POSTER

Visuo-spatial ability and wayfinding performance in real-world

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Keywords Wayfinding • Visuo-spatial ability • Individual differences

Background

In literature, there are not many studies which have investigated the relation between visuo-spatial ability and wayfinding in real world. In general, these works could be classified into two types: self-assessment studies, in which researchers ask people about their wayfinding ability, their type of navigation strategies or their daily spatial behaviour, in particular their awareness of orientation and their memory for usual spatial behaviour (e.g. Kato and Takeuchi 2003, Prestopnik and Roskos-Ewoldsen 2000); and behavioural studies, in which researchers ask a person to solve visuo-spatial tasks and perform wayfinding tasks. Our work uses this type of investigation method. The few studies presented in literature have shown mixed results. For example, Rovine and Weisman (1989) examined the relation between visuo-spatial ability, measured by spatial relation test and embedded figure test and wayfinding. They did not find any correlation between spatial relation test and wayfinding performance while embedded figure test scores were significantly correlated to wayfinding measures. To date, Blajenkova et al. (2005) have showed that individual differences in visuo-spatial ability, measured by a mental rotation test, resulted in differences in way-finding performance.
In general, there is little agreement in literature on the role plays from visuo-spatial ability to improve wayfinding performance. From our point of view, these results are biased by considering the visuo-spatial ability as a unique instead of a multi-component ability (Giusberti and Nori 1999). In particular, experiments that investigated spatial ability are concentrated on the study of a specific spatial aspect, that is the ability to use simultaneous spatial information. On the contrary, spatial memory is not an unitary but a multi-component system and it includes a wide range of abilities: visual, sequential and simultaneous. The importance of looking at specific subcomponents of spatial memory is supported by the visuo-spatial working memory, which is the cognitive system involved during the resolution of visuo-spatial tasks, proposed by Logie (1995). Fenner et al. (2000) have overcome this problem using six different tasks that are able to measure the different aspects of visuo-spatial ability. In their research, the authors examined the effect of visuo-spatial ability on wayfinding performance in young (5–6 years) and old (9–10 year) children. Results revealed that young children with high visuo-spatial ability (HV-SA) exhibited superior wayfinding compared to low visuospatial ability (LV-SA) children. This effect was not present in old children.
In spite of these results, the aim of our work was to examine which may be the influence of visuo-spatial ability, considered as a multi-component ability, on wayfinding performance. Particularly, we predict that: HV-SA participants perform the wayfinding better and faster than LV-SA participants who should hesitate more than high visuo-spatial ability participants, during wayfinding task in a large-scale environment. Finally, we investigated which visuo-spatial tasks would best predict wayfinding performance.

Method

Participants

The group was made up of 20 participants (11 males and 9 females) with HV-SA and 17 participants (9 males and 8 females) with LV-SA. They ranged in age from 19 to 32 (mean = 24.32 years, SD = 2.85).

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Materials

Six visuo-spatial tasks, similar to these utilised by Fenner et al. (2000), were used to distinguish the participants' visuo-spatial ability: Mental rotation task, Corsi Block task, Mental folding task, Standard Progressive Matrices, Copying task, Spatial problem task. The order of the six tasks was randomized.

Wayfinding Test. To measure wayfinding, a route of approximately 360 m was individuated in the botanical garden, that is a moderately dense wooded area of approximately 2.5 ha of the University of Bologna. A stopwatch was used to record wayfinding travelling-time.

Procedure

Each participant was tested individually. The participants had to solve the six visuo-spatial tasks, described above, in order to assess their visuo-spatial ability.

Successively, participants were taken by walking from the Department of Psychology to the starting point of the route that was inside the botanical garden. Then each participant was told that he/she would be taken on a walk through the botanical garden. Each participant was taken along the route, walking beside the experimenter from the starting to the ending position. At the ending position, the experimenter asked participants to walk along the same route to the starting position, that is they were asked to pass through the route in a reverse direction, without assistance and with the experimenter walking behind them. The experimenter recorded errors (i.e. every time participants took a wrong direction), frequency of hesitations (i.e. every time participant stopped to think about the way to take) and travelling-time.

Results

One way between participants ANOVA was performed on way-finding errors for participants assigned to the HV-SA and LV-SA group on the basis of their responses on the six visuo-spatial tasks. The analysis showed that LV-SA group performed more wayfinding errors (mean = 3.88) than HV-SA group (mean = 1.90); $F(1, 35) = 5.51$; $P < 0.05$.

A one way between participants ANOVA performed on frequency of hesitations revealed a significant effect: LV-SA group performed more hesitations (mean = 2.82) than HV-SA group (mean = 1.50); $F(1,35) = 5.34$; $P < 0.05$.

One way between participants ANOVA performed on travelling-time did not reveal any significant differences.

In order to assess which visuo-spatial aspect was mainly involved in wayfinding performance, we carried out a series of correlation between scores obtained from participants on each visuo-spatial task, that is we considered the number of correct responses for each task, and the wayfinding errors. The analysis revealed that there was a significant negative correlation between Corsi Block task ($r = -0.45$, $P < 0.01$), Copying task ($r = -0.61$, $P < 0.001$), Spatial problem task ($r = -0.47$, $P < 0.01$) and wayfinding errors.

Conclusions

The present results provide evidence that HV-SA participants exhibit superior performance in wayfinding than LV-SA ones. Moreover, our results show that the wayfinding behaviour of the HV-SA participants is different from those of the LV-SA participants: the latter hesitate more than the former during travelling, even if there is not any difference in travelling-time. From our data, it seems that LV-SA participants adopted a wayfinding strategy similar to those adopted by people who use a landmark strategy to navigate through the environment (e.g. Nori and Giusberti 2006). Indeed, a landmark style person, when moving through the environment, uses patterns that are perceptually salient or important for him/her (i.e. a shop, a church...), that is landmarks. Moreover, from our results, it seems that HV-SA people adopt a wayfinding behaviour similar to those adopted by route or survey users. A route person memorizes paths in form of a mental list of distances and directions that must be followed according to a specific sequence of motor actions. The spatial relations among landmarks are based on body references, that is an egocentric frame of references or coordinates. Survey style users move through the environment on the basis of landmarks and routes to connect landmarks, they are also able to mentally represent an overall configuration of the environment. These people are able to encode directions and distances between places regardless their position, that is they are able to use allocentric frames of references or coordinates. From our data, it seems that LV-SA participants, like landmark cognitive style users, have not been able to memorize the right spatial relation between a landmark and the next one, so they need to look-see around the environment to catch some patterns perceptually salient, in order to help them to recognize the correct direction.

On the contrary, HV-SA people have probably acquired a more accurate mental representation of the path based on the right relations among landmarks. These people could be route or survey cognitive style users. In the first case, participants learn the route in terms of an intrinsic reference system based on egocentric coordinates; they acquire, represent and use spatial information in the same manner that is based on egocentric coordinates. As well-known in literature, this correspondence makes easier moving in the environment (e.g. Féry and Magnac 2000). This type of spatial representation is particularly useful in way-finding task similar to those that we used, where participants had to memorize a sequence of landmarks and paths, which is exactly a route competency. As regards survey users, these people are able to use both egocentric and allocentric coordinates when they have to solve a wayfinding task. So in this case, when they navigate through the environment, they probably rely on egocentric coordinates in order to reach the goal, since the usage of these coordinates turns out to be the most useful and economic in terms of cognitive sources (encode/retrieval coincidence; Tulving and Thompson 1973). In both cases, people use their mental spatial representation comparing it to the external environment: probably this process does not require to stop during travelling. It could be considered as an on-line updating of spatial information.

Finally, as regards visuo-spatial tasks which were mainly involved in wayfinding performance, our data support the idea that wayfinding is mediated by a variety of visuo-spatial abilities. Indeed, the tasks which better predict the wayfinding ability are Corsi Block task, Copying task and Spatial Problem task. Corsi Block task requires to be correctly solved a spatial ability in which the temporal variable is particularly important while Copying task and Spatial Problem task require participants to relay exclusively on an abstract, internal representation characterized by an object-centred reference system, that is allocentric coordinates. In other words, basic spatial abilities such as spatial-sequential memory and spatial-inferential memory are related to the navigation in large-scale environment.

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