Navigation processing influences episodic memory

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Theoretical background

Learning and recalling personal events located in space and time engage the episodic memory (Tulving, 1987). On the other hand, different spatial representations are used to grasp the environment, depending on the action to be done (Mellet et al., 2000). A link between the efficiency of episodic memory and the spatial representations is then proposed (Burgess, 2002; Nadel & Moscovitch, 1998). Among the spatial representations, we propose that self-centred navigational processing (Berthoz, 1997; Ekstrom et al., 2003; Whishaw, McKenna, & Maaswinkel, 1997) could constrain recollection from the episodic memory. This last one differs from egocentric processing which suppose an active updating of the information due to the permanent subjects' changes in localisation or orientation, and is thus inadequate for episodic memory (Burgess, Becker, King, & O'Keefe, 2001).

The relationship between spatial and mainly allocentric spatial representation on one hand and episodic memory on the other hand ("the cognitive map theory"), is mainly due to the involvement of the hippocampus in both abilities (Nadel & O'Keefe, 1978; Nyberg et al., 2000; O'Keefe & Dostrovsky, 1971). Recent assumptions concerning the episodic memory as a state of awareness (Wheeler, Stuss, & Tulving, 1997), as well as the significant findings on visual imagery (Crawley & French, 2005) and spatial memory and navigation (Etienne & Jeffery, 2004; Maguire et al., 1998; Whishaw, McKenna, & Maaswinkel, 1997; Worsley et al., 2001) have led us to revisit this functional link.

The present study aimed at distinguishing between "the cognitive map theory" and our new proposal, by answering the following question: Which type of spatial processing of an episode, allocentred or self-centred navigational, is significantly related to encoding and retrieving of an episode in and from the long-term memory? To answer this question we designed an experimental situation allowing the maximization of the navigational as well as of the allocentric processing.

Materials:

Twenty-two undergraduate and graduate students went through three experimental phases: 1) training with the spatial tasks, 2) spatial processing test

associated to learning of birds' names and pictures (i.e. episodic learning) and 3) assessment of the episodic memory of birds' names. Each spatial task was tested in a "within-subject" design.
In the navigational task (N), participants had to process space through a route-type navigation (they viewed and simulated navigation in the environment). In the allocentric task (A), participants had to process space through an object relation manner. Conditions did not contain any additional rehearsal time or imagery of items to discard a possible level of processing effect.
Episodic memory was assessed here with a recognition test of the item associated with a Remember-Know-Guess paradigm. The episodic recollection was assessed on previously presented items (names and pictures of a bird), rather than on spatial characteristics.

Results

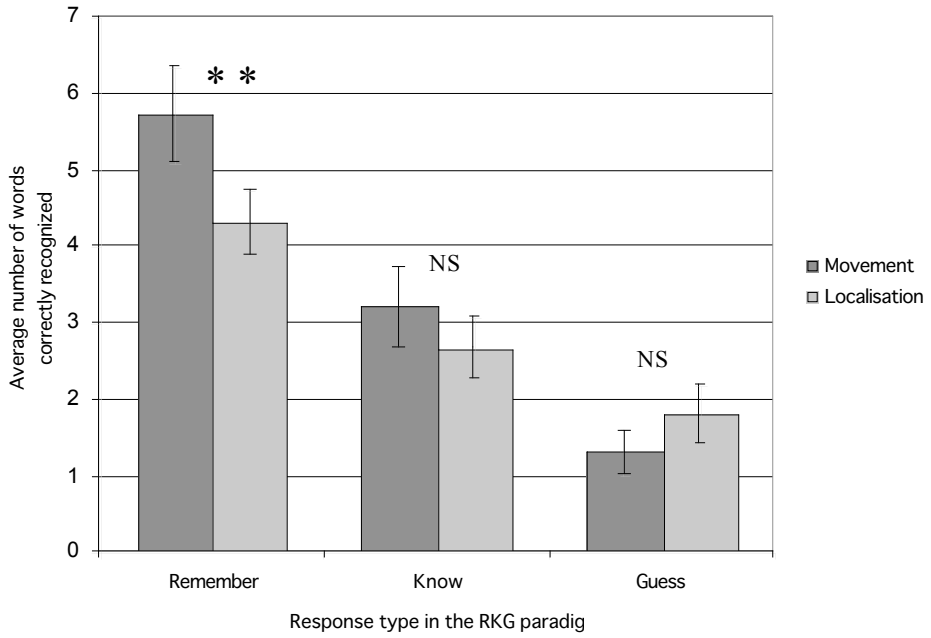

Fig. 1. : Recalled word number according to response type in the Remember-Know-Guess procedure.

An ANOVA was conducted on the total number of correctly recognized words, using spatial tasks (N condition vs. A condition) as within-subjects factors. An alpha-level of .05 was used for all statistical tests.
We predicted an effect of the type of spatial task carried out during the study phase on the total number of correctly recalled words. Figure 1 shows means and standard deviations for all variables recorded during the recall test. There was a significant main effect of the task ($F(1, 21) = 17.16$, $MSE = 2.97$, $p = 0.023$; item, $F(1. 27) = 6.52$, $MSE = 2.80$, $p = 0.016$). An average of 10.27 words (SD= 0.56) were correctly recognized in the N task with respect to 8.81 words (SD= 0.38) for the A task
In addition, we expected a significantly higher number of words correctly recognized and categorized as "remembered" in the N condition than in the A

condition especially for R responses. This is supported by the significant interaction (see Figure 1) between spatial conditions and RKG procedure responses type: $F(2, 42) = 2.33$, $MSE = 4.30$ $p = 0.10$, item, $F(2, 54) = 5.80$, $MSE = 7.99$, $p = 0.005$. A significant effect is observed for R recognized words $F(1, 21) = 6.23$, $MSE = 3.50$, $p = 0.02$; item, $F(1, 27) = 12.75$, $MSE = 1.34$, $p = 0.001$. A mean of 5.72 words (SD= 0.43) is reported following an N task for R responses whereas 4.31 words (SD= 0.63) are reported after an A task. Furthermore, the ANOVA analysis carried out on the number of K and G recognized words did not provide significant difference between conditions (N vs. A) ($F<1$).

Discussion

In this study, we explored the relationship between the encoding degree in the episodic memory and the type of spatial representations (self-centred navigational and allocentric) as the episodic memory and spatial processing are intimately linked and depend on the hippocampus. However, episodic memory and spatial processing are in the majority of the research studied into a single perspective that is the "spatial memory" or "memory of spatial information" (Holdstock et al., 2000; King, Burgess, Hartley, Vargha-Khadem, & O'Keefe, 2002). Instead of focusing on memory of spatial information, we propose to focus on episodic memory. The item to be remembered was not a spatial characteristic, but it was simply an item belonging to one specific time and place (i.e. episodic). Still, this item was learned in a spatially augmented reality emphasizing one or the other type of space processing. The learning condition that maximized self-centred navigational information processing allowed greater performance of episodic retrieval (i.e. event located in a particular space and time).

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