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Unitization supports lasting performance and generalization on a relational memory task: Evidence from a previously undocumented developmental amnesic case

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ABSTRACT

Recently, the amnesic case D.A. was shown to circumvent his relational memory impairments, as observed in the transverse patterning (TP) task, using a self-generated unitization strategy, and such performance benefits were maintained over extended delays (Ryan et al., 2013). "Unitization" encourages fusing of distinct items, through an action, into a single unit from which the relations among the items may then be derived. Here, we provide the first documentation of the developmental amnesic case, N.C., who presents with relatively circumscribed lesions to the extended hippocampal system, and with impaired episodic memory. Despite impairments on standard versions of TP, N.C. benefited from unitization, showed evidence of transfer to novel stimuli, and maintained his performance over extended delays. These findings suggest that self-generation is not a requirement for the successful implementation of unitization, and further provides the first evidence of rapid transfer and long-lasting success of a learning strategy in a human amnesic case.

1. Introduction

Amnesia is often characterized by a pervasive impairment in the ability to bind together separate pieces of information to form novel relations (Cohen and Eichenbaum, 1993; Eichenbaum and Cohen, 2001; Moses and Ryan, 2006; Ryan et al., 2000). The transverse patterning (TP) task is often used to examine the role of the hippocampus in forming these novel relations. In TP, the relations among three items are learned, where each item wins in the context of one of the other items and loses in the context of the other item, similar to the childhood game of "rock, paper, scissors". Humans (Moses et al., 2008; Rickard and Grafman, 1998; Rickard et al., 2006) and non-human animals (Alvarado and Bachevalier, 2005; Alvarado and Rudy, 1995; Driscoll et al., 2005, but see Bussey et al., 1998; Saksida et al., 2006) show impaired TP performance following hippocampal lesions.

Despite the relational memory impairments typically observed in amnesic cases, we have recently demonstrated that a unitization strategy can be used to compensate for such deficits (Ryan et al., 2013). An amnesic person with bilateral damage to the medial temporal lobe (MTL), D.A., reported using a self-generated strategy in TP, in which he imagined pairs of items interacting with one another in order to determine the winner. Using unitization, D.A. was able to learn multiple sets of novel relations and retain them over considerable delays (e.g., months). Despite D.A.'s improved performance with unitization, two other acquired amnesic cases with MTL damage, K.C. and R.F.R., did not show such improvements. We have speculated that differences in improvements with unitization across patients are likely related to differences in their patterns of damage. D.A. has bilateral damage MTL damage affecting his hippocampus, perirhinal cortex, and parahippocampal cortex, with additional right-sided damage to his entorhinal cortex as well as the anterior temporal lobe. In contrast, K.C. and R.F.R. both have more diffuse patterns of damage that includes the anterior temporal lobes bilaterally. Given the differing patterns of damage across cases, it remains unclear whether other amnesic cases can benefit from D.A.'s self-generated strategy. Specifically, unitization may only support behavior if it is self-generated. However, given K.C.'s and R.F.R.'s extensive cortical damage, it is difficult to ascertain whether performance benefits were not observed because they did not self-generate the

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unitization strategy, or because they have more diffused patterns of damage. Specifically, K.C. and R.F.R. may not have benefited from unitization because their damage extends to areas which may be necessary for the underlying processing mechanisms that support unitization, such as the left anterior temporal lobe (see Ryan et al., 2013 for a more in depth discussion).

To investigate the potential utility of a unitization strategy beyond D.A., we report here the first documentation of the developmental amnesic case, N.C., whose damage is limited to the extended hippocampal system (Aggleton and Brown, 1999), including the mediodorsal nuclei of the thalamus bilaterally and volume reductions in the right fornix and both mammillary bodies. N.C. has a considerably different pathology from D.A., K.C., and R.F.R, yet he presents with a classic neuropsychological profile of episodic amnesia. We investigated whether N.C. would show performance benefits from unitization, despite the absence of self-generation of the strategy, and whether he would be able to transfer the unitization strategy to novel problem sets. N.C.'s demonstration of successful and lasting performance provides compelling evidence of rapid and lasting transfer in an amnesic case, and underscores the importance of replication, particularly when relying on the case study method to inform our understanding of learning strategies and of the brain–behavior relationship (Rosenbaum et al., 2014).

2. Methods

2.1. Amnesic case

N.C. is a young right-handed male with 14 years of education, having completed high school and 1 year of technical college. He was aged 19 at the time of the first two sessions and aged 20 for the remainder of the sessions. At approximately 10 days of age, N.

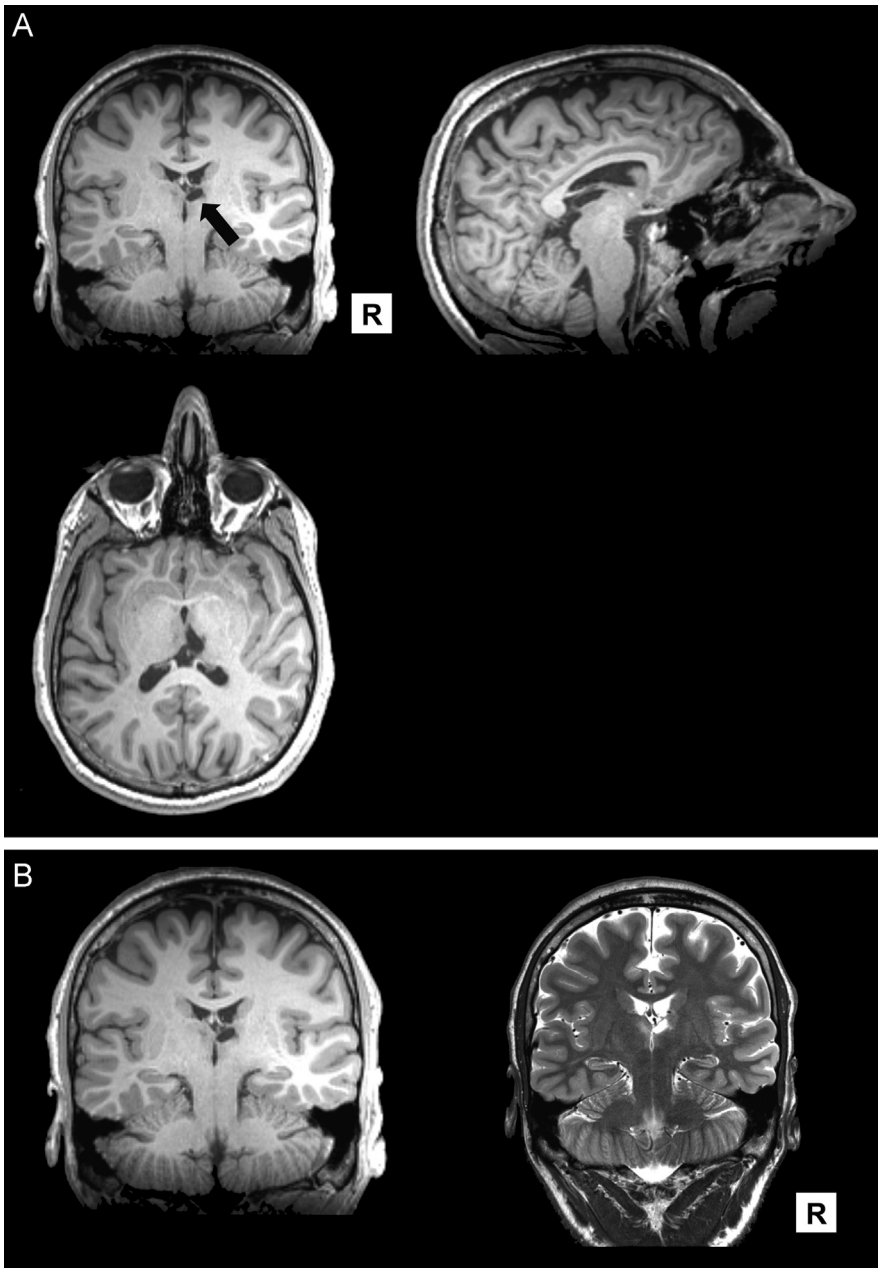

Fig. 1. (A) T1 weighted MRI scans of N.C., with arrow pointing to his right thalamic lesion. (B) T1 weighted and T2 weighted MRI scans (left and right, respectively) showing that N.C.'s lesion shows slightly hypointense on the T1-weighted image and hyperintense on the coronal T2-weighted image.