the term ‘procedural knowledge’, sometimes called implicit memory, denotes knowledge of how to accomplish a task, and often pertains to knowledge which unlike ‘declarative knowledge’ cannot be easily articulated by the individual, or knowledge that is nonconscious.

https://www.youtube.com/watch?v=iBA4vWQRBA0
rats learn, across days, to efficiently reach and grasp a small sugar pellet over those days, the muscle patterns used in grasping adapt over those days, the area of primary motor cortex taken up by neurons associated with the reaching limb grows if ACh inputs to the primary motor cortex are removed, neither the learning nor the changes in motor cortex occur

Kargo and Nitz, JNS, 2003 mod. from Conner et al., Neuron, 2003
Rats learn, across days, to efficiently reach and grasp a small sugar pellet. Over those days, the muscle patterns used in grasping adapt. If ACh inputs to the primary motor cortex are removed, neither the learning nor the changes in motor cortex occur.

**Graphs:**

- **A:** UNTRAINED vs. TRAINED
- **B:** TRAINED w/out ACH
- **C:** Area (mm$^2$) changes over days

**Key:**

- Whisker
- Trunk
- Hindlimb
- Neck
- Shoulder
- Nonresponsive

**Legend:**

- □ Intact
- ■ w/out ACH

**Figure:**

- **X-axis:** Time (ms)
- **Y-axis:** Value

**Notes:**

- mod. from Conner et al., Neuron, 2003
rats trained to make a nosepoke if they detect a 4 kHz tone show improvements in detection over days of training.

Over the same time period the topographic representation of pitch in primary auditory cortex changes such that more neurons respond to 4 kHz tones.

In separate experiments, pairing of a 9 kHz tone with stimulation of ACh neurons in the basal forebrain changes the topographic representation in primary auditory cortex such that more neurons respond to 9 kHz tones.
in training (below), the rat is taught to move to the goal to obtain reward

subsequently, on test trials (above), the maze is turned upside-down and the rat demonstrates whether he has learned to ‘make a left’ at the ‘T’ (a response strategy) or to ‘move to that place in the room’ (a place strategy)

if the rat is asked this question early in training (within the first couple of days), one tends to see a ‘place’ strategy and ACh is high in the hippocampus

if the rat is asked this question late in training, one tends to see a ‘response’ strategy and ACh is high in the basal ganglia

early in training, when one would normally expect a ‘place’ strategy, inactivation of the hippocampus (the home of ‘place cells’) results in the emergence of a response strategy

late in training, when one would normally expect a ‘response’ strategy, inactivation of the basal ganglia (proposed to select responses via the direct pathway) results in the emergence of a place strategy

thus, the animal has learned two separate strategies which compete for expression
episodic memory (memory for events and their ordering - a form of explicit memory):

hippocampal cell activity in a ‘place’ often depends on the places previously or subsequently visited (this is termed retrospective and prospective place coding)

for one block of trials, the animal must travel to the west end when placed at either the N or S start point

for the next block, the animal must travel to the east end when placed at either the N or S start point

about half of all hippocampal neurons fire spikes (green dots) when the animal is in a certain part of the maze (here the S arm) – this is seen irrespective of the direction taken after reaching the middle

some hippocampal neurons fire in a certain place, but only if they reached that place from the N as opposed to the S side – their activity depends on the character of the full episode and is termed ‘retrospective’

other hippocampal neurons are ‘prospective’ – they fire in a certain place depending on where the animal will go from that place – they too have activity dependent on the full episode

adap. from Ferbinteanu and Shapiro, Neuron, 2003
working memory: holding items in memory (7±/−2) is achieved through interaction of the prefrontal and parietal cortex.
an example: prefrontal ‘top-down’ influences on parietal cortex during an oculomotor delayed response task – inactivation of prefrontal cortex via cooling depresses ‘working memory’ responses of parietal cortex neurons and increases errors

parietal neuron has delay-period activity specific to the N and NW targets

delay-period activity for the same neuron is depressed when prefrontal cortex is inactivated

error rate (percent saccades to wrong site) for each of 8 directions used increases when prefrontal cortex is inactivated

Chafee and Goldman-Rakic, JNP, 2000