From the real to the virtual-world: Individual differences in navigation

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When was the last time you got lost? Have you ever travelled to a new place without a map only to find that minutes later you were wandering around desperately looking for a familiar landmark or a person who can orient you? Have you ever taken the subway to a different part of town and exited to the street level only find yourself completely disoriented? Why is it that we all have that friend who is constantly getting lost sometimes even in his/her hometown? At the same time, why is it that some of us are just not only naturally good at navigating but actually enjoy the thrill of exploring and learning about our environment? The project detailed below touches on some of these questions by investigating how individuals differ in their acquisition and development of spatial knowledge.

Classical frameworks on the acquisition and development of spatial knowledge (Shemyakin, 1962; Siegel and White, 1975) suggest that individuals first learn landmarks followed by the routes that connect them, eventually integrating these into a more holistic and metric survey level representation. During the last decade, it has been proposed that spatial microgenesis does not always follow a strict stage-like development but rather proceeds in a more continuous or quantitative fashion (Montello, 1998). The *continuous framework* proposes that some individuals are capable of integrating complex spatial information that allows them to perform accurate metric calculations with minimal exposure in the environment.

We have been working on a project investigating the behavioral and neural correlates of the acquisition and development of spatial knowledge of an unfamiliar university campus (Ambler campus of Temple University) over a period of three weeks, with particular emphasis on individual differences. In their first visit to the campus, subjects learned two routes located at different areas of the campus and were asked to remember the name and position of several buildings on each route. During the following weeks, subjects learned these routes for a second and third time together with a connecting route. At each stage, their integrated configurational knowledge was probed by asking them to complete a variety of online and offline tasks including direction estimation, distance estimation and sketch mapping (see figure 1). A subset of subjects also participated in an fMRI experiment where a recognition task was used to probe the subject's memory for buildings around the campus.

Behavioral results revealed large individual differences in the initial acquisition of spatial knowledge, suggesting that spatial microgenesis does not necessarily follow a stage-like development (as proposed by classical frameworks) but proceeds in a continuous fashion. This was particularly true during initial acquisition (first session) where several subjects showed evidence of metric knowledge and developed accurate representations of the environment with minimal exposure. Data from the fMRI experiment further complemented these results. A whole brain analysis that looked at performance-related activations revealed an exclusive activation of the retrosplenial cortex (RSC) among the top performers. It seems that while both top and bottom performers were able to accurately recall buildings from the Ambler campus (recognition accuracy was above 85% for both groups) the top performers were not only identifying these buildings but possibly situating them within their mental representation of the campus. This is consistent with the role of the RSC in supporting mechanisms that allow for situating a scene within the broader spatial environment (Epstein, 2008; Wolbers & Wolbers & Büchel, 2005) by integrating egocentric spatial information into a survey-level representation during navigation.

Virtual Ambler

Perhaps one of the main drawbacks of the real-world study was that the testing procedure was too long (9 hours distributed over 3 weeks) and required a certain amount of commitment from the participants. In an effort to collect more data from different samples of the population, we created a virtual model of the Ambler campus (see figure 2). The model was created using *Google Sketchup*[1] and later exported to the gaming engine *Unity 3D*[2] allowing subjects to actively navigate around the virtual campus. We are now currently working in developing web-based application which will structure the virtual world and the different spatial tasks together in an immersive videogame-like experience. Although subjects tested in the desktop virtual reality environment will not benefit from proprioception, pre-pilot testing suggests that the previous three-week testing procedure can be reduced to a 90 minute session. Having the real-world data as a basis for comparison, we hope that Virtual Ambler will allow us to test a larger sample of the population and answer specific questions regarding individual differences in spatial ability and knowledge transfer.

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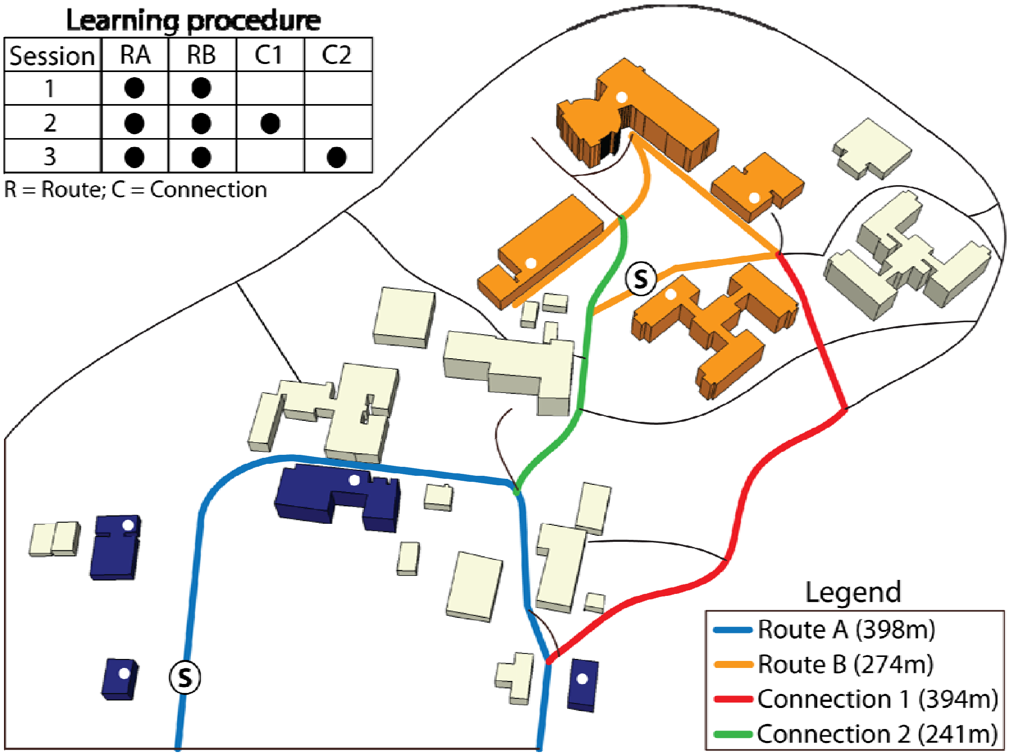
[1] http://sketchup.google.com/

[2] http://unity3d.com/

Figure 1 - The Ambler Campus



Learning procedure

Session	RA	RB	C1	C2
1	●	●		
2	●	●	●	
3	●	●		●

R = Route; C = Connection

The Ambler campus with the two main routes and the two connection routes. The table on the top left corner details the testing procedure over the three week period.

Figure 2 - Virtual Ambler

Figure 2 - Snapshots from the two routes of the virtual Ambler campus

References

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