The Evolution of Memory: from Flatworms to Neanderthals to Homo Sapiens

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One common characterization of the function of brains is that brains are for moving. When life forms were mostly sessile like the first multicellular organisms, sponges, about 600 million years ago, cells had nuclei but little resembling brains. At about 550 million years ago, the first animal life forms appeared that intentionally moved about, such as ocean-dwelling or pond-dwelling flatworms, and their movements required brains. However, it was not movement, *per se*, for which brains were required. These first moving life forms moved to eat things, they moved to avoid eating things, they moved to avoid being eaten, and they moved in order to reproduce. All of these activities required decision-making, which is also another common characterization of brains. The chief purpose of the executive functions of the frontal lobes (e.g., Baddeley's central executive, 2001; Goldberg, 2012) is decision-making. But this decision-making is not made *ad hoc* or willy-nilly. It is based on prior experience and the simulation of possibilities based on prior experience. That process required cells and neurons that could memorize objects, places, and other life forms. In other words, efficient and effective decision-making required the ability to *memorize*. The present paper will trace the evolution of inchoate learning and memory systems, which may have been simple associative learning (the binding of disparate stimuli) in order to make decisions. Current thinking is that multiple memory systems exist, e.g., semantic, procedural, visuospatial-episodic, working memory). It is the purpose of the present paper to show that these multiple memory systems may have first relied on a single feral learning and memory system (associative learning or associative conditioning) and that the subsequent diversity of animal forms made additional contributions to modern memory systems. The present paper hypothesizes that there were two additional quantum leaps in memory (after the development of associative learning): one at the divergence of mammals from reptiles (about 200 million years ago), and a second at the divergence of primates from mammals (about 80 million years ago). The divergence of mammals from reptiles began with the natural selection for bigger brains with its accompanying behavioral flexibility, which meant that mammals became less reflexive and much more responsive to changing and disrupted environments. An episodic memory system may have been well in place at the time of this divergence but it may have expanded at this time to not only recall episodes but also simulate future episodes. It will also be argued that the divergence of primates from mammals provided an additional boost to memory systems, particularly semantic memory because of the unique way primates at that time competed with other animals for nutritious fruit (compared to less nutritious leaves or grass). These small, clever, nocturnal, tree-dwelling primates competed with other animals by social vocalizations, enhancing an auditory memory system rather than the simple visual recognition of fruit and may have formed the proto-basis for the semantic memory system.