Learning - U shaped pattern of development can be explained by unstable production rules being created, then replaced by better ones as the model learns. e.g. **Bowerman** - learning of past tense verbs; puzzle solving (**Richards and Siegler**); radiological diagnosis in medical students (**Lesgold et al**).

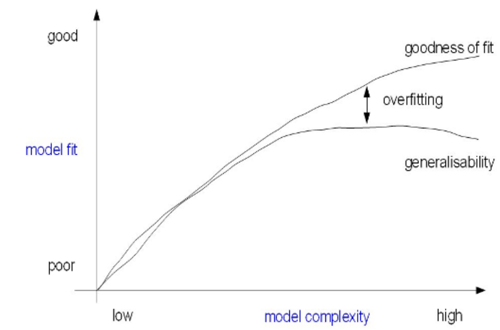
Decision making: Gaissmaier et al (2008) - used ACT-R to show how the recognition heuristic -**Goldstein and Gigerenzer** - could be modelled and produce results similar to that of human performance (e.g. on the German cities recognition task) - and argue that this suggests that this model of how the heuristic works is psychologically plausible.

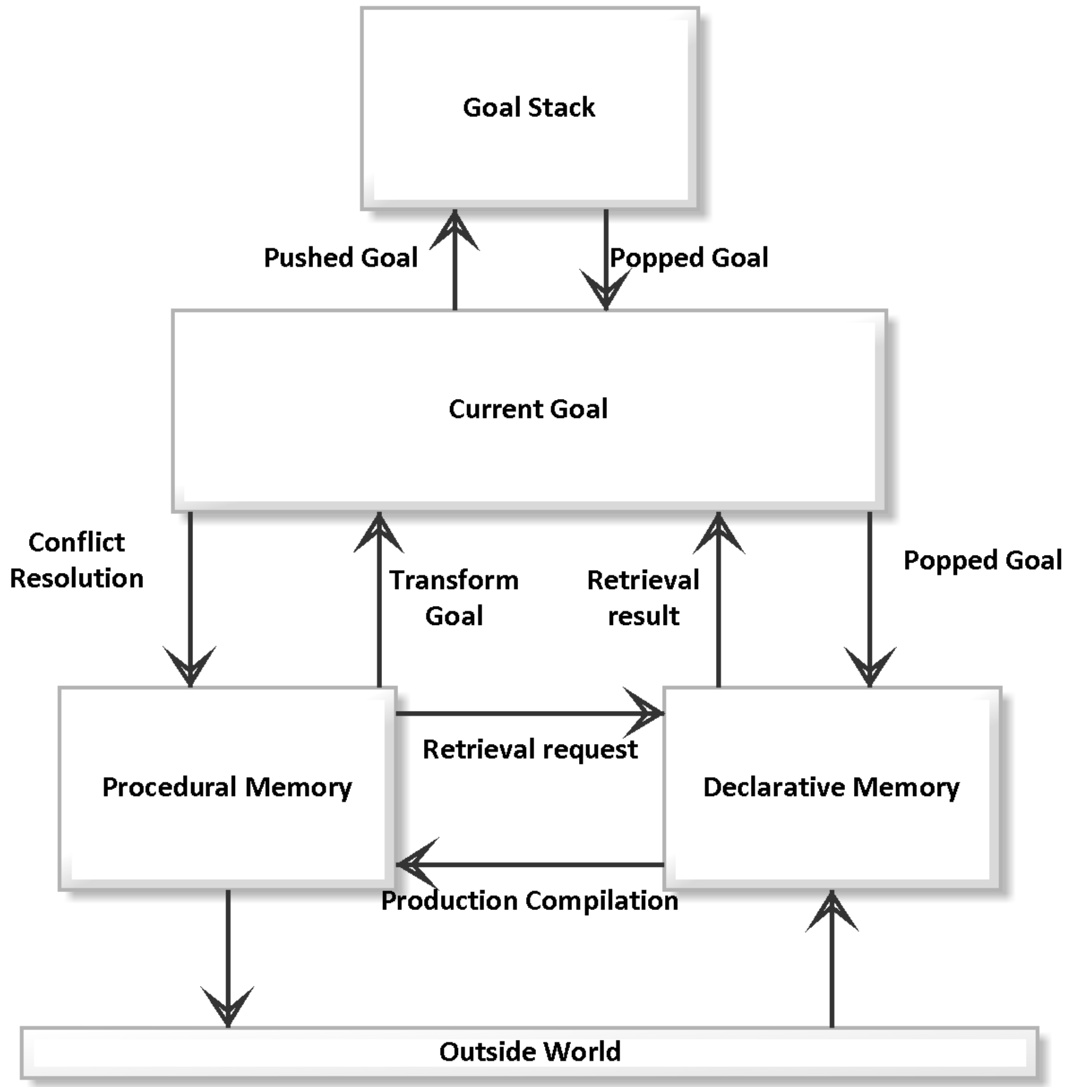
Model makes the distinction in LTM between procedural memory (how I do something) and declarative memory (what I know). Good evidence for this in humans - e.g. Amnesia. Work by **Squire & Cohen** - e.g. HM - was able to get better at doing a jigsaw (procedural) but had no memory of having done it before (declarative).

Procedural memory: stores procedures in the form of production rules ... IF <condition> THEN <action> e.g. In the arithmetic example, ACT-R will use a procedure such as add1-count to resolve 3+4 the first time through (like children learning to count on from a number). Second time through, it will retrieve the result directly from declarative memory (activation). **Siegler** criticises - some children learn by rote ... therefore, cognitive models tend to reflect individuals, rather than aggregated populations in this respect.

Another argument that the two are distinct is **Rabinowitz and Goldberg's** work on a 'transfer' task. Found participants with less training of the nature C+3=F were able to perform better on F-3= (C) tasks than those that had received more. Procedural memory is less flexible than declarative memory; also shows that the model having a route to take facts and codify them into procedural knowledge via production compilation process (from dependency goal chucks in declarative memory)

Similar observations are seen in problem solving - e.g. the 'set' effect - people become too fixated on solving a problem in a particular way and if the problem changes slightly, they have difficulty in adapting.





Activation is used in both procedural memory and declarative memory. e.g. in **Anderson et al**'s list memory demonstration - declarative memory - and also in procedural memory - better procedures receive more activation through more use. Activation is a limited resource within the model.

Newell: Models are good if they behave in a way that fits human performance; are psychologically valid and are parsimonious. Overfitting of a model (**Pitt & Myung**) to human data is undesirable.

Anderson and Lebiere (after Newell) -12 Criteria developed

How well does ACT-R do on the Newell test?

Well: On behaving robustly in the face of error and learning criteria (as do PDP models)

Well: On being rational and adaptive (can see how the model reaches its conclusions and how it adapts over time - e.g. through generalising dependency goal chunks in declarative memory into procedures - connectionist models are more fixed once trained)

Poorly : On being realisable within the brain - ACT-R focuses on levels 1 and 2 of **Marr**'s explanatory framework - i.e. computational and algorithmic. Hardware (level 3) not considered - but, ACT-RN (a later development) is a hybrid.

Poorly : On natural language - ACT-R's programming language for production rules is cryptic, even by the standards of most computer languages!

Declarative memory: stores facts in chunks. E.g. in the list memory (**Anderson et al**) chunks represent lists as a set of groups, of between 2-6 items. Each group in a list and each item in the list is stored in a chunk. Allows different groups and different items in each group to have different levels of activation - as in human STM. Fan effect (**Anderson**) operates - i.e. the more you know about a concept, the harder it is to recall all of the facts associated with it. Partial matching and positional confusion happens due to the wrong chunks being above the activation threshold (when the right ones are below it)

Key finding on the list memory example is that performance of the model in both f**orward recall accuracy and latency matches** what is observed in **human participants** closely.

Tim Holyoake 2010, http://www.tenpencepiece.net/