Perceptual Foundations for Cognitive Linguistics

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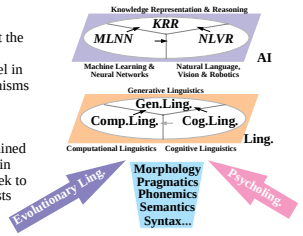
Abstract

In this paper, we argue that the role of metaphor can be understood at a deeper level in terms of perceptual mechanisms being usurped as general cognitive, and eventually, linguistic mechanisms. Whereas others have explained how metaphor could explain various phenomena, we seek to explain why metaphor exists and why these phenomena emerge.

In exploring this theme we will draw on theories and models, mechanisms and results from various areas of Artificial Intelligence and Cognitive Science.



Integration

Both Artificial Intelligence and Linguistics are under pressure to integrate ideas from other fields. The traditional foundations have been expanded and new subareas are taking more of the spotlieht.

Identity Crisis

What is identity?

People and objects are always in different positions, they may be clean or dirty, far or near, big or small - and as they grow older, people grow, get pimples, grey hair, wrinkles etc. They're never the same.

There is no such thing!

Our neural systems appear to be good at correlating similar things, whether they occured simultaneously, or recently (in short-term memory) or in the more distant past (medium and long-term memory).

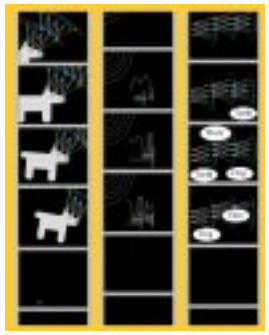
And the brain isn't fussed about what signals it correlates.

We have a good idea about how self-organization works in the cortex, how the brain groups similar things together and separates them from dissimilar things. The organization of the angle-sensitive edge detectors is the classic case - but if the environment is dominated by lines at a particular angle, more real estate will be used for discriminating fine movement around that angle. This is provably directly related to the information conveyed by the perceptual variation. An animal or a person who is deprived of one sense will not have information coming to the part of the cortex which normally processes such information, and the territory tends to get annexed by the neighbouring modalities. Thus a congenitally blind person will have better tactile and auditory discrimination than a seeing person.

Woof

Let's consider what is involved in recognizing a dog. Visually, our features detectors recognize various edges and lines, various textures and colours, various extremities of vertices, various angles and orientations that occur. We hear the patter on the grass, the clatter on the verandah, the scratch on the door and the woof which announces his presence. Each of these sounds involves multiple frequencies which tend to start and stop and modulate in synchrony, and thus cluster together because they occur more or less synchronously.

In fact, there is evidence that those that originate from the same source tend to have the same characteristic frequencies of neural firings from the frequency detectors which seems to allow them to be grouped together as a single stimulus.



Models of the brain: an AI & Cog.Sci. perspective

Artificial Intelligence

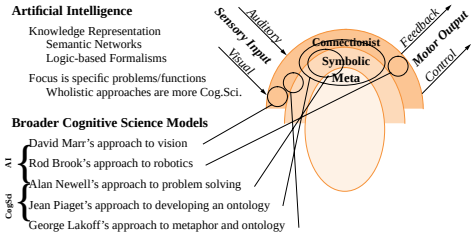
Knowledge Representation
Semantic Networks
Logic-based Formalisms

Focus is specific problems/functions
Wholistic approaches are more Cog.Sci.

Broader Cognitive Science Models

AI
- David Marr's approach to vision
- Rod Brook's approach to robotics
- Alan Newell's approach to problem solving

CogSci
- Jean Piaget's approach to developing an ontology
- George Lakoff's approach to metaphor and ontology



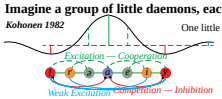
Note the bias to *understanding* versus *behaviour*

Competitive Learning — Self-Organizing Maps

- An early model of neural learning — well-analyzed with mathematical abstractions (*Kohonen*)
- Closely related to psychological models of learning and perception

Imagine a group of little daemons, each waiting around for a specific event.

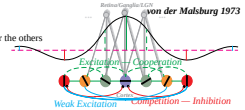
Kohonen 1982



One little daemon puts his hand up for a rectangle, another for a circle
One daemon likes p's and another likes q's
One daemon likes inside corners, another outside corners
One daemon likes lines at 89 degrees, another at 91 degrees

- Such daemons are common neurological and psychological *constructs*
- SOMs can produce them *without supervision* (teacher or critic)
- The model is essentially *competitive*
  - Whichever daemon is the strongest is the winner
  - It's 'no holds barred' — if one gets ahead it can hinder the others

von der Malsburg 1973



It's Winner-takes-all Similarity Matching!

Blackboards

Now consider what happens when we experience something over a period of time. Over a short period of time, we tend to have short memory of the stimuli and our processing of it. This may play a part in the processing of further information as it arrives. It is like in a lecture theatre where we have a loop of blackboards which get cycled round and round: where a clean board emerges from the bottom when we push the loop up, but we can still see what's on the old boards up top. We can use the information that is still on the previous boards, but we can only write on the bottom board, though we can incorporate relevant information into the work we are currently engaged in. Time is translated into space, but the information that is stored is a processed composite involving the information currently arriving and the information we've processed and stored recently.

Teamwork

Several modalities processed independently

- looking for new patterns
- recognizing old patterns
- classifying similar patterns

Pipeline

Several timepoints/snapshots ina pipeline

←memory for recent events
- multiple activations/associations emergent

→multiple hypotheses/predictions

Integration

Several levels of integration

- patterns across space, time & modality
- patterns recognized in multiple modalities
- patterns recognized in differerent frames

The Cortex

We will begin our story in the cortex, although some of the relevant perceptual processing has already been carried out by this stage. The visual, auditory and sensory-motor cortices are in truth parts of a single fairly uniform cortex. On first brush, it is like a map. The material, the paper, is uniform, but neurons from all over the body project to the cortex. Neurons of the same type and source tend to project to the same general region, and form a topological map in the shape of a distorted homunculus whose proportions reflect the importance of particular organs, and the number of neurons coming from the region. In the case of vision and audition, the map is simpler although the distortions also exist.

Let us concentrate on vision for the moment. Although we have a sense of a full hemispherical range of vision, this is largely reconstructed from a combination of memory, low resolution peripheral vision and high memory foveal vision, as well as information of other kinds such as divergence, focal length, lighting conditions, etc. The processes involved in this reconstruction involve similar neurons looking for similar things in different parts of the visual field. Neurons which see similar levels of intensity will tend to fire together. A network of excitatory and inhibitory connections ensure that we end up with a set of local experts for different pheneomena. We move from blob detectors to angle-sensitive edge detectors, to angle-sensitive line detectors, until we eventually get up to grandmother detectors (according to a waggish tradition which has a little too much truth in it - the number of types of faces we can recognize is apparently limited and we get to that point fairly early on in life - thus your baby may have a detector especially for you, but the converse is unlikely).

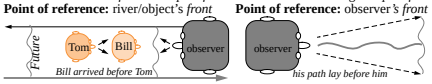
Lakoff's Metaphors we Live and Talk by *(1980)*

Pike's Unified Theory of Human Behaviour *(1967)*

Clark&Clark's What's in a word? *and* **Space, Time and Semantics** *(1973)*

Variant 1a/b: *river of* time *into past/future*
Point of reference: river/object's *front*

Variant 2a/b: looking *into past/future*
Point of reference: observer's *front*



Implications

Recursion is Bunk

There is no recursion. There is however something called recurrence: this is what happens when something is copied from a higher blackboard to a lower one, and has the effect of retaining a concept in memory - in a neural model it may even involve a feedback connection from the deeper layers to the perceptual layers. Recurrence has been shown to provide mechanisms for stereopsis and feature enhancement.

There is a limited short term memory: a certain number of blackboards. We package things up and store them on the blackboards, but we can have only a limited number of these packages - there is no infinite stack so we can't have a context-free grammar.

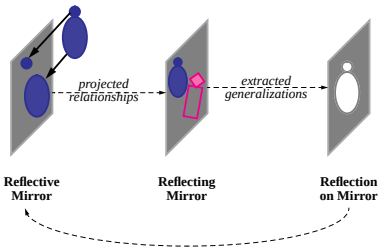
When we move to different levels we get different classes, but eventually we have to run out of levels.

Preliminary Pudding

Matching similar frames and then associating things which occur in similar frames gives rise to computionally sound models which have been implemented for various linguistic levels by a variery of researchers.

The 'packages' we can get using these models include phonemes, syllable/ morpheme structure, and a kind of noun phrase and clause structure - these occur at the top level and may well be one and the same construction, one being marked as infinite and the other as finite: one is something substantive which can be a topic, the other is something informative which can be a statement. In such a model, we have no need to invoke special rules to handle subjacency. A 'house that Jack built' or 'old woman that swallowed a fly' kind of sentence is just turning statements into contextualized topics. Each new clause just adds an extra line to the semantic picture being built up, it doesn't change what we've got.

Piaget's Sticky Mirror



Clark, Clark, Lakoff, Piaget & Pike

Piaget

- proposed a complicated but profound mechanism for language learning
- recognized **similar** relationships and turned them into building blocks

Pike

- developed a way of recognizing phonological classes from contextual **similarity**
- generalized this to a method of structuring all human behaviour

Metaphor

- the roots of Cognitive Linguistics lie in the recognition of the ubiquity of metaphor
- metaphor is about **similarity** of concept across different contexts

Similarity is the Name of the Game

Metaphor & Similarity

- Nothing is the same - just similar
- Similar contexts define paradigms/frames
- Similar percepts/constructs define concepts

All concepts involve metaphor

Metonomy & Information

- Information is what you don't already know
- Abbreviation is efficient in a shared context
- Metonomy is a consequence of abbreviation

Each word/morph invokes a frame

Creationist Evolinguistics

- Language is a changing convention
- Language is negotiated rather than learned
- Language acquisition is a creative act

Share context then convey concept

The Process

Recognize patterns separately
Produce behaviour separately

Generalize contexts/frames
Recognize structural relations

Classify the variable parts
Use the invented classes

Associate patterns & behaviour
Associate across modalities

The Result

Multimodal infrequent concepts
Unimodal frequent structures