts in relation the overcoming of perceptual egocentrism with a more complex perspective-taking mechanism, which consists in the ability of performing a mental rotation on ourselves by maintaining a main perspective of the environment (Berthoz, 2011). In other words, according Berthoz, the perceptual egocentrism abandonment lies in the ability, based on mental rotation skills, to simultaneously use egocentric, allocentric and heterocentric perspectives. Second, the gender difference plays a key role in spatial thinking. Berthozsummarizes: “numerous data in the literature provide evidence for gender differences in spatial orientation. In particular, it has been suggested that spatial representations of large-scale environments are more accurate in terms of metric information in men than in women but are richer in landmark information in women than in men” (Lambrey & Berthoz, 2007).

Criticisms of Piaget by Hughes and Rochat demonstrate the difficulty in conceiving research paradigms on the topic. In this sense, the evolution of digital systems for the representation of space provides valuable tools for the construction of effective tools. Starting from this assumption, the present project intends to investigate the relationship between chronological age and perspective taking skills and mental rotation, and the relationship between gender difference and perspective taking skills and mental rotation. The hypothesis about the relationship between age and skills under investigation, gained in the study of the cited scientific literature, is that these skills are developed in an extended period, ranging from 5 to 11 years, and cover a good part the first cycle of education. In particular, if the perspective taking skills begin to appear as three years old, the mental rotation ability that allows to integrate 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).

Regarding the difference between the genders, the assumption is that gender is not a variable that intervenes only on the age of acquisition of skills under investigation, but that represents a structural difference that persists into adulthood.

Material and methods

The research project involved the ex-novo development of a non-invasive investigation tool, which could be significant for the identified target - that could make sense to the children, according to Hughes (Hughes & Donaldson, 1979) - and that could advantageously use the representation of space capabilities offered by the new media and the confidence that the current generation of primary school students shows to possess with such systems. The video game 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. The use of terminology "subjective point of view", "semi-subjective point of view", objective point of view" refers to the classification proposed by J. Mitry in The Aesthetics and Psychology of the Cinema (Mitry & King, 1997).

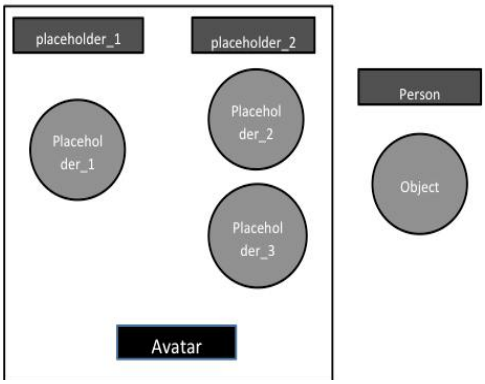

Figure 1. Position of the elements in the game space

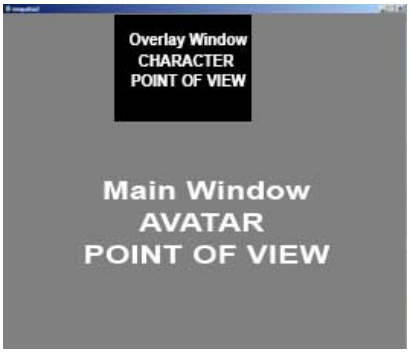

Figure 2. Task 1 - points of view

In the second task the user has in front of him one man. 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.

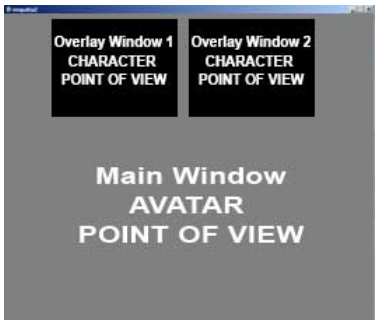

Figure 2. Task 2 - points of view

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.

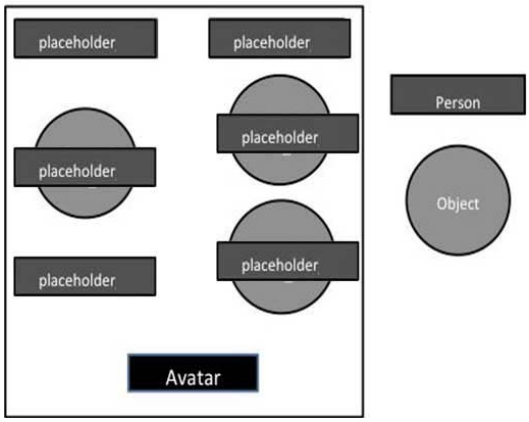

Figure 4. Task 3 - Position of the elements in the game space

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 2 - Position of the elements in the game space). 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.

Results

Table 1. Group composition by age and sex and the overall scores obtained for individual task.

Age (months)	Age (years)	Sex	Score task 1	Score task 2	Score task 3
80	6,7	f	4	4	2
83	6,9	f	4	4	3
84	7,0	m	5	4	3
86	7,2	m	4	5	3
87	7,3	f	5	4	5
87	7,3	m	5	5	4
88	7,3	f	4	4	5
88	7,3	f	5	4	4
88	7,3	f	5	4	4
88	7,3	m	5	5	4
88	7,3	m	6	6	4
88	7,3	m	6	5	5
89	7,4	f	5	4	4
90	7,5	f	5	5	3
90	7,5	f	5	4	4
90	7,5	f	5	5	3
90	7,5	f	5	4	4
90	7,5	m	6	6	2
90	7,5	m	6	5	3
90	7,5	m	6	6	3
91	7,6	f	6	3	4
91	7,6	m	8	6	4
91	7,6	m	7	8	5
92	7,7	m	7	7	5
99	8,3	f	7	8	4
99	8,3	f	6	5	5
101	8,4	f	9	5	7
101	8,4	f	8	6	5
101	8,4	f	9	8	4
101	8,4	m	8	6	6
101	8,4	m	8	7	7
101	8,4	m	8	9	4
102	8,5	f	7	7	5
103	8,6	f	7	5	4
103	8,6	m	7	6	5
103	8,6	m	9	7	4
103	8,6	m	6	8	6
103	8,6	m	8	9	7
105	8,8	m	6	6	5
105	8,8	m	7	8	5
105	8,8	m	6	7	4
106	8,8	f	7	4	5
106	8,8	m	8	7	5
107	8,9	f	9	9	7
107	8,9	f	7	9	4
107	8,9	f	7	5	3
107	8,9	m	8	6	3
108	9,0	f	8	8	7
110	9,2	f	7	8	5
110	9,2	m	8	7	5
112	9,3	m	8	7	6
115	9,6	f	7	8	7
117	9,8	f	8	8	5
120	10,0	m	8	8	6
123	10,3	m	9	7	5
124	10,3	f	8	6	4
126	10,5	f	8	8	5
128	10,7	m	9	7	3
135	11,3	m	9	8	7
137	11,4	f	9	8	5
137	11,4	f	7	8	5
138	11,5	f	7	6	6
138	11,5	f	8	8	6
138	11,5	m	10	9	9
139	11,6	f	7	9	5
140	11,7	f	9	10	7
140	11,7	m	10	10	6
141	11,8	m	10	10	8
142	11,8	m	10	10	7
148	12,3	m	10	9	8

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. 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. Table 1shows group composition by age and sex, and the overall scores obtained for individual task.

The relationship between age and performance
Analysis of variance

ANOVA was conducted on the number of successes in task 1 using as BETWEEN FACTOR age and dividing the sample into three groups (6-7 years, 8-9 years, 10-11 years). The results indicate a significant difference in the performance of the subjects relating to the factor taken into consideration [$F(2,67)= 60.67$, $p<0,001$] (Table 2). The data seem to suggest a significant difference in the number of successes achieved in the first task in relation to the age of the subjects.

Table 2. Task 1.

Task 1			
Group (age in years)	**6-7**	**8-9**	**10-11**
Mean (score)	5,38	7,52	8,71
SD	1,013	0,911	1,105

ANOVA was conducted on the number of successes in task 2 using as BETWEEN FACTOR age and dividing the sample into three groups (6-7 years, 8-9 years, 10-11 years), the results indicate a difference significant in the performance of the subjects relating to the factor examined [$F(2,67)= 35.84$, $p<0,001$] (Table 3). The data seem to suggest a significant difference in the number of successes achieved in the second task in relation to the age of the subjects.

Table 3. Task 2.

Task 2			
Group (age in years)	**6-7**	**8-9**	**10-11**
Mean (score)	4,88	7,0	8,29
SD	1,15	1,39	1,31

ANOVA was conducted on the number of successes in the task 3 using as BETWEEN FACTOR age and dividing the sample into three groups (6-7 years, 8-9 years, 10-11 years), the results indicate a significant difference in the performance of the subjects relating to the factor examined [$F(2,67)= 18,43$, $p<0,001$] (Table4). The data seem to suggest a significant difference in the number of successes achieved in the third task in relation to the age of the subjects.

Table 4. Task 3.

Task 3			
Group (age in years)	**6-7**	**8-9**	**10-11**
Mean (score)	3,75	5,14	6,00
SD	0,90	1,22	1,54

Correlation between age and score

Percentages of success in the three tasks were then calculated in relation to the age groups (Table 5).

Table 5. % Score (10 attempts).

% Score (10 attempts)			
	Age 6-7	**Age 8-9**	**Age 10-11**
Task 1	54%	75%	87%
Task 2	49%	70%	83%
Task 3	38%	51%	60%

We calculated the Pearson correlation coefficients and coefficients of determination between the variables age (calculated in terms of months) and scores at the task 1 (R= 0.77, R^2=0.58) (Graph 2), age and scores at the task 2 (R= 0.73, R^2=0.54) (Graph3) age and scores at the task 3 (R= 0.63, R^2=0.39) (Graph 4).

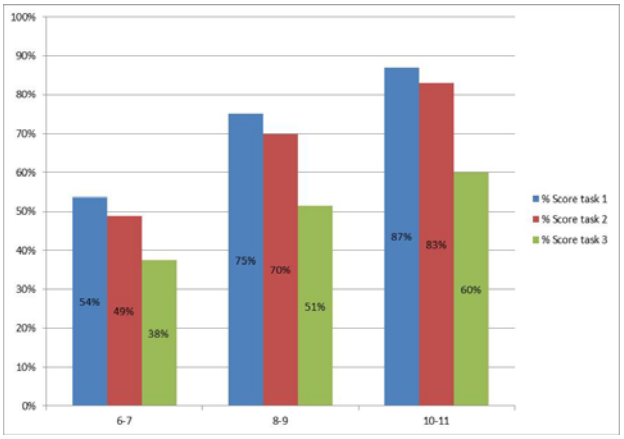

Figure 1.

The data seem to indicate a strong correlation between age and the scores obtained in the first two tasks and appear to indicate the presence of a moderate correlation with respect to age and the scores obtained in the third task. The analysis of the data seems to support the hypothesis that between 6 and 11 years the scores to the three tasks significantly increase.

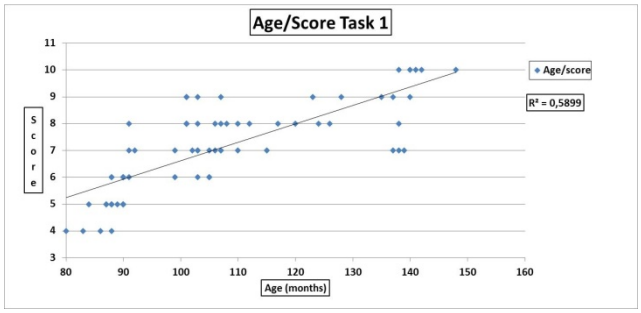

Figure 2. Age/score task 1.

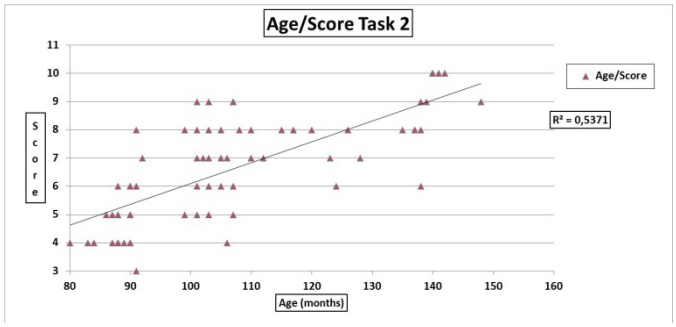

Figure 3. Age/score task 2.

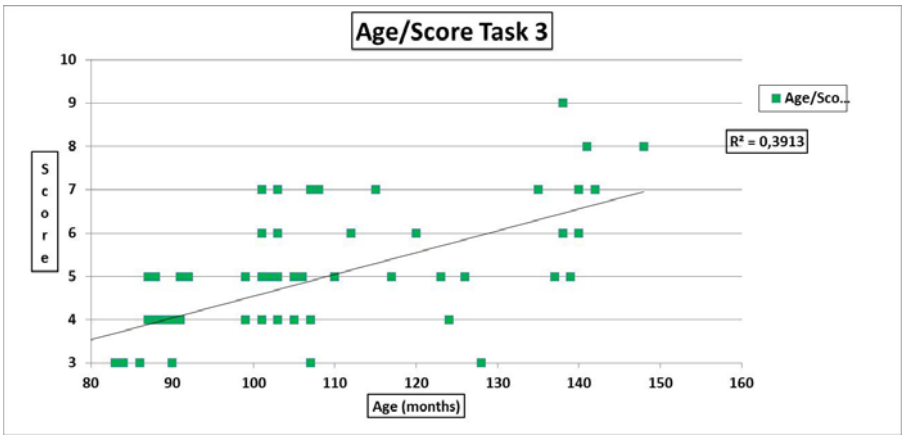

Figure 4. Age/score task 3.

Relationship between gender difference and performance

In order to assess 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). We conducted a T-Student test on scores obtained on at the task 2 by females and males. The results did not highlight significant differences in the performance of the subjects relating to the factor examined (t [68]= 0.705, p = 0.379).

The data seem to indicate the presence of a significant difference in the scores of the first two tasks ($p < 0.05$) in relation to sex, while there were no differences in scores obtained on the third tasks ($p > 0.05$) in relation to sex.

We then calculated the percentage of success in the three tasks in relation to sex and age (Figure 5 and Table 5, Figure 6 and Table 6) and the statistics for the percentage of success in the three tasks in relation to sex and age (Table 7, Table 8).

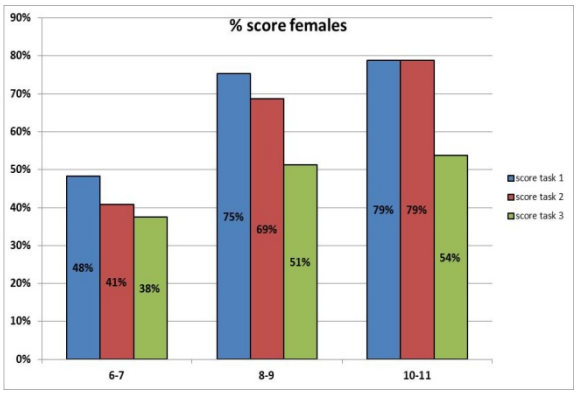

Figure 5. % score for females.

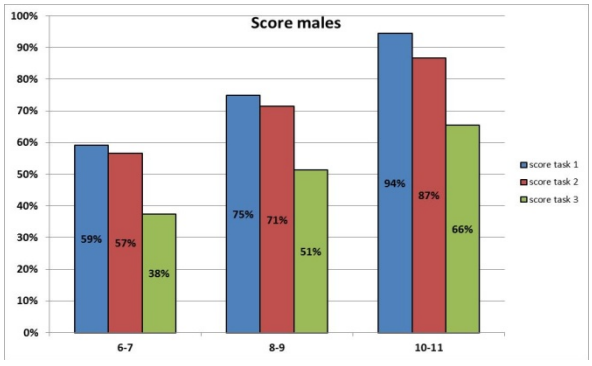

Figure 6. % score for males.

Table 6. % score for females.

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

Table 7. % score for males.

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

Table 8. Statistics (females).

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 9. Statistics (males).

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

Discussion and conclusion

The tests conducted regarding the relationship between age and performance show a significant difference in tasks obtained in relation to the age group selected; the success rates for the three age groups analyzed seem to indicate a gradual improvement in performance in the three tasks in relation to the increase of age. In particular, the task 3 appears to be the one that presents a greater challenge.

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. The age between 6-7 years and 12-13 years of age is defined, in common parlance, a "critical period."

It is the age when the child learns the change point of view, realizes that the world can not be seen one way, that space can be manipulated, that it is possible to consider the thoughts and emotions of others. It is the age in which the capacity for empathy develops, which is not only the emotional contagion that takes place between mother and child, but it is the ability to remain yourself putting

at the same time yourself in the place of others, to see the world through the others' eyes.

The ability to change point of view is extremely important from the cognitive point of view: if, during the critical period when it opens a "window" for this power, this is not acquired, once you close the "window", the child will remain locked in a unique vision of the other. We can imagine the child of seven to ten years, blocked in its ability to develop different cognitive strategies, such as a person trapped in a maze with a single output, a single view of the world. To leave the path traced, the child must make a shift, move from an "egocentric perception" to an" allocentric perception", inhibiting the usual way (A. Berthoz & Jorland, 2004). The ability to manipulate these mental pathways is the basis of our ability to think, is a fundamental mechanism for the development of thought and the construction of our relationship with the world and with others.

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TIJELO I PROSTOR: DOBNE I RODNE RAZLIKE U ZASTUPLJENOSTI PROSTORA

Sažetak

U radu se govori o pitanju zastupljenosti prostora kod djeteta, od Piageta do neuroznanosti, opisujući referentne sustave koji se natječu u zastupljenošću prostora i piagetovskom konceptualnom okviru, te izvješćivanju znanstvene raspravu o "zadatku tri planine" i prostorne teorije empatije. Eksperimentalni projekt namijenjen je istraživanju odnosa između kronološke dobi i vještine preuzimanja perspektive i mentalne rotacije, a odnos je između spolne razlike i vještina preuzimanja perspektive i mentalne rotacije. Hipoteza o odnosu između dobi i sposobnosti koja se ispituje, stečena u proučavanju citirane znanstvene literature, je da su te vještine razvijene tijekom duljeg vremena, u rasponu od 5 do 11 godina, a pokrivaju dobar dio prvog ciklusa školovanja, konkretno ako se vještine perspektivnog preuzimanja počinju pojavljivati oko treće godine, mentalna rotacija kao sposobnost omogućuje da se integriraju različite perspektive u koherentnu funkcionalnu zastupljenosti prostoru u potpunosti se manifestira samo na prijelazu deset / jedanaest godina, potvrđujući pogled Piageta i Inheldera u 1948. (Piaget & Inhelder, 1948). Obzirom na razlike među rodovima, pretpostavka je da rod više nije varijabla koja intervenira samo na dobi od stjecanja vještina pod istragom, ali to predstavlja strukturnu razliku koja ne prolazi u odrasloj dobi.

Ključne riječi: *zastupljenost prostora, perceptivni egocentrizam, empatija, preuzimanje perspektive.*

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