STUDYING THE CONNECTION BETWEEN SPATIAL NAVIGATION AND MENTALIZATION IN CHILDREN BY USING VIRTUAL REALITY

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INTRODUCTION

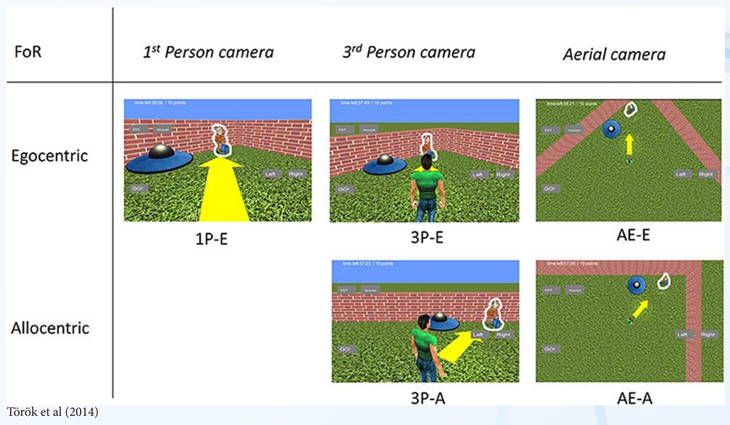
During spatial navigation, while constructing a cognitive map of the environment we rely on information registered relative to different reference frames [1]. We often rely on egocentric reference frames that use body-centered coordinate systems. In contrast, we also tend to rely on allocentric reference frames, which use coordinate systems attached to the environment or landmarks [2]. Some researchers claim that children are born with allocentric representations, but at a certain age, they prefer egocentric representations, which might be influenced by experimental manipulations [3,4]. In contrast, the legacy of Piaget's work suggests that the viewpoint independent strategy requires maturation of spatial cognition, which manifest later at the action level [5,6,7,8].

Interestingly, the emergence of the "Theory of Mind" and the ability to switch to allocentric spatial reference frames has similar developmental milestones between the third and the fifth year. However, there are different approaches in the development of the mentalization too. In contrast with the early observations demonstrating a sudden shift in this ability at the age of 4 [9, 10,11], recent studies suggested that few months-old toddlers are able to apply the „Theory of Mind" implicitly [12,13,14]. In spite of the new results many researchers [15] questioned that children understand beliefs in implicit tasks and explain children's performance by the adaptation of behavioral rules [16] or with conceptions as „altercentric viewpoint" [17] and submentalizing [18].

Based on these former results, we hypothesized a correlation between spatial perspective taking and the cognitive operations required by mentalization in the development.

MATERIALS AND METHODS

We used a computer program, made by Ágoston Török[19], in which the player has to locate and collect lost space aliens who landed on Earth. There were 5 different camera setups. These setups included a 1st person view, a 3rd person view, and a bird-eye view. The view control modes were two kinds: egocentric (the camera was attached locked to the position of the avatar) and allocentric (the camera was locked to the environment). We used the combination of these configuration: **1st person view – egocentric reference, 3rd person view – egocentric reference, 3rd person view – allocentric reference, bird-eye view – egocentric reference, bird-eye view – allocentric reference.** The participant's task was to collect lost space aliens within a square-shaped area and take them to two alternative target locations that were only visible at the start of the game, and later was only visible upon approaching them. The performance was scored in time efficiency and route efficiency. The **route performance** was the ratio of the players actual trajectory and the shortest possible route multiplied by 100. The **time performance** measured the difference between the actual and the optimal delivery time, also scale between 0 and 100. **The sample included 26 preschoolers with a mean age of 55.8 months (4.65 years, STD = 11.92 months).** We also measured the Theory of Mind with a digitalized Sally-Anne test[10] to correlate the mind reading ability with the spatial navigation performance. In this latter task children had to recognize that Sally who did not see when Anne changed the location of the golden egg had other belief than the observer, due to their different access to the relevant information. This difference is determined by their position and their spatial perspective.



Török et al (2014)

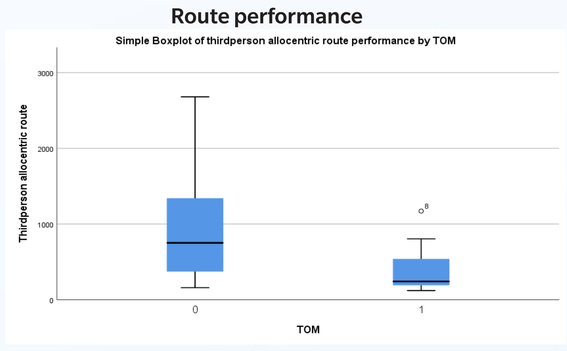
We hypothesized that the children who had the ability to switch to the others viewpoint also performed better in the 3rd person allocentric navigation setting because they were able to disengage from their own viewpoint. We also assumed, that there will be no difference in the 1st person - egocentric navigation ability between the 2 mentalization group levels.

RESULTS

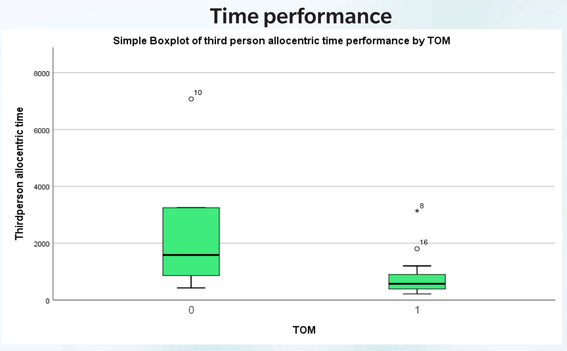
Concerning the 3rd person allocentric viewpoint, we found a highly significant difference in navigation performance between children at different levels of mentalization. Children who solve the Sally-Anne task can navigate better in the ground level allocentric orientation view point than the rest of the children. This difference in performance was consistent in both time and route efficacies. In contrast, there is no difference between the 2 mentalization groups concerning the egocentric navigation on the ground level which supports our second hypothesis.

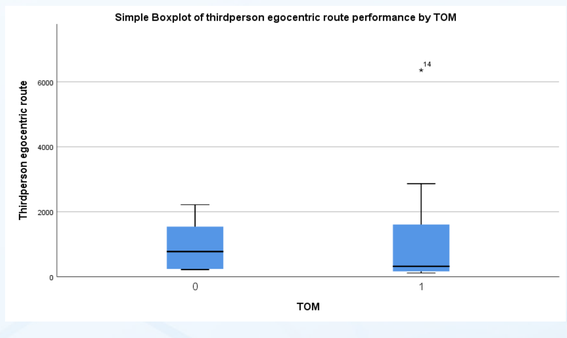
Differencies in time performace	Sig
Third person egocentric viewpoint and TOM	0.329
Third person allocentric viewpoint and TOM	0.008
Birdeye egocentric viewpoint and TOM	0.016
Birdeye allocentric viewpoint and TOM	0.036
First person egocentric viewpoint and TOM	0.637
Differencies in route performace	
Third person egocentric viewpoint and TOM	0.487
Third person allocentric viewpoint and TOM	0.026
Birdeye egocentric viewpoint and TOM	0.091
Birdeye allocentric viewpoint and TOM	0.152
First person egocentric viewpoint and TOM	0.803

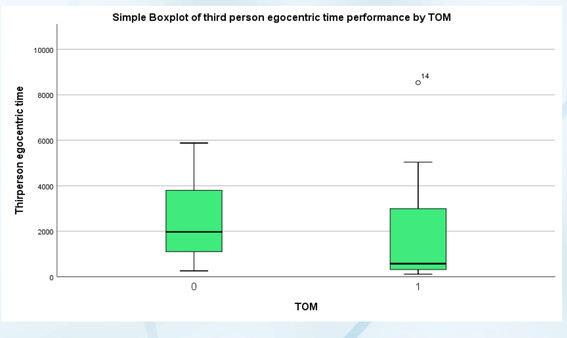
Route performance

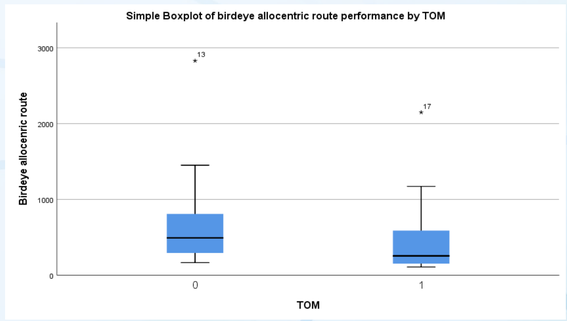


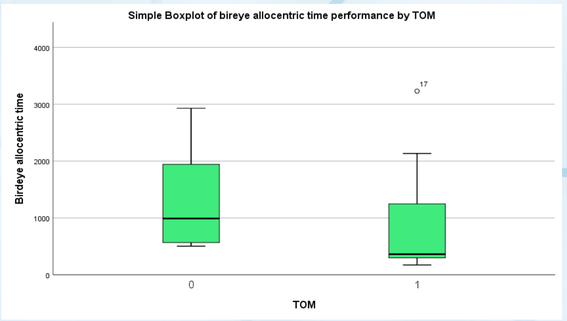
Time performance

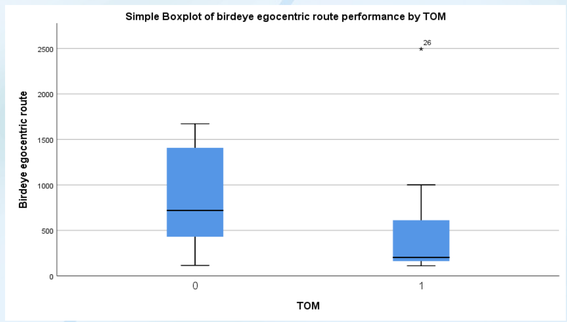


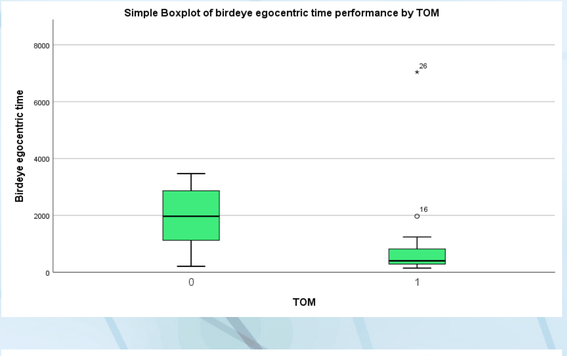


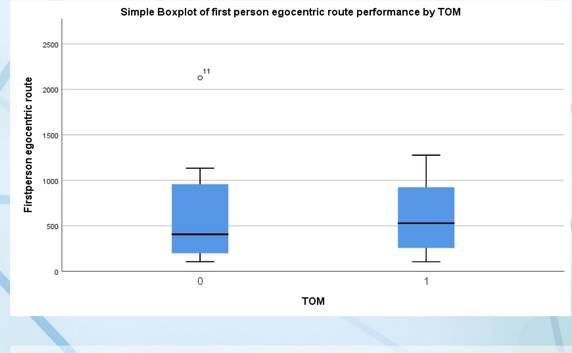


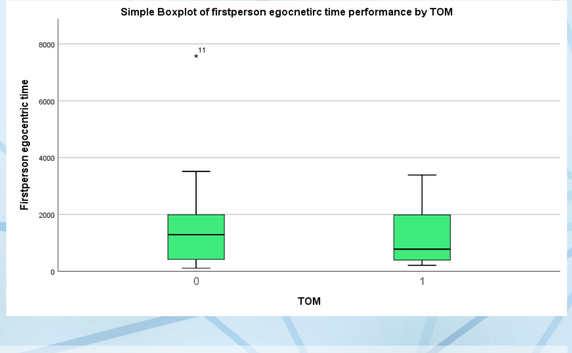












DISCUSSION

Based on the results, the ability to use a coordinate system attached to the environment instead of the person's own body may help to understand the dependency of the source of information on spatial positions. This understanding may be supported the mentalization ability. However, it is also conceivable that understanding of people's different mental states facilitate the use of a body-independent coordinate system during navigation.

CONCLUSION

We conclude that the development of the allocentric representation and the onset of the Theory of Mind are non-independent but how they interact with each other during the early childhood is a subject of further research.

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