The Hippocampus: Where a Cognitive Model meets Cognitive Neuroscience

Bradley C. Love (love@psy.utexas.edu) and Todd M. Gureckis (gureckis@love.psy.utexas.edu)
Department of Psychology, The University of Texas at Austin; 1 University Station A8000; Austin, TX 78712 USA

Models and Cognitive Neuroscience

The goal of the present work is explore possible mappings between an existing model from cognitive psychology and functional brain regions. There are numerous possible mappings between these somewhat different levels of analysis. For the the Supervised and Unsupervised STratified Incremental Network (SUSTAIN; Love, Medin, & Gureckis, 2004; Sakamoto & Love, in press) model, the mapping is straightforward: aspects of the model appear to map onto functional structures in the brain.

SUSTAIN holds that humans represent category information in terms of natural bundles of information, referred to as clusters. For example, knowledge of mammals might be represented by several clusters (e.g., primates, four-legged mammals, whales, bats, etc.). SUSTAIN posits that learners form new clusters in response to surprising events, such as when a child is first told that a whale is a mammal and not a fish.

In this poster, we will focus on SUSTAIN's cluster formation process. Our hypothesis is that a healthy and intact hippocampus is necessary for forming new clusters to support cortical learning in the temporal lobe (cf., Gluck & Myers, 1993). Forming new clusters can be seen as constructing conjunctive codes. A wide variety of tasks rely on the formation of conjunctive codes such as episodic memory (a conjunction of item and context), sequence memory (item and position), list discrimination (item and list), and item relations (item and item). All of these tasks appear to rely heavily on the hippocampus (see Brown and Aggleton, 2001, for a review). Assuming reduced ability to form new clusters, SUSTAIN has been able to model developmental trends in infant learning (hippocampus not fully developed) and performance by amnesiacs with hippocampal lesions (Gureckis & Love, 2003).

Rules and Exceptions: An Aging Study

Our account of hippocampal function predicts that normal aging will disproportionately affect performance for exception items in rule-plus-exception classification studies. To master an exception, a cluster must be recruited to encode it, despite the fact that similar clusters or conjunctive codes likely already exist in memory. As we age, an accumulation of cortisol released in response to stressful events differentially leads to atrophy and reduceas the functioning of the hippocampus (Lupien et al., 1998). In the study design, three items from category A and three items from category B followed a simple rule (e.g., if large, then category A. if small, then category B.). The exception items ran counter to these rules. SUSTAIN predicts that older adults will form one cluster for category A and B, leading to increasing rule application and insensitivity to old vs. novel rule-following items with increasing age. In contrast, SUSTAIN predicts younger adults will recruit one cluster for each exception, storing them apart from rule-following items, which leads to predictions counter to those of the older population.

Human Results

Thirty-seven University of Texas undergraduates and thirty-seven healthy older adults (51-84 years-old, mean=67.9) recruited from the Austin VA outpatient clinic participated in the study. All of SUSTAIN'S predictions held. Only a subset of results are reported here. In the learning phase, item type (rule vs. exception) and population interacted such that the younger population exhibited a smaller difference in accuracy (.27 vs. .61) for exception and rule-following items than did the older population, $F(1, 72) = 35.39$, MSe = 1.09, $p < .001$. For the older population, performance on rule-following and exception items for the learning and test phase negatively correlated (r=-.38 and -.72, respectively), whereas these correlations were positive for the younger population (r=.52 and .49, respectively). In transfer, subjects from the older population made rule consistent responses to studied rule-following items and all novel items at about the same rate, .70 vs. .69, $t < 1$, whereas the younger population applied the rule more frequently (.88 vs. .77) to the studied examples, $t(36) = 4.99$, $p < .001$.

References

Brown, M. P., & Aggleton, J. P. (2001). Recognition memory: What are the roles of perirhinal cortex and hippocampus? *Nature Neuroscience*, 2, 51-61.

Gluck, M. A., & Myers, C. (1993). Hippocampal mediation of stimulus representation: a computational theory. *Hippocampus*, 3, 491-516.

Gureckis, T.M., & Love, B.C. (2004). Common Mechanisms in Infant and Adult Category Learning. *Infancy*, 5, 173-198.

Love, B.C., Medin, D.L, & Gureckis, T.M (2004). SUSTAIN: A Network Model of Category Learning. *Psychological Review*, 111, 309-332.

Lupien, S.J., DeLeon, M, DeSanti S, Convit A, Tarshish, C., Nair, NPV, McEwen, B.S., Hauger, R.L., & Meaney, M. (1998). Longitudinal increase in cortisol during human aging predicts hippocampal atrophy and memory deficits. *Nature Neuroscience*, 1, 69-73.

Sakamoto, Y., & Love, B. C. (in press) Schematic Influences on Category Learning and Recognition Memory. *Journal of Experimental Psychology: General*.