Dissociation of Memory Systems in Pigeons (Columba livia)

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Abstract: A version of the serial response time task (SRT) used by Nissen and Bullemer (1989) to demonstrate implicit learning in patients with Korsakoff's amnesia was used to investigate learning and memory in pigeons. Knowledge of sequential structure is indicated by faster response times to a repeating structured sequence relative to randomly generated sequences, and is contrasted with memory for the specific responses occurring within a sequence. Results indicate that avian memory can be separated into distinct subcomponents, which may mirror the well-known implicit/explicit distinction from human neuropsychology.

Introduction:

Over the last decade, one of the most intensely studied issues in cognitive psychology has been the notion of multiple memory systems (see Schacter & Tulving, 1994); this is the idea that memory may not be a single, unitary faculty, but rather might be separated into several functionally and biologically distinct components. Numerous distinctions have been proposed, and have proven quite useful in cognitive science and neuropsychology. For instance, Nissen & Bullemer (1989) and Reber (1967) have developed experimental tasks that demonstrate residual memory capacity in human temporal lobe amnesics. These results are usually interpreted in the context of an implicit memory / explicit memory distinction. Despite their apparent usefulness, multiple memory systems have not yet taken a strong foothold in the field of comparative psychology, perhaps due to related issues concerning awareness and consciousness in nonhuman animals. This research attempts to demonstrate the feasibility of this dissociation strategy in comparative psychology.

Method:

5 male white carneaux pigeons (Columba livia) were maintained at 80% of free-feeding weight. Sessions took place daily in three-key LVE operant chambers. On each of 75 daily trials, a bird first completed a series of five key pecks, each cued by the illumination of one of three response keys. Following the sequence, all 3 keys were illuminated and reinforcement was provided, contingent on pecking the first key in the preceding sequence. The procedure produced two measures of performance: response times to the 5-key sequence and accuracy at recalling the first key of a sequence. The former presumably reflects a bird's ability to learn and execute the structured sequence of cues, while the latter indicates memory for specific responses.

Results:

Experiment 1: Birds were initially trained on the following 6-item sequence

Center – Left – Right – Center – Right – Left – …

Each trial began at a randomly determined position in the sequence. The last item in the list (left) was followed by the first (center), yielding a repeating loop. Figure 1 shows the characteristic decrease in response times under the structured condition (red). Each data point represents a block of 5 days. When cue locations no longer structured, but generated randomly (green), response times were reliably slower, $t(4) = 2.79$, $p < .05$. In both conditions, accuracy remained greater than chance performance of 33% (figure 2), indicating impaired sequence performance, with no effect on memory for the items performed within the sequence.

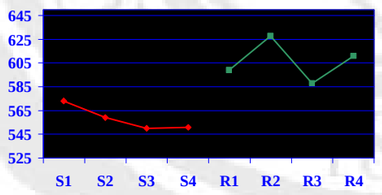

Figure 1: Response times

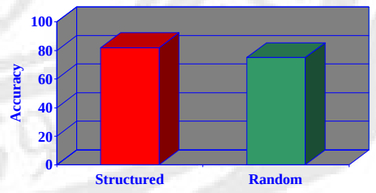

Figure 2: Choice accuracy

Experiment 2: The structured sequence was reinstated, and the required exposure duration for the the first (to-be-recalled) item of each trial was gradually decreased from 5.0 seconds down to 0.0 seconds.

As exposure durations became shorter, accuracy decreased (purple line; right axis), $F(10,4) = 11.888$, $p < .001$. Presumably this was due to less rehearsal time for the to-be-recalled information. However, the shorter duration had no effect on response times (green line, left axis), $F(10,4) = 0.915$, $p < .53$. Notice that these results are exactly the opposite of those from experiment 1.

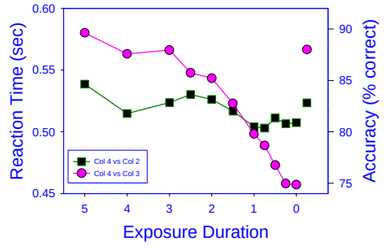

Figure 3: Results from experiment 2

Conclusions:

These data suggest that multiple memory system frameworks as used in human neuropsychology may also be relevant to nonhuman memory systems. The results reported here show a dissociation between two kinds of memory; Experiment 1 showed disruption of a performance measure (response time) while leaving accuracy unaffected. Experiment 2 showed exactly the opposite result, suggesting that the two systems involved can function independently of one another. The precise memory systems involved remain to be determined. Note however, that the serial response time component is modeled after one widely accepted as reflecting implicit or procedural memory in humans. Meanwhile, the identification component may share some important features with explicit or episodic memory, in that it requires a specific reference to past events. While use of the terms "implicit" and "explicit" in reference to avian memory may be premature, the data reported here do suggest that memory systems approaches may be as useful in comparative psychology as they are in neuroscience.

References:

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Reber, A.S. (1967). Implicit learning of artificial grammars. *Journal of Verbal Learning and Verbal Behavior, 6*, 855-863.