

CISC452/CMPE452/COGS400
Cognitive Modeling

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Why Cognitive Modeling?

1. To understand cognitive processes better.
 - Understanding language, learning, perception, recognition, memory, logic processing, computation, attention, decision making
2. To computationally implement a cognitive process.
 - Create a model of the mind.
 - Can we build an actual mind some day?
3. Compare and evaluate the various explanations of the cognitive processes.
4. Predict outcomes of cognitive processes.
5. May not be fully accurate to account for human errors and uncertainty – different from computational modeling.

Earlier Approaches

- Rule based approaches
 - Need an expert to understand and define rules
 - Uses symbols (physical symbol systems – PSS) and has serial execution
- Constraints
 - Multiple if-then-else coding can get very complicated
 - Difficult to extract rules – tacit knowledge which is difficult to transfer
 - Cannot implement asynchronous data flow and parallel processing

Learning in Brain Neurons

- Influenced by survival, emotion, and memory of past experience (good and bad)
- Influenced by the demand of physical system
- Influenced by evolution (rote learning, copy others)
- Layout of neurons and synaptic connections change accordingly
 - Repeated simultaneous firing of neurons strengthens synapses
 - Skill learning by doing something repeatedly
 - Skill learning, rewarding experience
 - Chemicals within the brain changes to generate stimuli for firing of neurons

Learning in ANN

- Reorganize or restructure ANN
- Change firing threshold
- Increase connection strength by
 - increasing associated weight
- ANN has 3 main types of learning
 - Error correction learning (outcome based)
 - Learn from mistakes
 - Reinforcement/Correlation/Hebbian learning (outcome based)
 - Learn if rewarded – Named after Donald Heb
 - Competitive learning (criteria based)
 - Variation of Hebbian learning

The First Famous ANN

- ANNs implement Parallel Distributed Processing (PDP) where processing is done in a distributed network in parallel.
- The first ANN to achieve prominence was, however, hardwired in advance.
- This is the **Interactive Activation Model**, presented by McClelland and Rumelhart (1980, 1981).

Parallel Distributed Processing (PDP)

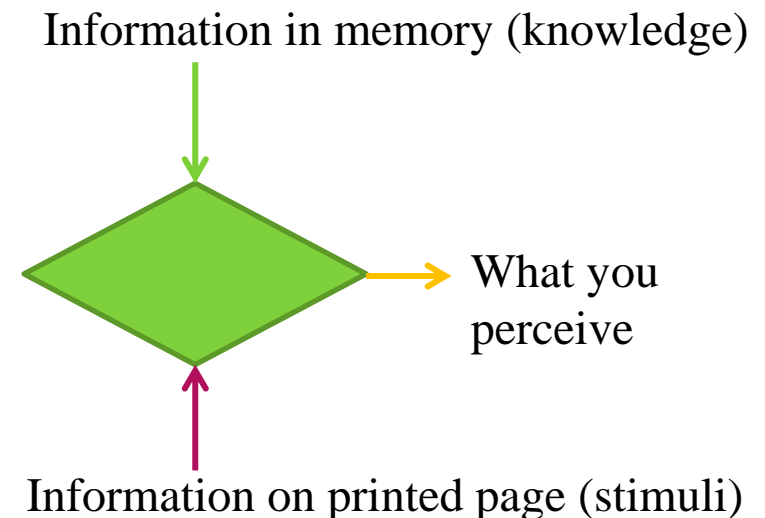
- PDP also explains how *top-down and bottom-up information is combined in a perceptual task, like word recognition.*



Jim McClelland

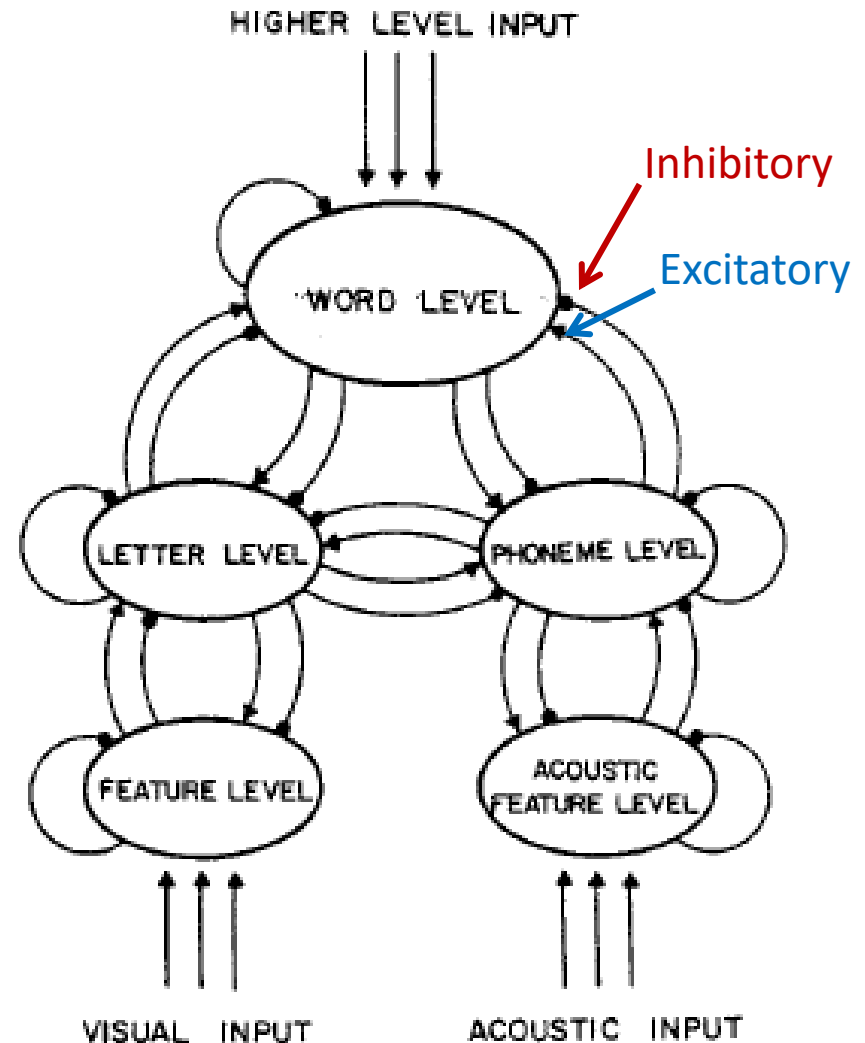


Dave Rumelhart



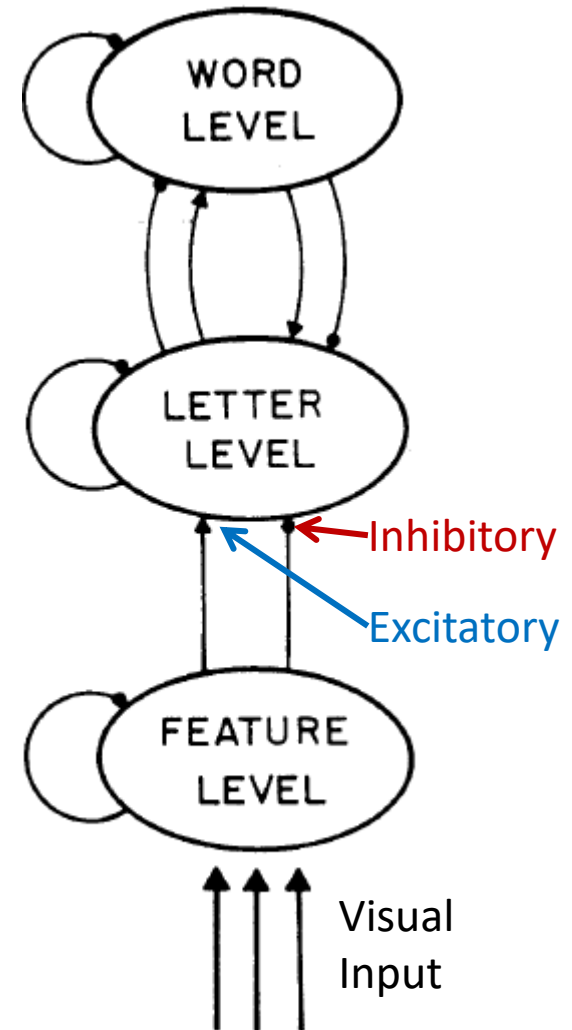
Word Perception

- Some of the processing levels involved in visual and auditory word perception has interconnection among nodes in the same layer (McClelland and Rumelhart, 1981).
- Assumptions: 3 levels where top and bottom level gets input from higher level and visual and acoustic inputs accordingly.



IAM – Simple Model – Part 1

- To make it simple and reduce interactions, initial model (part 1) considers
 - Reciprocity of activation between word and letter in paper on part 1.
 - Ignores phonological processes.
- Features are given as inputs.
- Discrete rather than continuous time.
- A word and letter level node connects with neighbouring word or letter nodes at the same or adjacent levels.



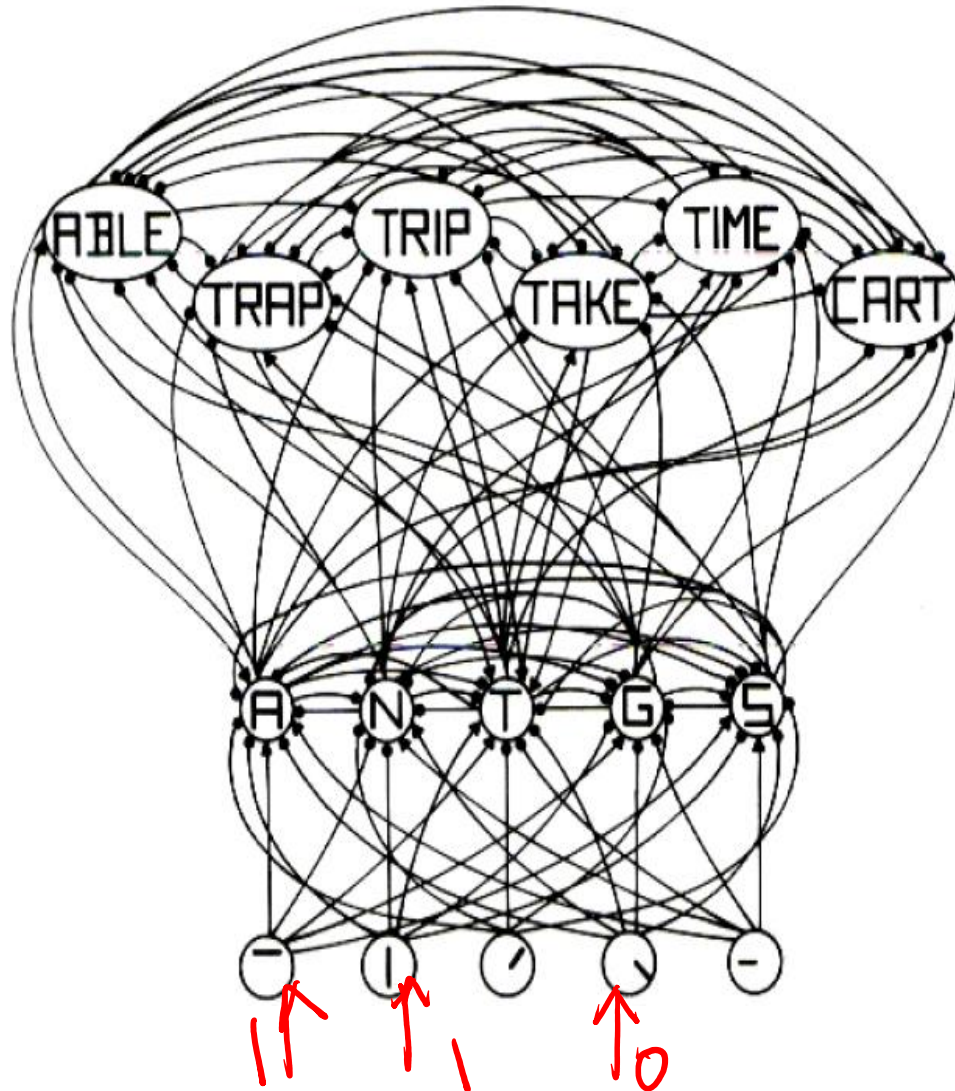
Input Features for Letters

- Simplified feature analysis of input font.
- Limited lexicon.
- Input consists of the visual feature detectors that are on for each letter.

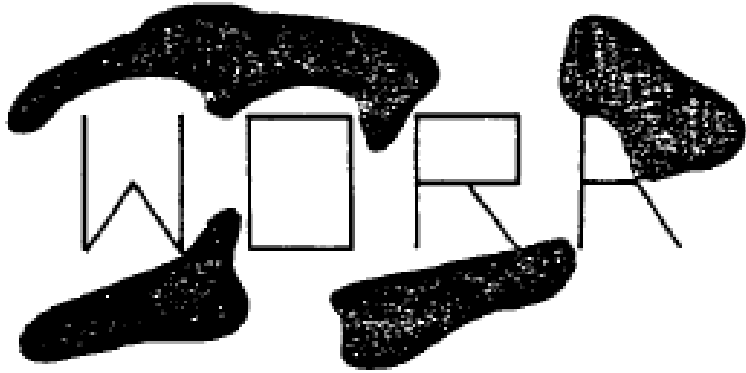


Font and feature analysis process is from Rumelhart 1970 and from Rumelhart and Siple 1974.

IAM Model



Sample Run of the Simulation Model



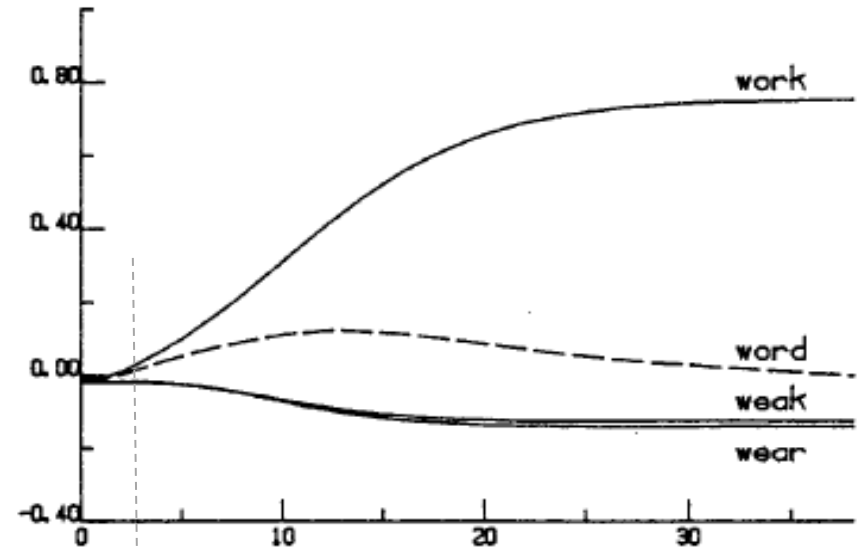
- W, O, R extracted but the last letter can be R or K.

Graph shows time-course of activations for selected nodes at word and letter levels respectively after the last letter is presented as input.



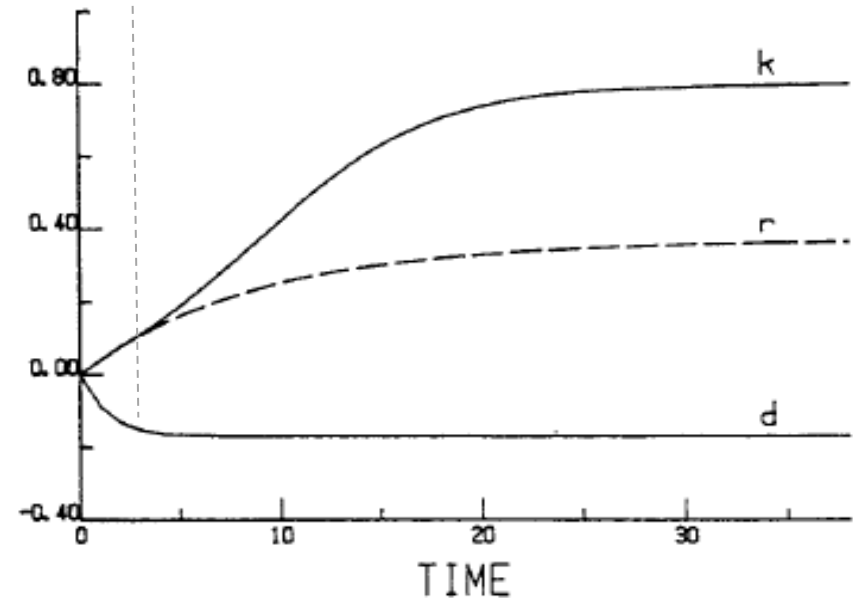
activation

word activations



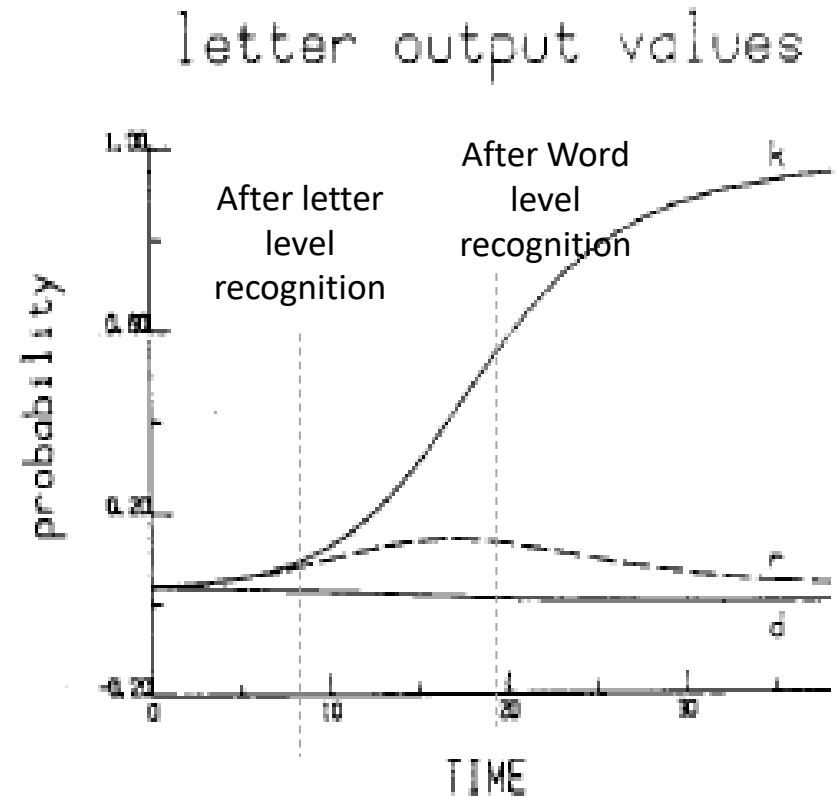
letter activations

activation



Output Probability

- In the previous simulation, word-to-letter and letter-to-letter level **inhibitions are set to 0** which is why k (feedback from both levels) and r (from only bottom) both have moderately high values.
- In this one inhibitory signals are active.



Final output as probability of the different letters

IAM – Context Effects in Letter Perception

- IAM is a model of context effects in perception of letters.
- Perception results from excitatory and inhibitory interactions of detectors of visual features, letters, and words.
 1. Visual input excites **detectors for visual features** in the display
 2. Active **features** *inhibit other features* and
 - Activate those letters which contain the features and
 - Inhibit letters which do not contain the features.
 3. Active **letters** *inhibit other letters* and
 - Activate words which contain the letters and
 - Inhibit words which do not contain the letters.

Feedback Cycles in the Model

4. Active **word** detectors mutually *inhibit* each other then
 - Send **feedback to letter level** to activate the letters they contain and inhibit letters they do not contain.
 - Feedback strengthens perception of constituent letters.
5. Active **letter** detectors
 - Send **feedback to feature level** to activate the features they contain and inhibit features they do not contain.
 - Feedback strengthens perception of constituent features.

Thus it cycles between the feature, letter and word. Letters in words are more perceptible because they get the reinforcement activation from word level.

Summary

- ANN models synaptic behaviour using excitatory and inhibitory connections represented by +ve and -ve weight values respectively.
- The structure and weights influence the behavior of ANN.
- IAM model is the first ANN model that demonstrates top-down and bottom-up information flow in word recognition.