

Types and uses of semantic networks : **genetic, practical + psycholinguistic aspects**

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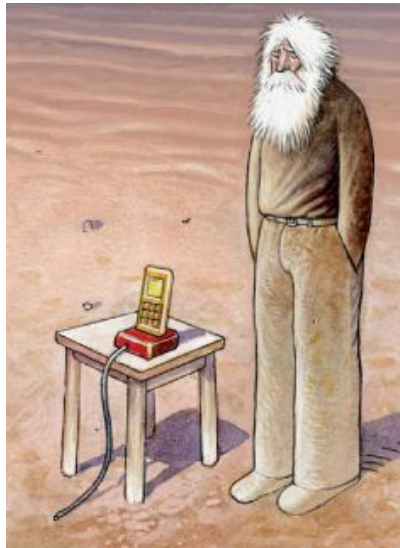
We **love** semantic networks, and here is **why**



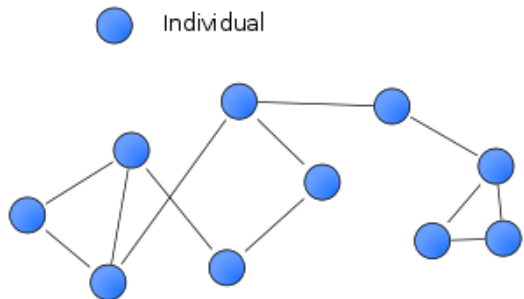
...because they contain a lot of meat

You are **not** alone
in this world

**JE SUIS
CHARLIE**



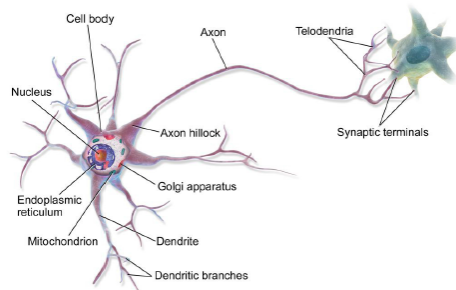
Actually, there are very few **ermites** in nature, and even those who are may occasionally feel the need to travel, to hang out and to socialize with others, be they ermites or not.



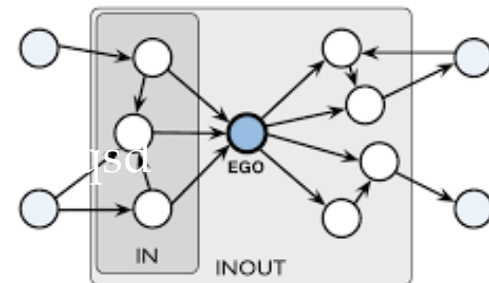


Networks are everywhere

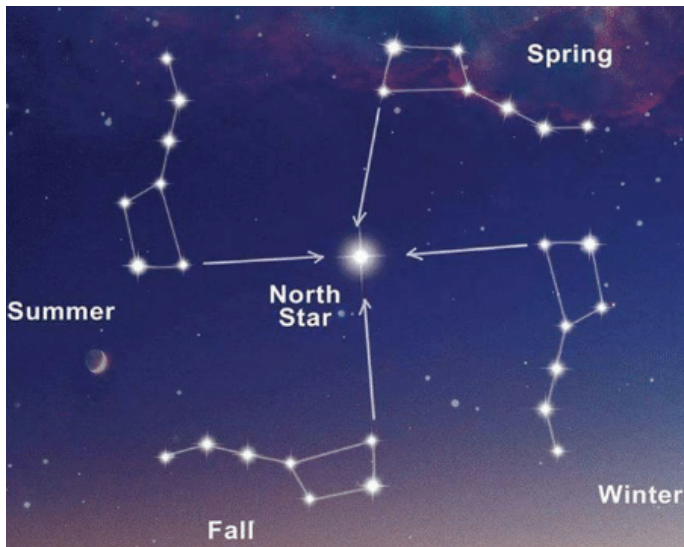
star system
geography
society
body
brain



Ego networks



Networks are everywhere, but, who makes the connections?



The network is in the eye of the beholder

Yet, having recognized it, we can

- we can refer to it;
- compare it to similar patterns;
- posit other objects with respect to it (use it as navigational instrument);
- travel along the paths of the network,
- etc.

Outline of the talk

1. Semantic networks

- ▶ What are they?
- ▶ Different types
- ▶ How did they come about?
- ▶ What are they for, or, what can they be used for?

2. Practical aspects

- ▶ Support encoding (ideas, messages)
- ▶ Support expression (word finding)

3. Summary and conclusion.

Maps and their ubiquitous uses

Cosmologists map the universe, geologists the land, biologists the genome, and psychologists map word knowledge. They map their domains to gain *theoretical* and *practical* insights that would not be forthcoming without an atlas to guide their inquiry.

Nelson, D. L., and McEvoy, C. L. (2005).
Implicitly Activated Memories: The Missing Links of Remembering.

Maps :

- ▶ means for revealing *structure* (neighbors, paths, proximity, hubs, ...)
- ▶ orientational means for *navigation*

Semantic networks

What **are** they and what are they **not**?

- ▶ Means to encode (represent) semantic information
- ▶ Knowledge maps supporting navigation (orientational guides).

Semantic nets do **not** correspond to the neuronal structure. For example, no concept or word is stored at a single cell. Neither do axons correspond (directly) to a semantic link (association).

Semantic networks, neural nets and the brain

Despite certain similarities, they are **not** the same

Neural Networks (NNs) and semantic nets (SNs) « have much in **common** and should be regarded as two points in a rich, quasi-continuous space of computational architectures rather than as radically different types of network. There are important **differences** in the nature and usage of links and in the degree to which computation can be thought of as local to individual nodes (although in restricted SNs the computation can be as local as it is in NNs). There are various ways of implementing or emulating SNs in NNs, and of forming hybrid SN-NN systems. »

Barnden, J.A. Lee, M.G. and Viezzer, M. In MA Arbib,(Ed.), Handbook of brain theory and neural **networks** (pp. 854-857) MIT Press.

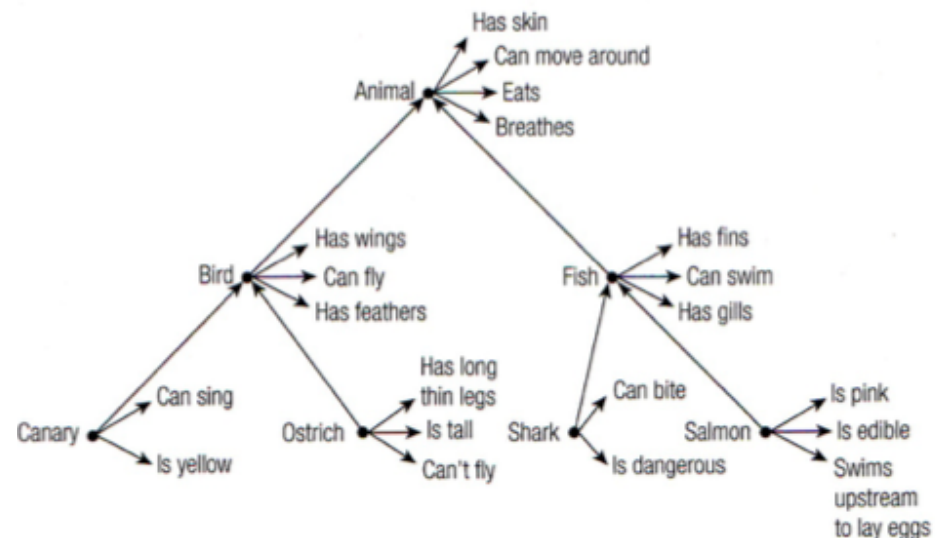
Semantic network

A **semantic network** is (generally) a graphic notation for representing knowledge in patterns of interconnected nodes. While being boosted by the work done by Collins and Quillian (a psychologist and a computer scientist, speculating about the representation of concepts and words in the human memory), semantic networks have become popular in AI and NLP to represent *knowledge* or to support *reasoning*.

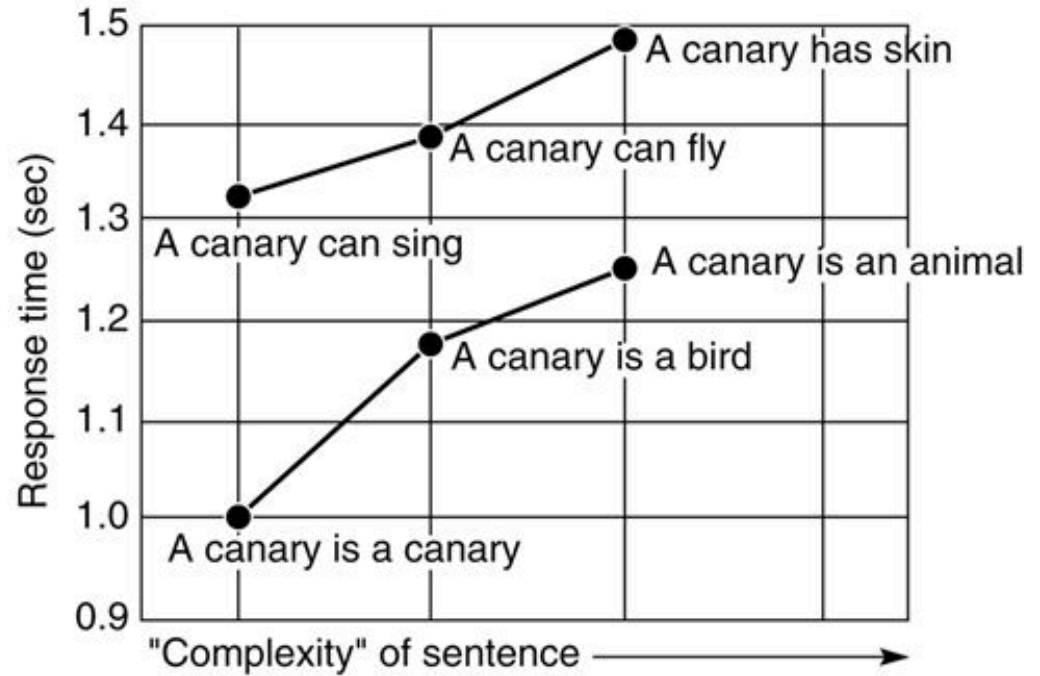
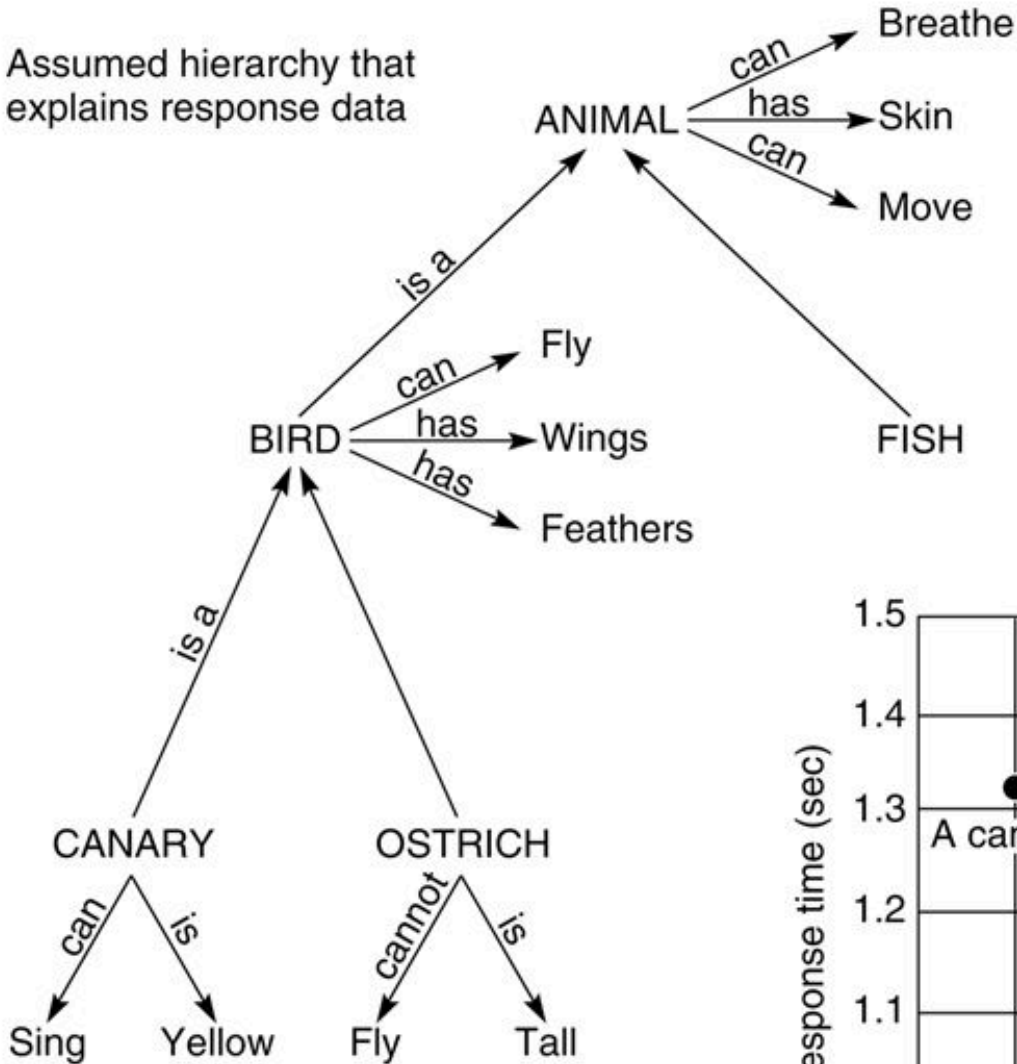
Collins, A. and Quillian, M.R. (1969). Retrieval time from semantic memory. *Journal of verbal learning and verbal behavior* 8 (2): 240–248

Simmons, R. F. (1972). *Semantic networks: their computation and use for understanding English sentences*. In: Schank, R. C., & Colby, K. M. (Eds.). (1973). *Computer models of thought and language*. San Francisco: WH Freeman, 63-113

Sowa, J. F. (2000) *Knowledge Representation: Logical, Philosophical, and Computational Foundations*, Brooks/Cole Publishing Co., Pacific Grove, CA.



Assumed hierarchy that explains response data



Psychological Reality of Networks

The networks embody two important principles : **hierarchical structure** and **economy**. Information relevant for a whole class of objects is represented only at the highest level, as it can be inferred for entities occurring further down in the hierarchy. The gained economy of storage, is, of course, paid by processing time.

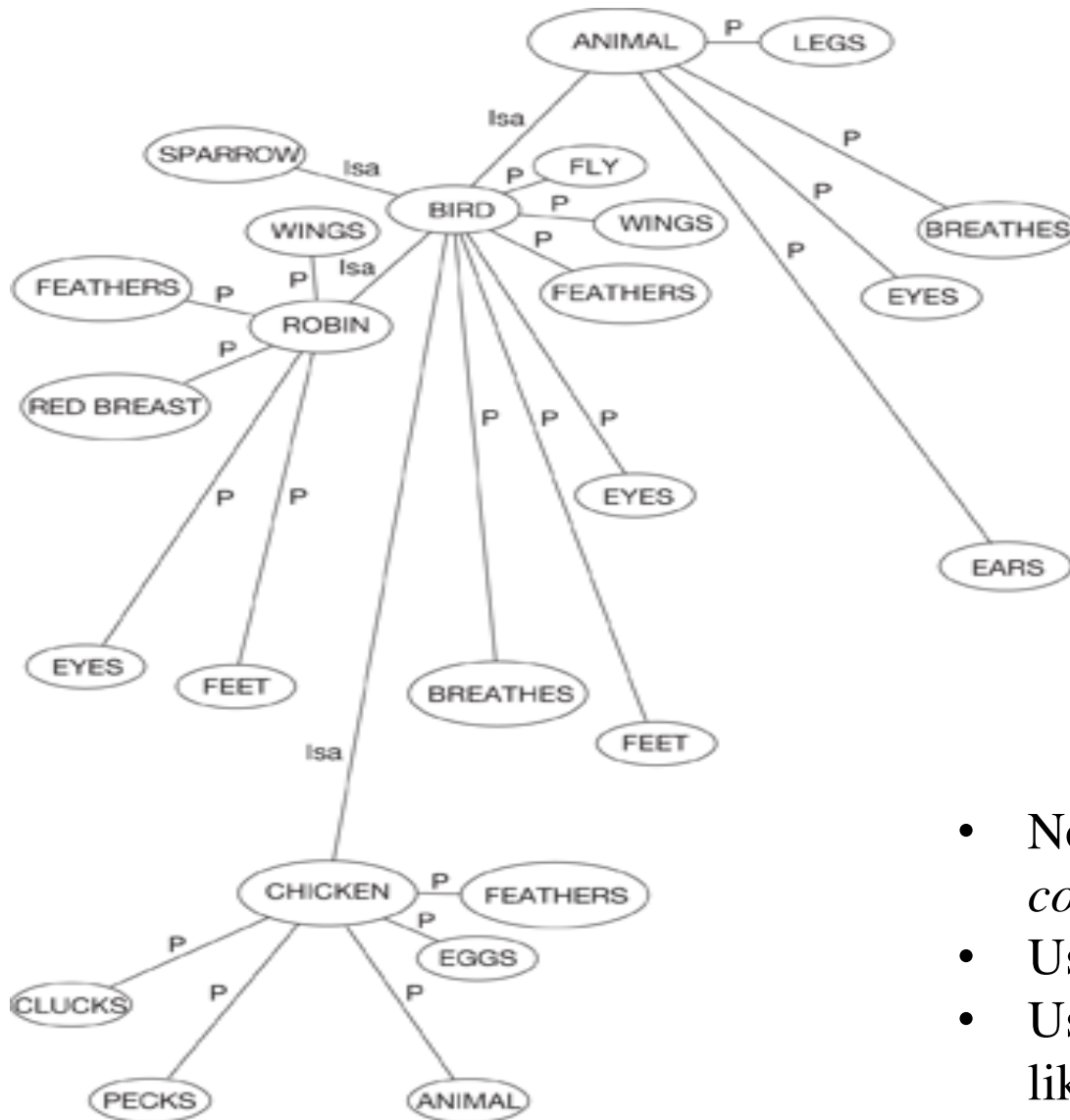
To test these hypotheses subjects were asked to judge the truth value of sentences like the following:

- ▶ (a) Canaries can sing – 1310 ms
- ▶ (b) Canaries have feathers – 1380 ms
- ▶ (c) Canaries have skin – 1470 ms

Frequently used facts are also verified faster, which tends to confirm the hypothesis that this information is stored with node:

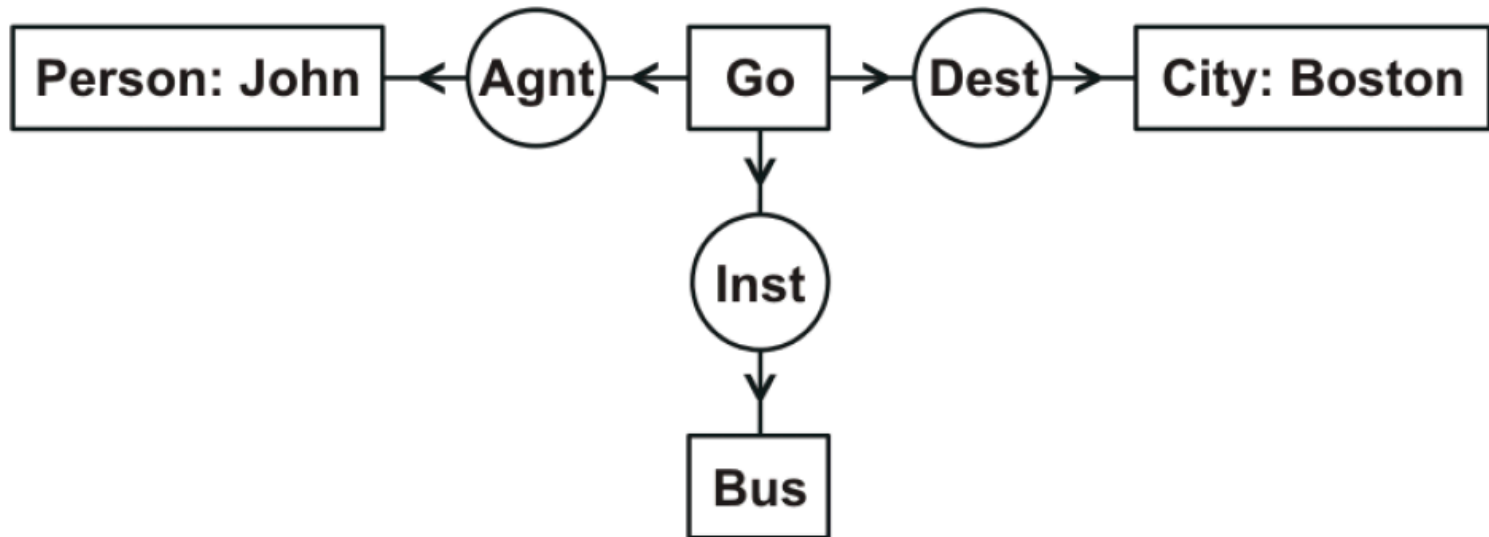
- ▶ Apples are eaten
- ▶ Apples have dark seeds

Modified Collin and Quillian Model



- No difference anymore between *concepts* and *attributes*
- Use of weighted links
- Use of spreading activation like in connectionist models

Sowa's conceptual graphs



John *went* by **bus** to **Boston**

Where is the semantics ?

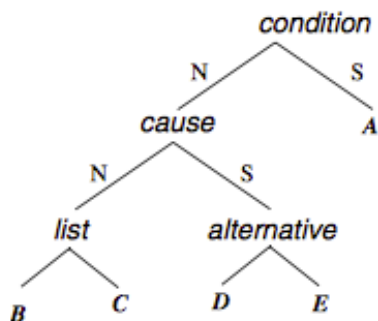
1. Conceptual level (message)

2. Word level

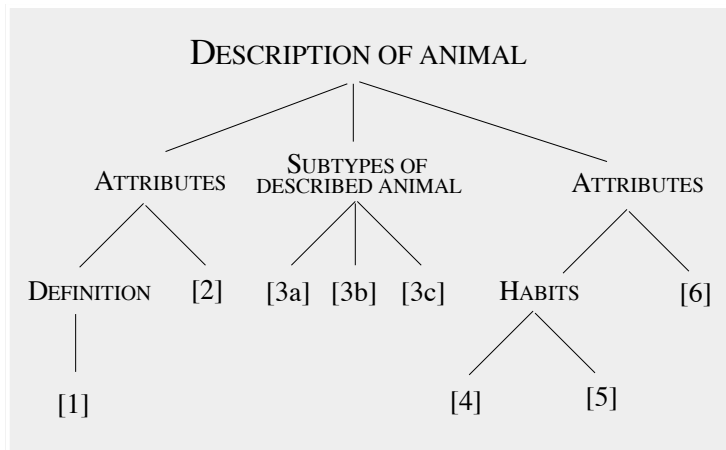
- ▶ but **words** have **meanings**, hence, they **encode** also a **conceptual structure**
- ▶ Yet, apart from having **individual meanings**, words are structured in the lexicon. They are organized into a network whose structure supports **wordfinding** (access, search, navigation). Hence the relevance of conceptual indexing (Roget's Thesaurus), association networks (**lexical graphs** : WordNet, JeuxDeMots, BabelNet, ...), or other kind of cataloguing methods (library science, Dewey,...).

Where is the semantics ?

- 1. Sentence level** (sentences are combined to form larger discourse entities, and, just as there are constraints to combine words at the sentence level, there are certain constraints to combine messages (propositions, clauses). See the work on **Rhetorical Structure Theory** (RST: http://www.wikiwand.com/en/Rhetorical_Structure_Theory)

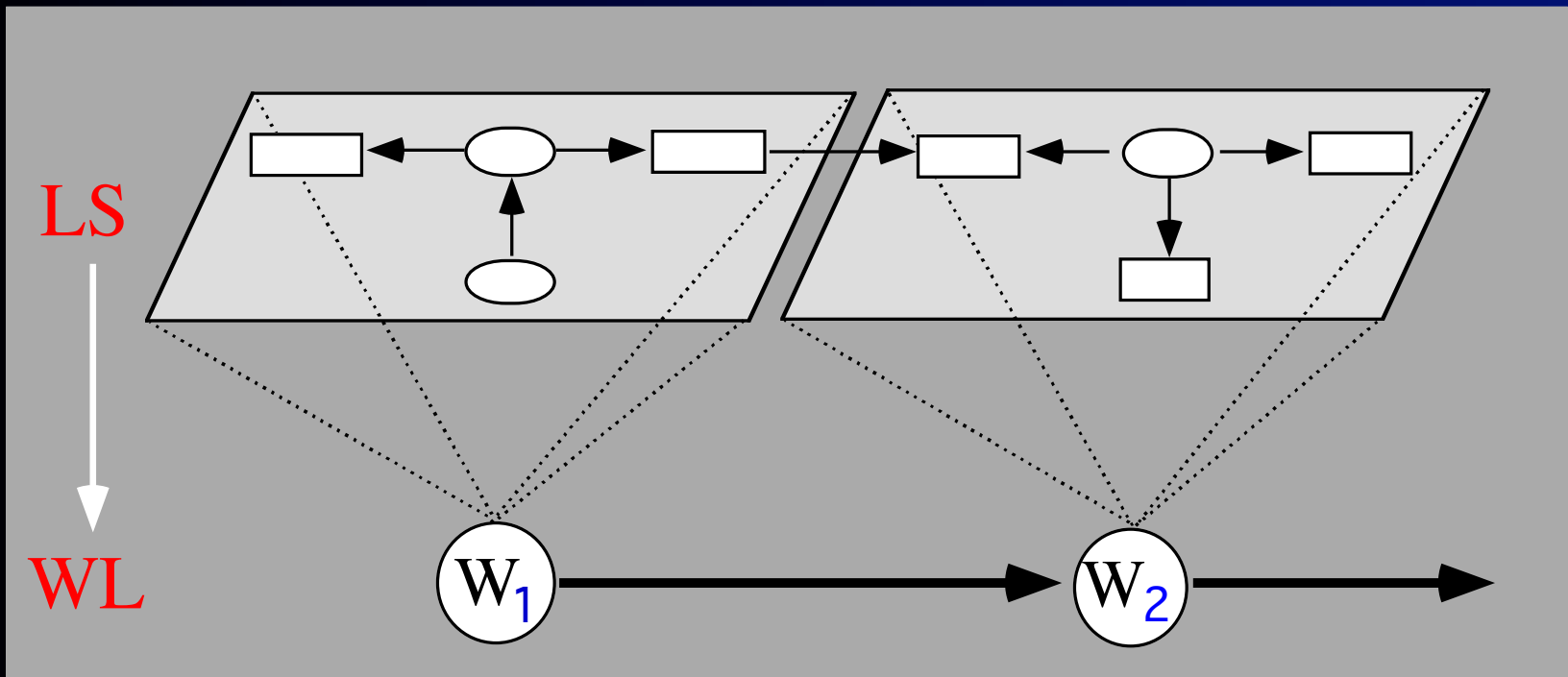


Example of RST structure



(1) The bat is a nocturnal animal. (2) It lives in the dark. (3) There are long nosed bats and mouse eared bats also lettuce winged bats. (4) Bats hunt at night (5) they sleep in the day (6) and they are very shy.

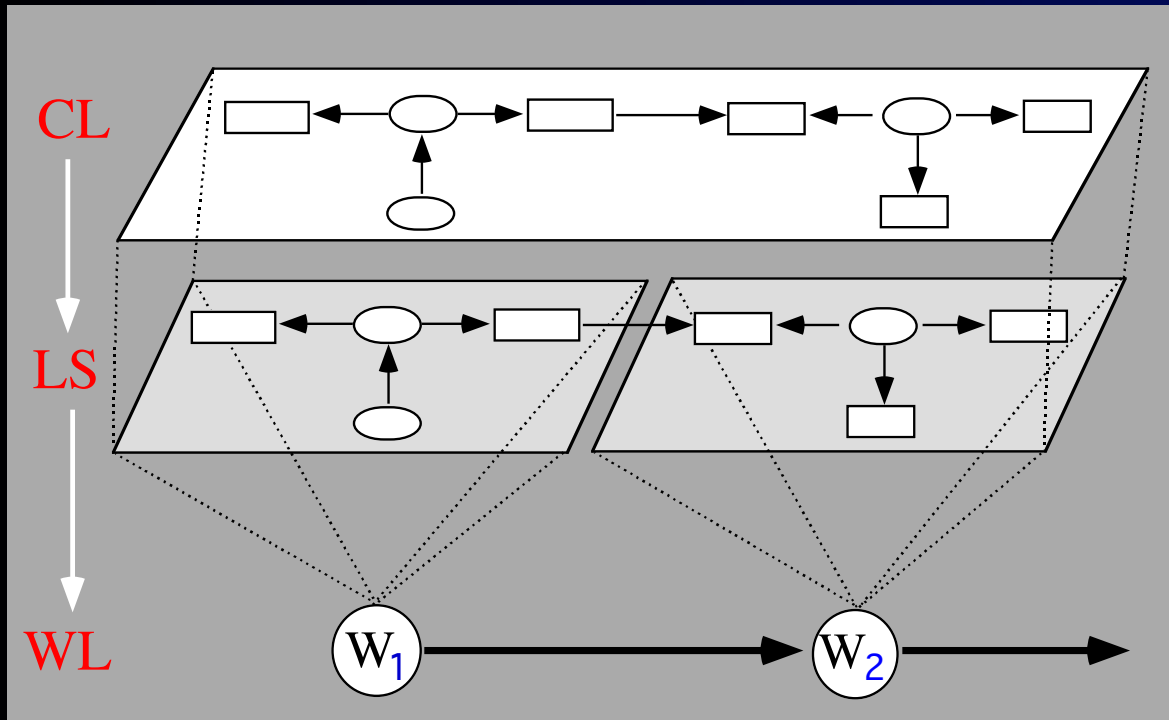
Words and their meaning



LS: lexical semantics; **WL**: words

Words are **but** shorthand labels
for **more** or **less** complex **knowledge graphs**
(conceptual structures)

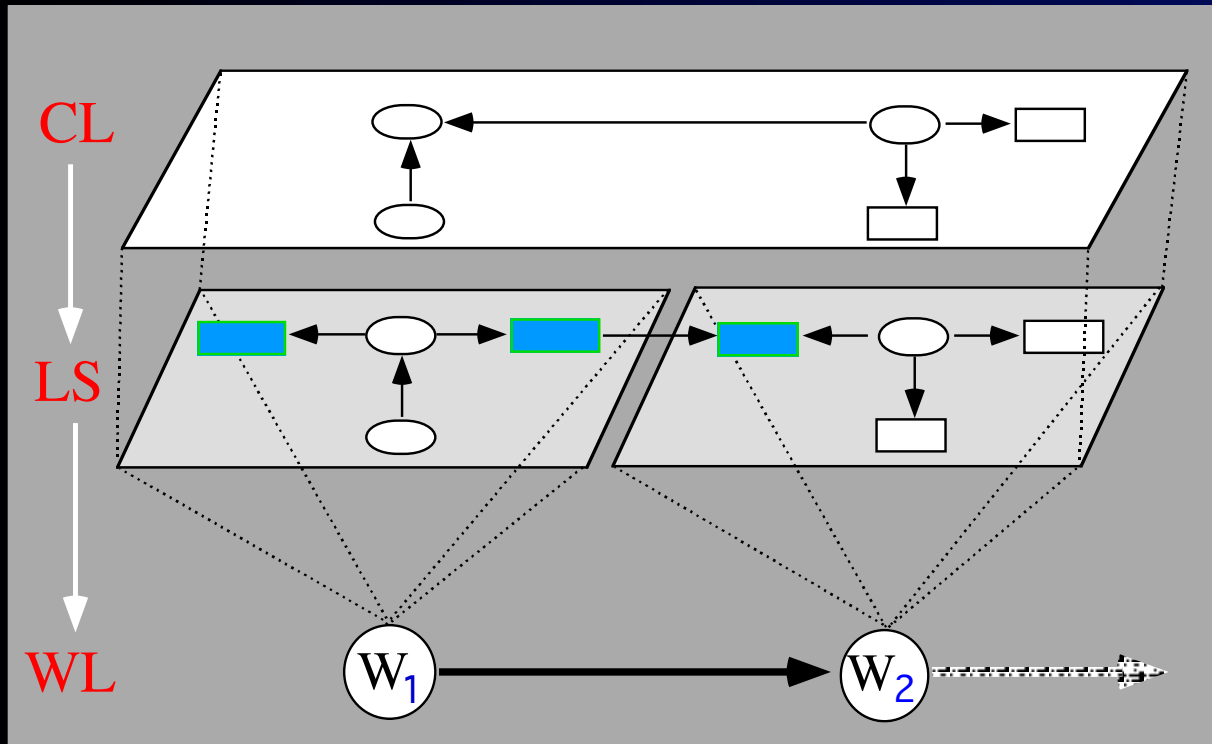
Entirely specified message



CL: conceptual level; **LS:** lexical semantics;
WL: words

Words are the **exchange money** i.e. interface between **language** and **thought**

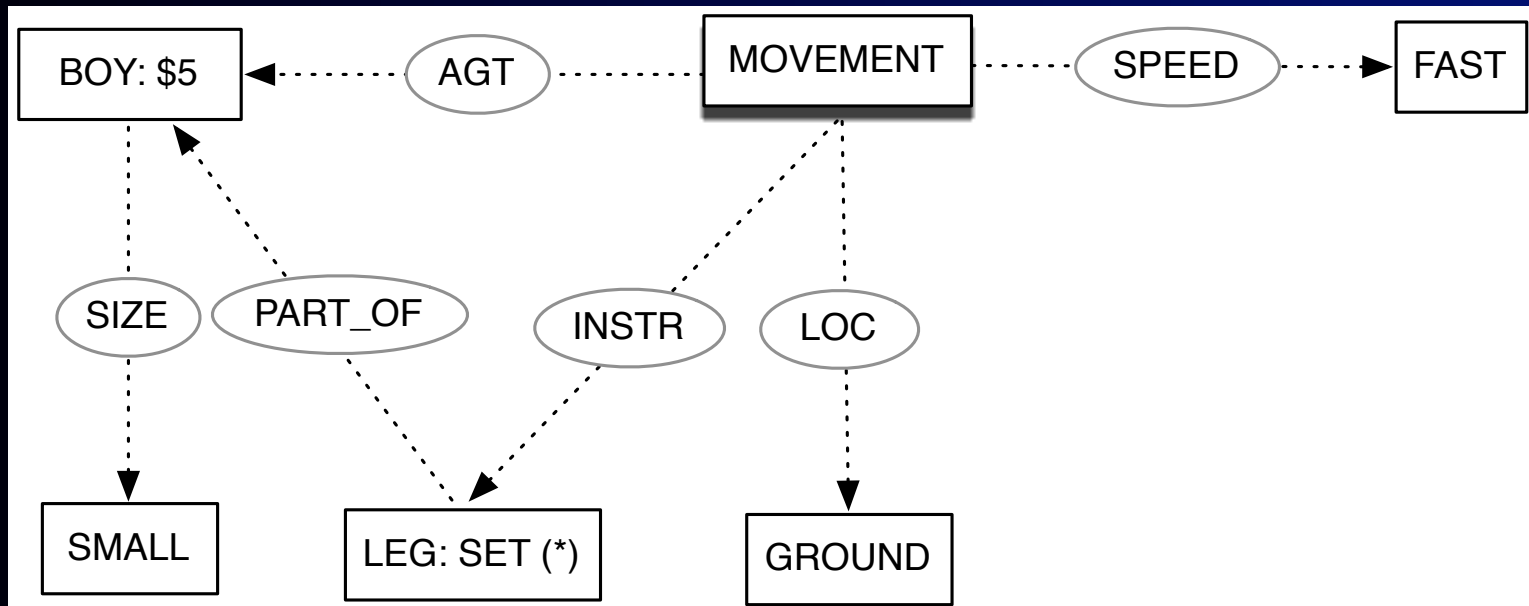
Underspecified message



CL: conceptual level; **LS:** lexical semantics
WL: word level

Words may
help or oblige us to clarify
underspecified thought

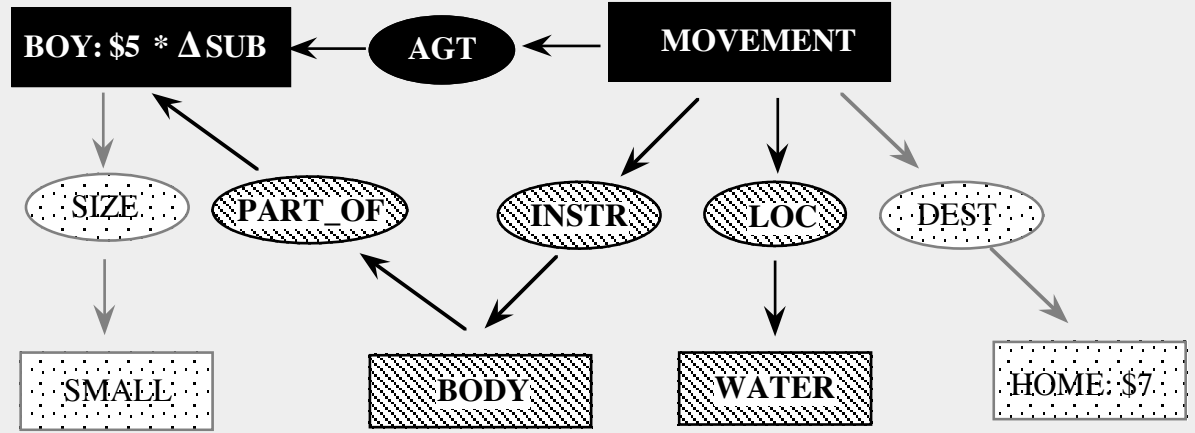
Graph encoding the idea of running



The feature 'size' is not relevant for the word's meaning

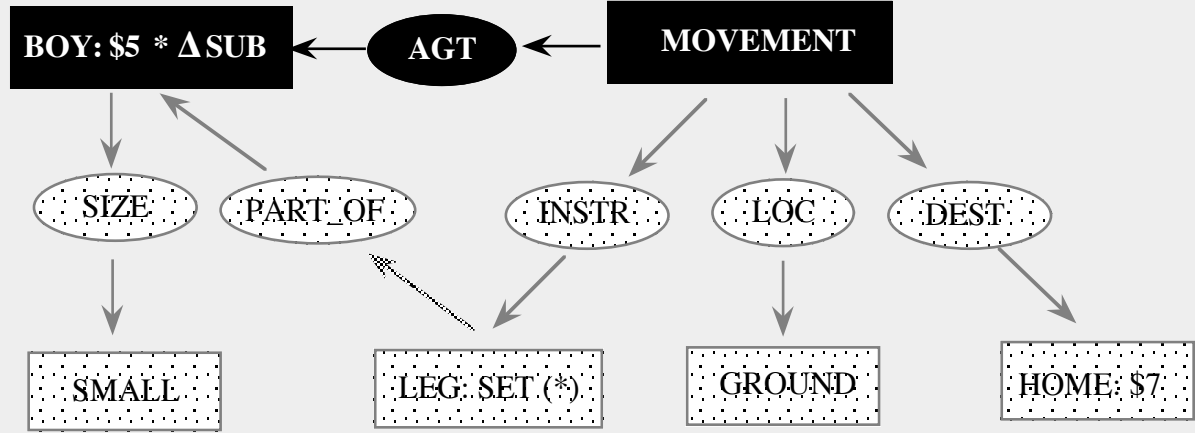
Two word graphs
 expressing
 more or less
 specific information
 (a) to swim, (b) to move

• VERB ('to swim', VB_INTRANS) is



• VERB ('to move', VB_PRO) is

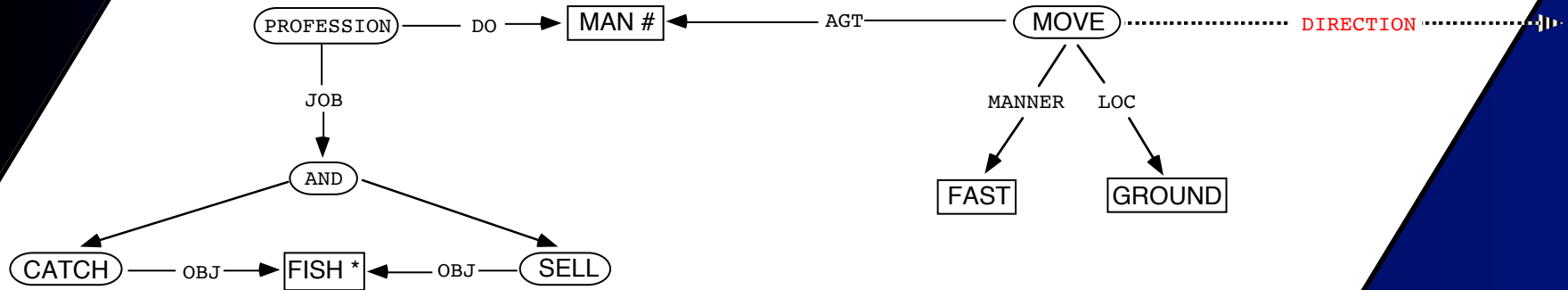
Correlation factor : 2



Language production

1. The use of **words** to **express** a **message**
2. Means : map (the conceptual structure underlying) **words** on a conceptual structure, the **message**
3. Conceptual structures can be quite ‘wordy’

Conceptual input



a **man** whose **profession** consists in **catching** and **selling** **fish** **moves** **fast** on the **ground** in direction of...

Conceptual structure (message)

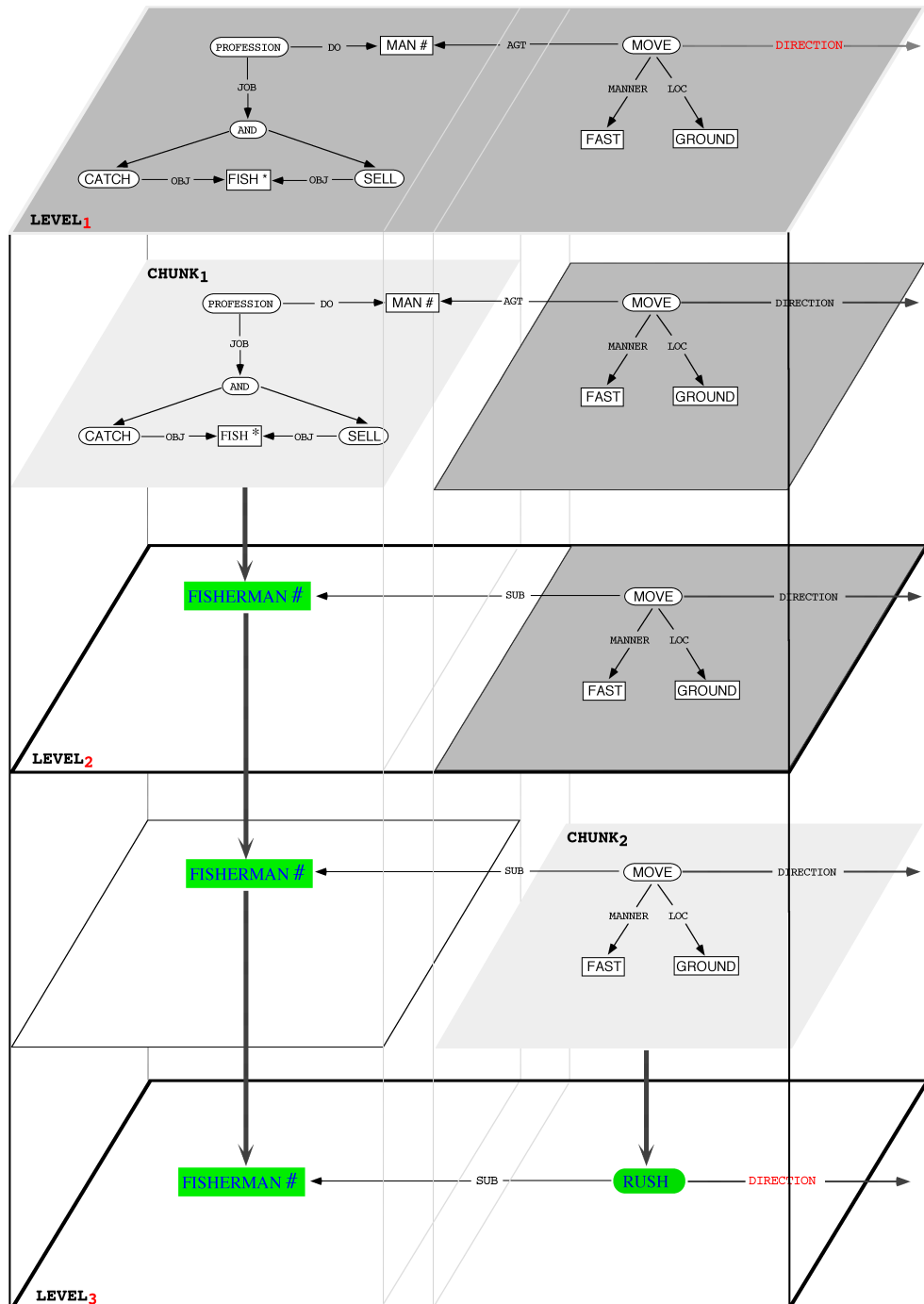
Lexical mapping of **chunk₁**

Result: lemma₁ = *fisherman*

Lexical mapping of **chunk₂**

Result: lemma₂ = *rush*

Lexically and functionally specified conceptual structure



Before expression

a **man** whose **profession** consists
in **catching** and **selling** **fish**
moves **fast** on the **ground** in
direction of...

After lexicalization

The **fisherman** **rushed** towards

Why do we have word-access problems, or, what happens when we are in this state?

Words in **books** and in the **brain** are fundamentally **different**.

- ▶ in books they exist as tokens (meaning and forms are represented together)
- ▶ in the brain they are decomposed. The elements representing meaning, form, sound are distributed over various layers. They need to be activated (**not accessed**). Yet activation takes time and is error prone. Actually one may question the very fact of symbolic representations in our mind.

We do not have access to all the relevant elements (meaning, form, sound) at the same time or **when needed**, which might hinder unification.

Analogy: while you may see the *eyes*, *ears* and *nose* you don't see the *entire face*.

Access vs. activation

"A potentially counterintuitive idea is that the individual sounds of words are **assembled anew** **each time** they are spoken rather than **retrieved as intact wholes**. Yet, patterns of speech errors and latency data suggest that this is the case. "

Zenzi M. Griffin and Victor S. Ferreira,
[Properties of Spoken Language Production](#), page 35.

In **Handbook of Psycholinguistics**
Traxler, M. and Gernsbacher, M. A. (Eds.), 2006

Words are distributed

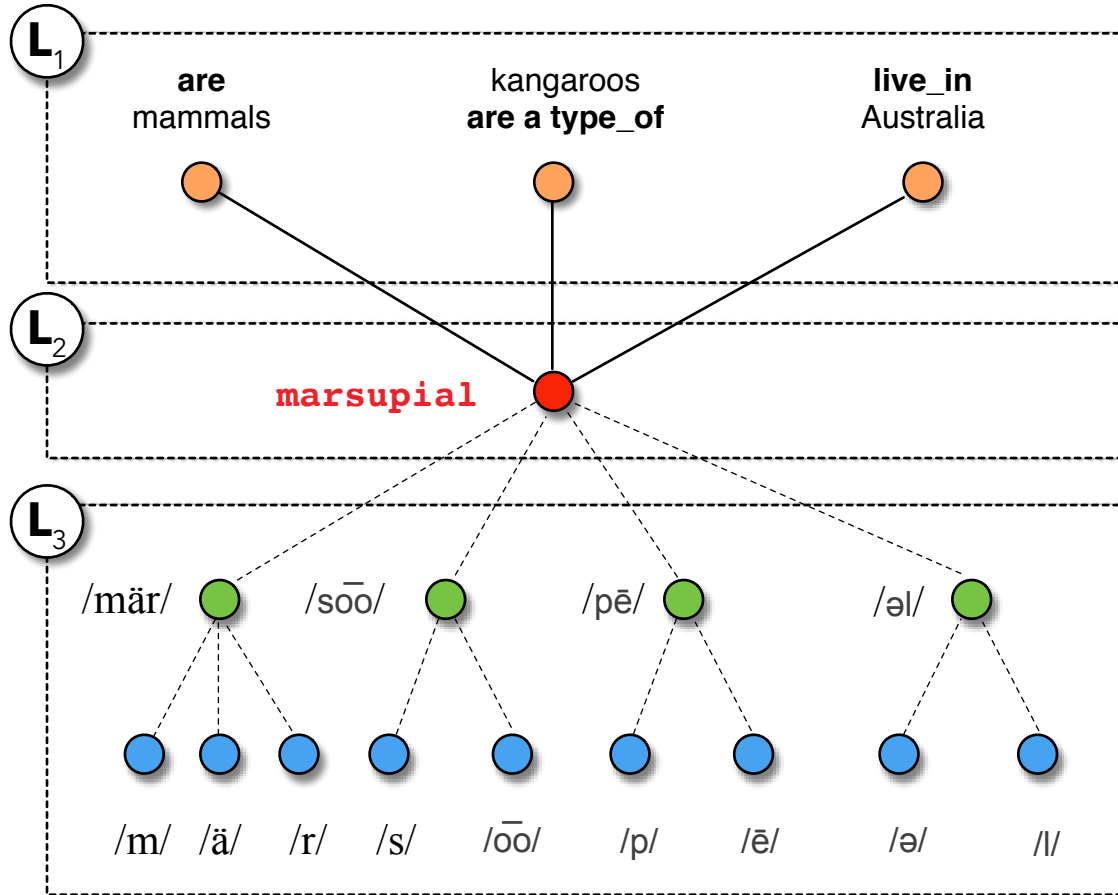
What's that?

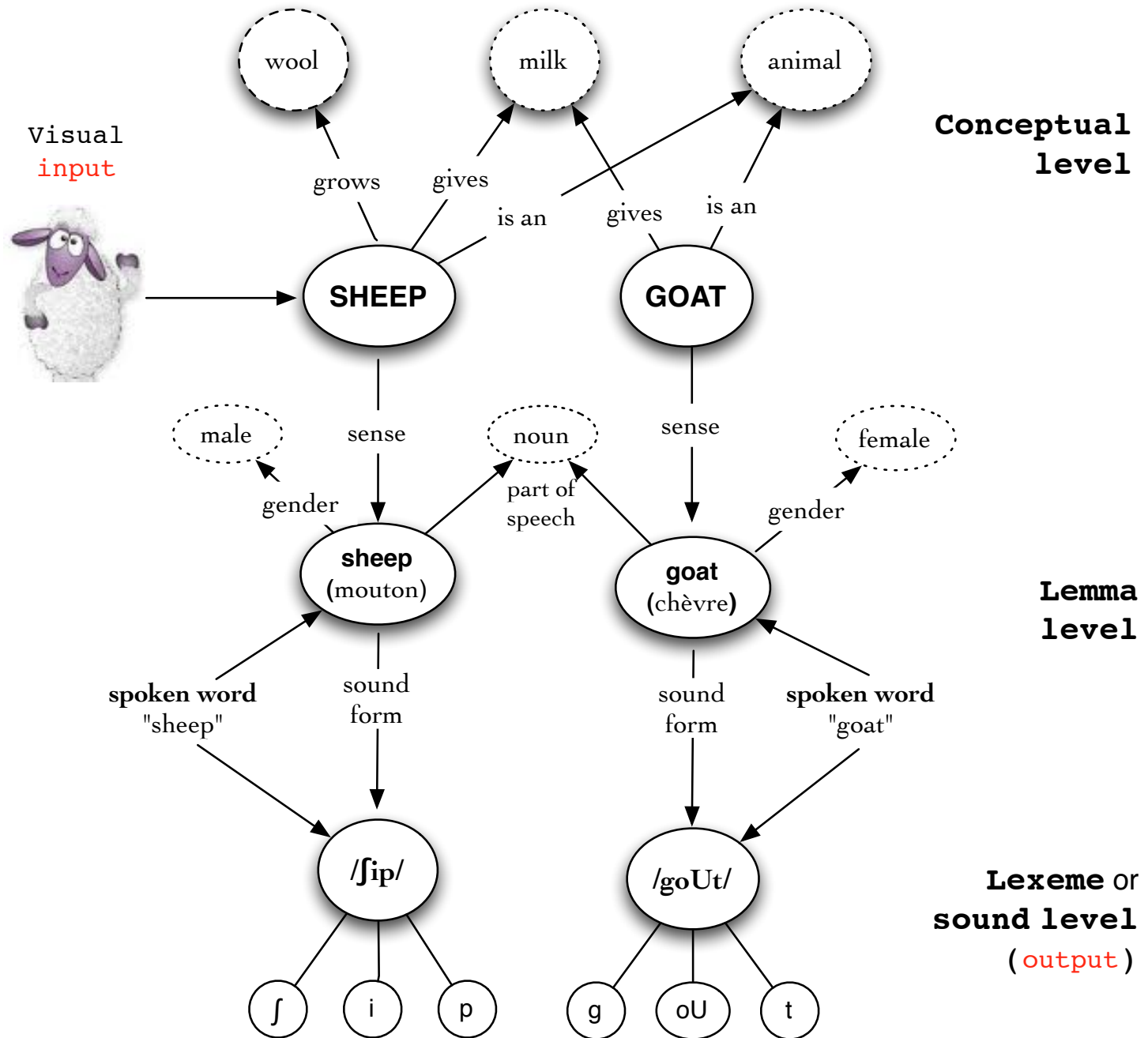


conceptual

Lexical
concept

Segments
phonemes





Semantic networks

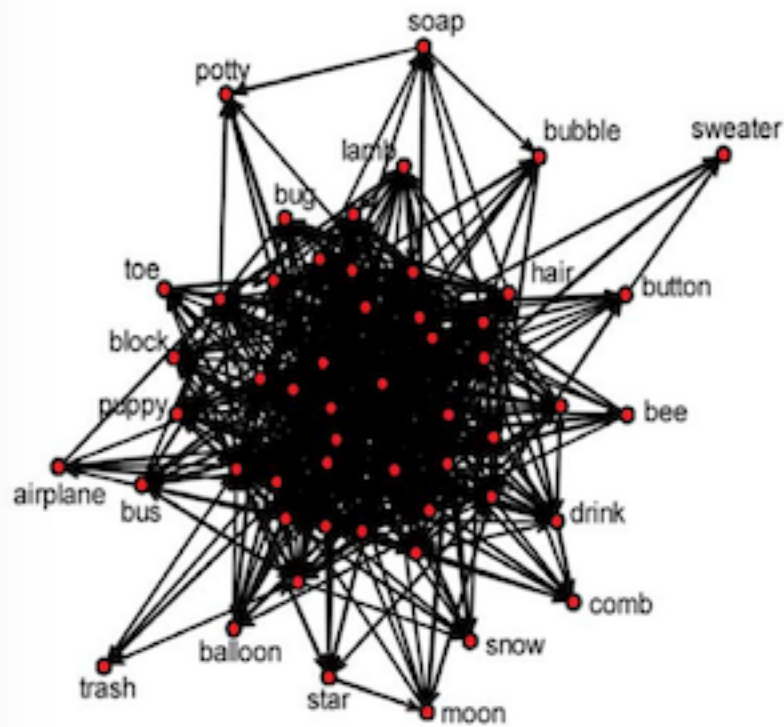
1. How did they come about?

- ▶ In the old days
- ▶ Recent past (Quillian, WordNet, JeuxdeMots)

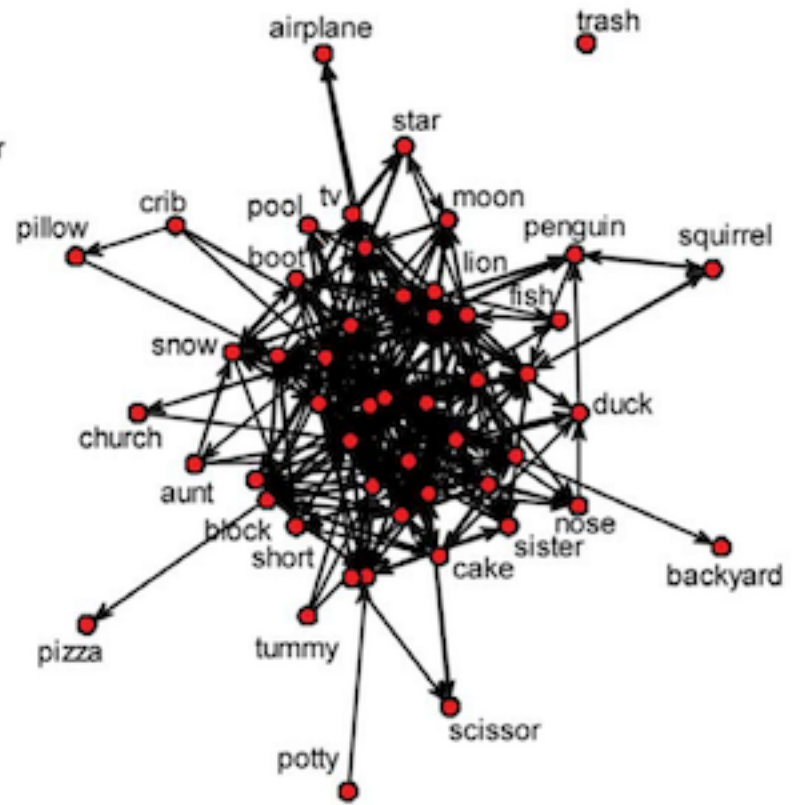
Semantic networks

What **are they for**, or, what **can they be used for**?

- ▶ Represent data
- ▶ Reveal structure (relations, proximity, relative importance)
- ▶ Support conceptual edition
- ▶ Support navigation



Typical Talker

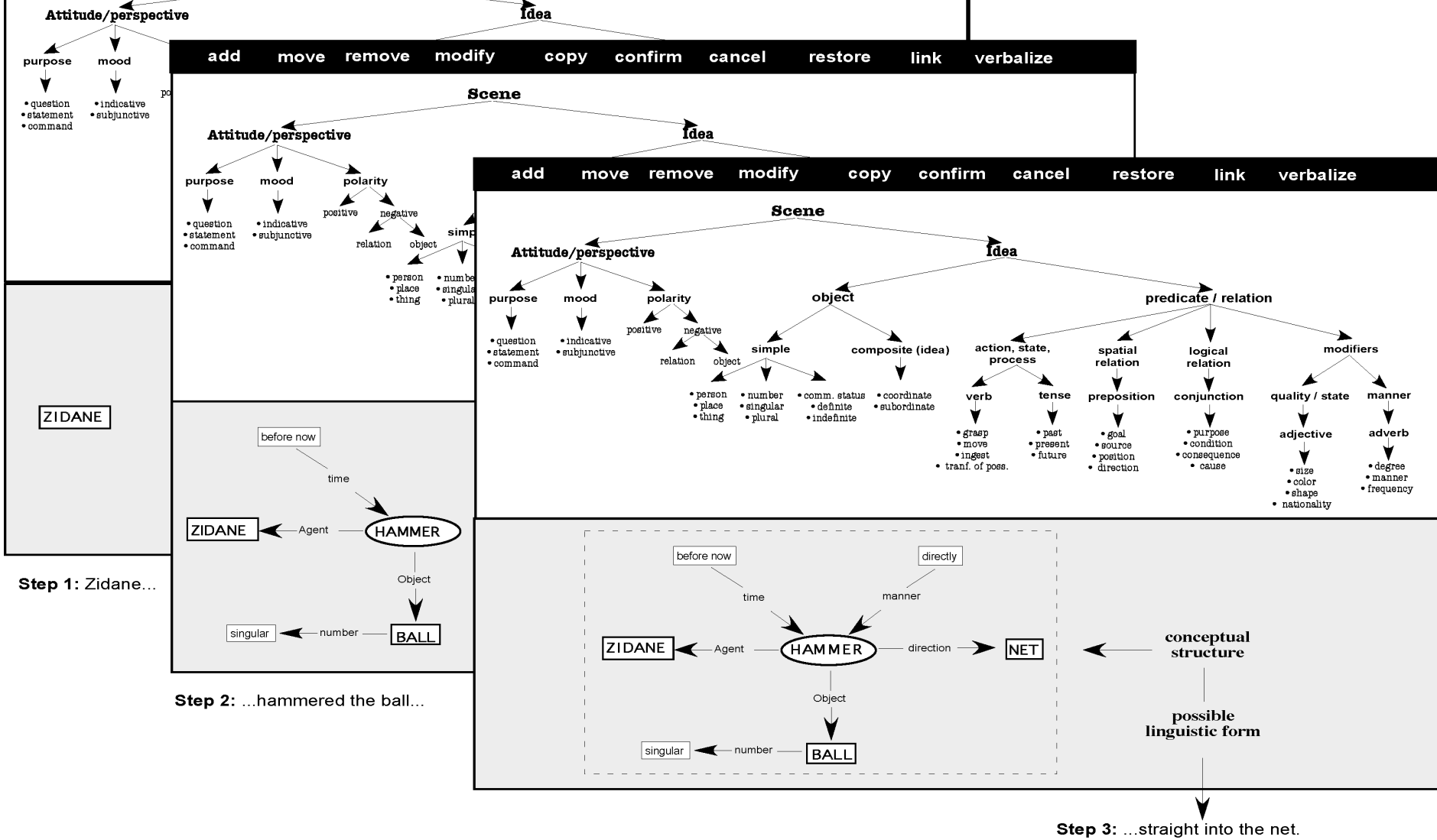


Late Talker

Learner profiles

Support conceptual encoding

- ▶ Sentence level
- ▶ Discourse level

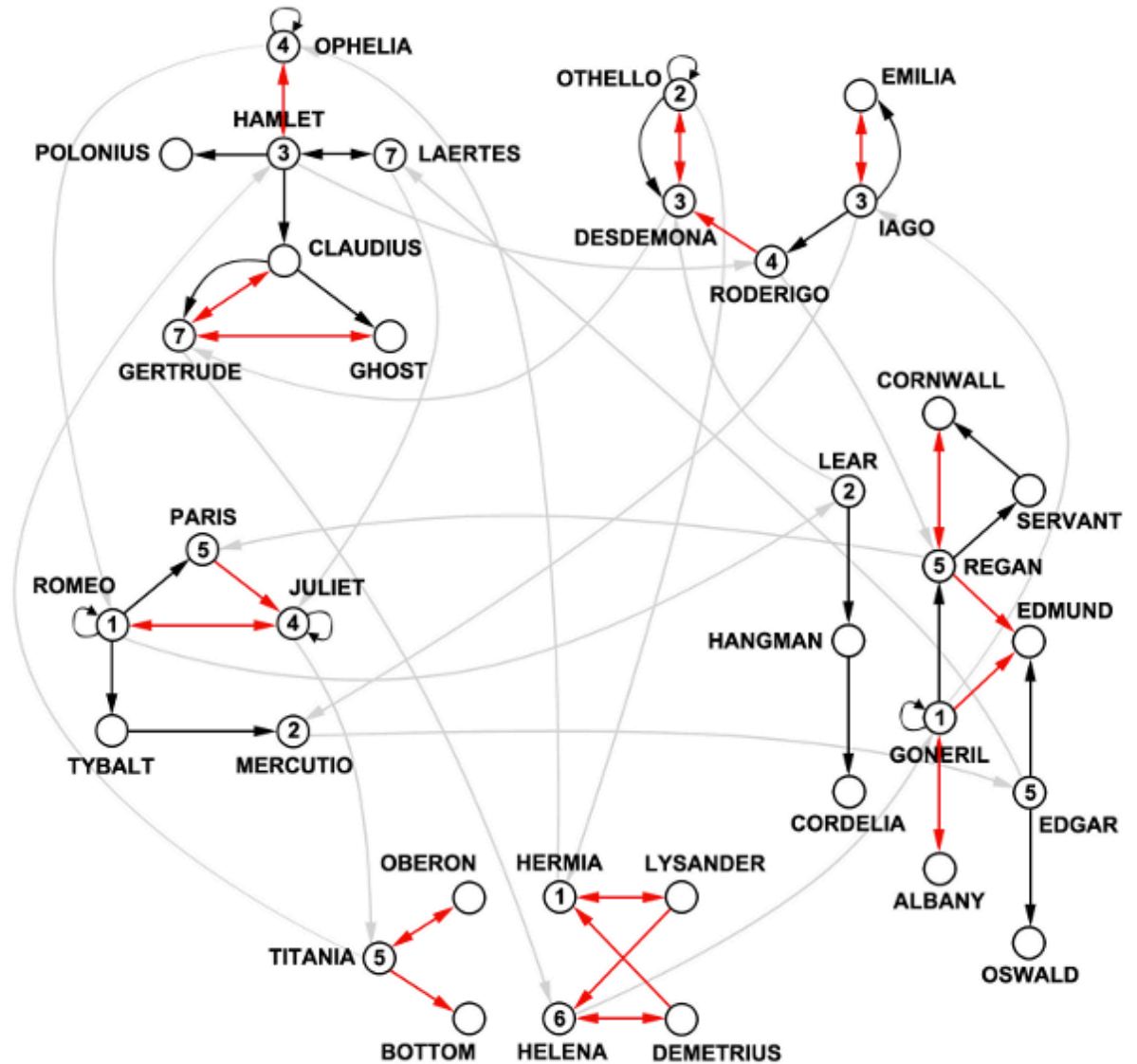


Conceptual editor for messages at the sentence level

- ▶ Zock, M., Sabatier, P. & L. Jakubiec-Jamet. (2008). *Message composition based on concepts and goals*. In A. Neustein (Ed.) 'International Journal of Speech Technology', 11, 3-4, pp. 181-193. Springer Verlag

Mindmaps or Conceptual editor for messages at the discourse level

topic
Hamlet



Check :

- balance
- completeness
- consistency
- relatedness

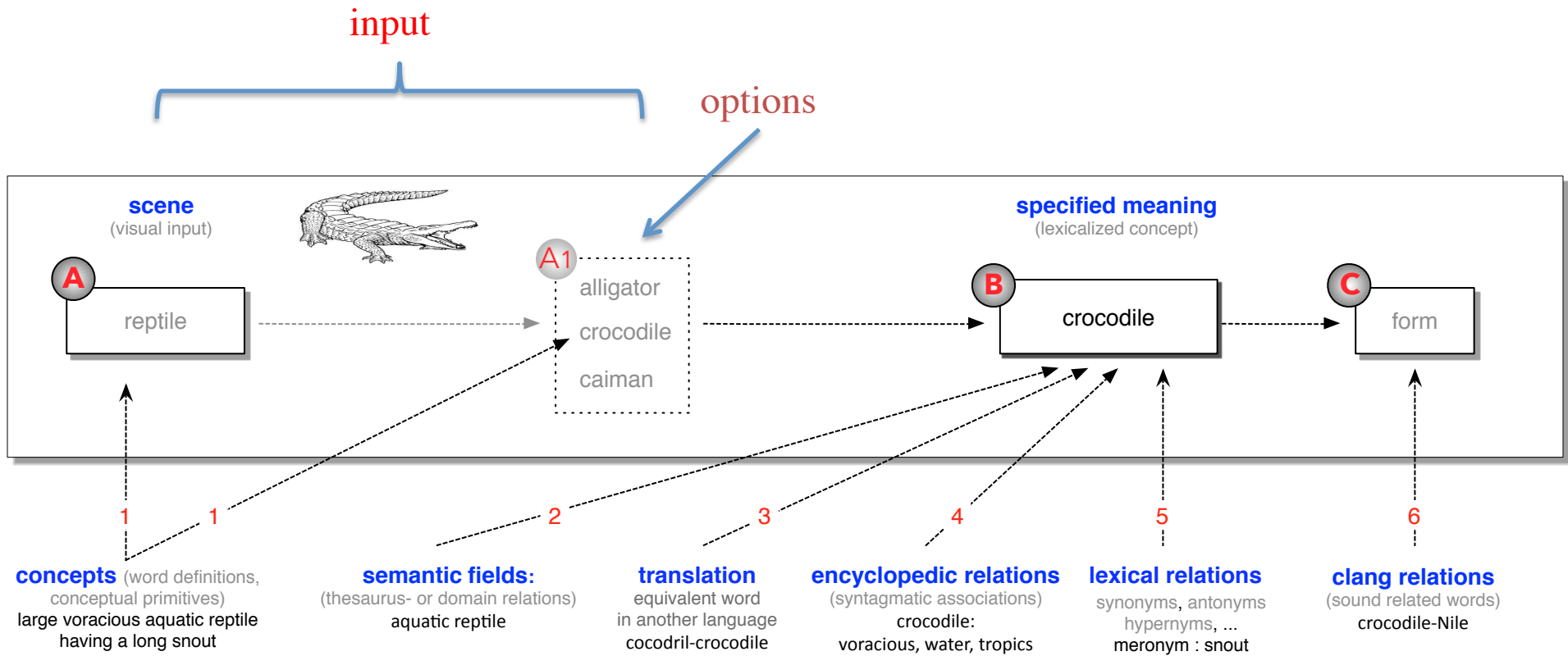
Despite our impression
of language being a
waterfall, ideas are,
and often ought to be
underspecified

Zock, M. (1996). *The power of words in message planning*. In COLING (International conference on computational linguistics). Copenhagen (pp.990–995).

<http://aclweb.org/anthology/C96-2167>



Underspecified input, or, the progressive synthesis of (what most of us would call) a word



Different access routes

The problem of lexical access

What's the problem?

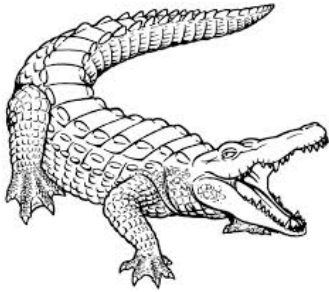
How to reduce quickly and naturally the search space

- ▶ Not too big (don't drown the user; google=overkill)
- ▶ Not too small (otherwise you may filter out the target)

Ancillary goal :

Build a **bridge** between the **input** and the **desired output** (target word), that is, accept as **input** whatever comes to the user's mind (**available information** at the onset of search).

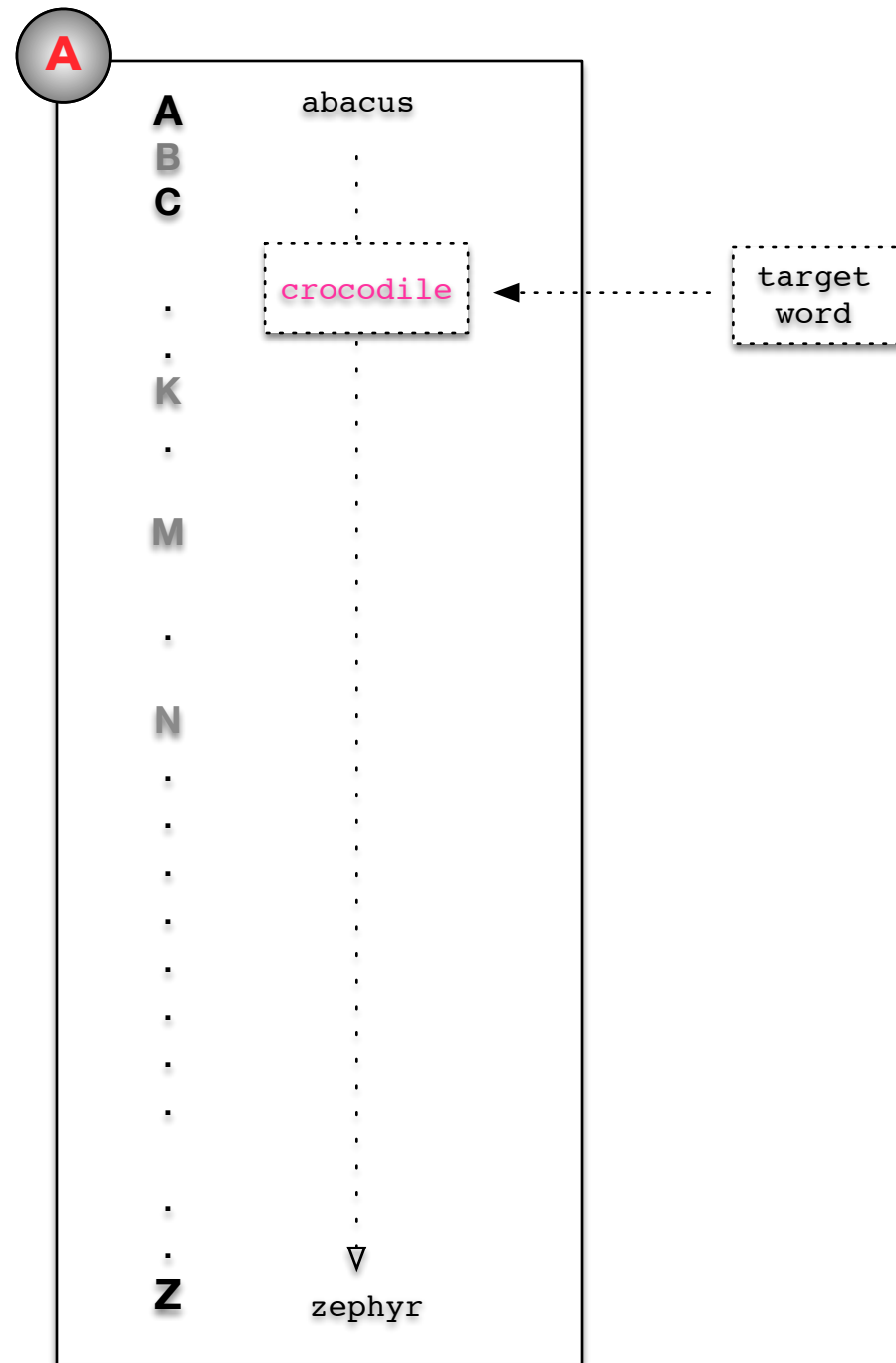
Idea to express



Search entire lexicon

i.e. reduce the
whole set to 1

Hypothetical alphabetically
organized lexicon
containing 60.000 words



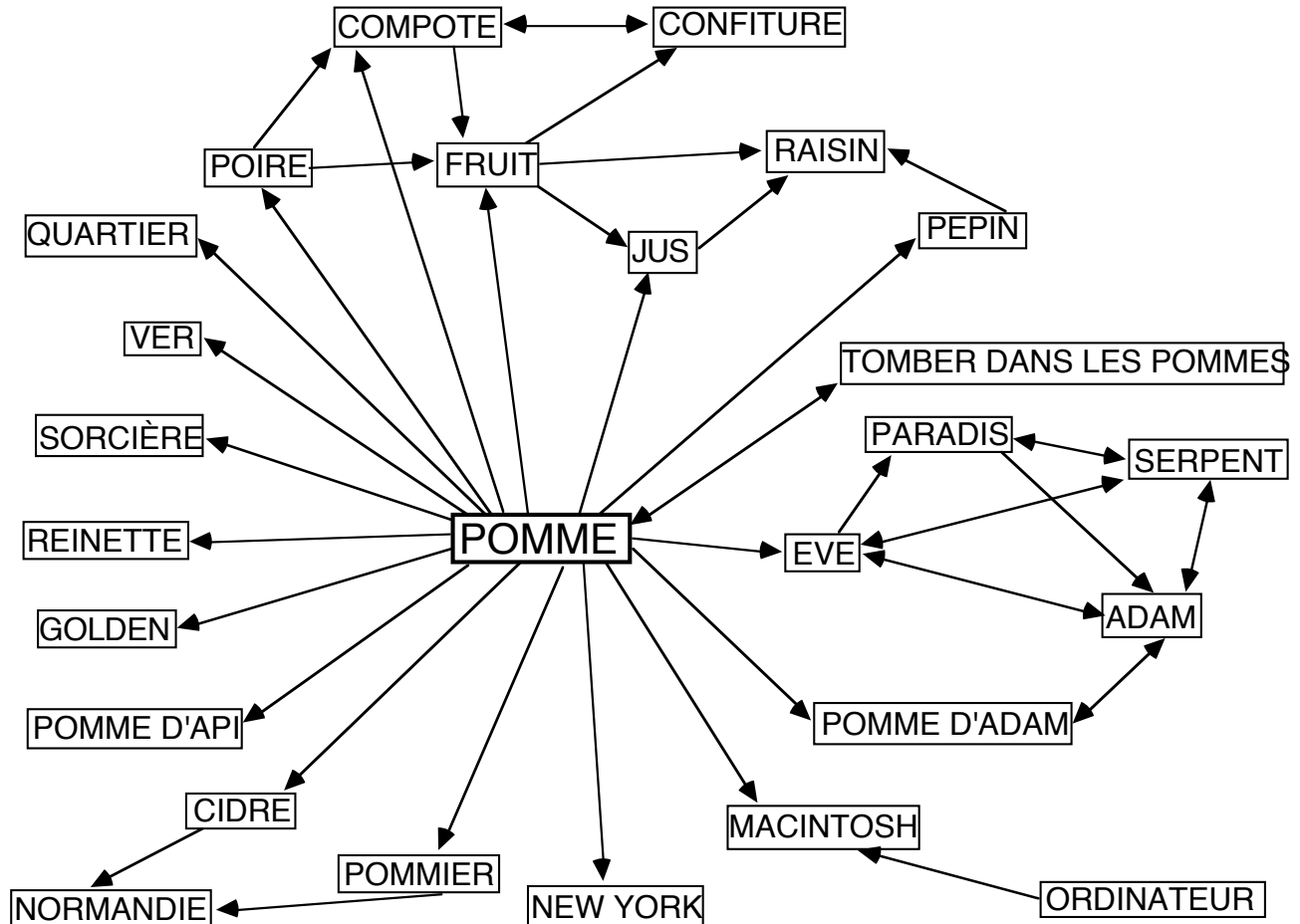
Possible solution :

Access via an association thesurus

	Language	Name	Link
1	English	Edinburgh Association Thesaurus (EAT)	<i>original</i> , but now dead link: http://www.eat.rl.ac.uk/ <i>revived</i> by Guy Lapalme : http://www-labs.iro.umontreal.ca/~lapalme/Word-Associations/
2	English	University of South Florida Free Association Norms	http://w3.usf.edu/FreeAssociation/
3	Russian English	Word Associations Network	http://wordassociations.net
4	Dutch + other languages	Dutch Word Association Database	http://www.kuleuven.be/semlab/interface/index.php http://www.smallworldofwords.com/en/ http://www.smallworldofwords.com/new/visualize/
5	German	Noun Associations for German database	http://www.psycholing.es.uni-tuebingen.de/nag/index.php
6	French	JeuxdeMots	http://www.jeuxdemots.org/diko.php http://www.jeuxdemots.org//AKI.php
7	Japanese	Japanese Word Association Database (JWAD)	http://www.valdes.titech.ac.jp/~terry/jwad.html http://faculty.tama.ac.jp/joyce/jwad.html

Association networks

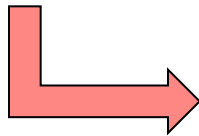
typed
untyped
weighted



Possible problems with the Edinburgh Association Thesaurus (E.A.T.)

Input: India

Output



PAKISTAN	12 0.14	FLIES	1 0.01
RUBBER	10 0.12	HIMALAYAS	1 0.01
CHINA	4 0.05	HINDU	1 0.01
FOREIGN	4 0.05	HUNGER	1 0.01
CURRY	3 0.04	IMMIGRANTS	1 0.01
FAMINE	3 0.04	INDIANS	1 0.01
TEA	3 0.04	JAPAN	1 0.01
COUNTRY	2 0.02	KHAKI	1 0.01
GHANDI	2 0.02	MAN	1 0.01
WOGS	2 0.02	MISSIONARY	1 0.01
AFGHANISTAN	1 0.01	MONSOON	1 0.01
AFRICA	1 0.01	PATRIARCH	1 0.01
AIR	1 0.01	PEOPLE	1 0.01
ASIA	1 0.01	PERSIA	1 0.01
BLACK	1 0.01	POOR	1 0.01
BROWN	1 0.01	RIVER	1 0.01
BUS	1 0.01	SARI	1 0.01
CLIVE	1 0.01	STAR	1 0.01
COLONIAL	1 0.01	STARVATION	1 0.01
COMPANY	1 0.01	STARVE	1 0.01
COONS	1 0.01	TEN	1 0.01
COWS	1 0.01	TRIANGLE	1 0.01
EASTERN	1 0.01	TURBANS	1 0.01
EMPIRE	1 0.01	TYRE	1 0.01
FAME	1 0.01	UNDER-DEVELOPED	1 0.01

India being the answer to the following stimuli

SARI	22 0.15	CAST	1 0.01	LOOP	1 0.01
CASTE	17 0.12	CATASTROPHY	1 0.01	MEDITATE	1 0.01
NADIR	11 0.08	CHINA	1 0.01	MILDEW	1 0.01
FAMINE	6 0.04	CLUBS	1 0.01	MISSION	1 0.01
AFRICA	5 0.03	COLONIES	1 0.01	NATIVE	1 0.01
PAKISTANI	4 0.03	COMPANY	1 0.01	PLAGUE	1 0.01
STARVING	4 0.03	CONSUMPTION	1 0.01	POVERTY	1 0.01
BEGGING	3 0.02	CONTINENTS	1 0.01	PRIESTESS	1 0.01
CASTS	3 0.02	COTTON	1 0.01	QUININE	1 0.01
NAPALM	3 0.02	COUNTRY	1 0.01	SAVER	1 0.01
STARVATION	3 0.02	EAST	1 0.01	SECT	1 0.01
CHARISMA	2 0.01	ELEPHANT	1 0.01	SERVANT	1 0.01
CURRY	2 0.01	ELEPHANTS	1 0.01	SETTLEMENT	1 0.01
INCENSE	2 0.01	EMPIRE	1 0.01	SHEEPSKIN	1 0.01
KHAKI	2 0.01	FAMISHED	1 0.01	STARVED	1 0.01
PARIAH	2 0.01	FURTHER	1 0.01	SUFFERING	1 0.01
RICE	2 0.01	GHOUL	1 0.01	THUG	1 0.01
SPICE	2 0.01	HEDONISM	1 0.01	THUGS	1 0.01
STARVE	2 0.01	INCA	1 0.01	TIGER	1 0.01
TURBAN	2 0.01	INDIANS	1 0.01	TOGA	1 0.01
ALE	1 0.01	ISLAM	1 0.01	UNCLEAN	1 0.01
AMERICA	1 0.01	LEPER	1 0.01		
BIZARRE	1 0.01	LIFE-SPAN	1 0.01		

Frequency and/or recency? weights are not everything

Output ranked in terms of frequency

PAKISTAN	12 0.14	FLIES	1 0.01
RUBBER	10 0.12	HIMALAYAS	1 0.01
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COONS	1 0.01	TEN	1 0.01
COWS	1 0.01	TRIANGLE	1 0.01
EASTERN	1 0.01	TURBANS	1 0.01
EMPIRE	1 0.01	TYRE	1 0.01
FAME	1 0.01	UNDER-DEVELOPED	1 0.01

Clustering by category

Countries, continents, colors, food, means of transportation, instruments, ...

PAKISTAN	12 0.14	FLIES	1 0.01
RUBBER	10 0.12	HIMALAYAS	1 0.01
CHINA	4 0.05	HINDU	1 0.01
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EASTERN	1 0.01	TURBANS	1 0.01
EMPIRE	1 0.01	TYRE	1 0.01
FAME	1 0.01	UNDER-DEVELOPED	1 0.01

Alternative ‘solution’

Roget's
Thesaurus

Peter Mark Roget

immediately -AA

VERBS: act, burst, cease, confront, contact, declare, deny, dispose of, draw, embark, follow, hand, inform, issue, leap, notice, notify, obey, order, perceive, precede, produce, provoke, react, recognize, regret, reject, release, replace, reply, resolve, respond, reward, rule, rush, seize, serve, start, stop, strike, surrender, surround, suspend, take effect, transfer, withdraw.

ADJECTIVES: accessible, alert, apparent, appealing, effective, evident, familiar, forthcoming, helpful, impressed, intelligible, noticeable, obvious, payable, recognizable, relevant, responsive, striking, suspicious, visible.

immeasurably -D

VERBS: help, improve, strengthen, suffer.

immensely -D

VERBS: enjoy, relieved.

ADJECTIVES: complex, complicated, damaging, detailed, difficult, encouraging, enthusiastic, exciting, expensive, experienced, fat, flattered, fond, gifted, grateful, helpful, important, impressed, impressive, interesting, likeable, pleased, popular, powerful, profitable, prolific, proud, readable, reassuring, relieved, rewarding, rich, sad, satisfying, strong, sympathetic, talented, valuable, varied, warm, wealthy.

Roget's Thesaurus (RT)

Based on the life long work of Dr. Peter Mark **Roget** (1779-1869), the 1911 edition includes over **29,000 words** classified into **1000 semantic categories** (ignoring several levels of subcategories).

Roget's thesaurus can be viewed as a bipartite graph, a graph in which there are two kind of nodes, *word nodes* and *semantic category* nodes, with connections allowed only between two nodes of different kinds.

In this graph, a *connection* is made between a **word** and **category** node when the word falls into the semantic category.

Top level classes

2nd level classes

Class.	Sect.	Nos.
I. ABSTRACT RELATIONS	1. EXISTENCE,	1-8
	2. RELATION,	9-24
	3. QUANTITY,	25-57
	4. ORDER,	58-83
	5. NUMBER,	84-105
	6. TIME,	106-139
	7. CHANGE,	140-152
	8. CAUSATION,	153-179
II. SPACE,	1. GENERALLY,	180-191
	2. DIMENSIONS,	192-239
	3. FORM,	240-263
	4. MOTION,	264-315
III. MATTER,	1. GENERALLY,	316-320
	2. INORGANIC,	321-356
	3. ORGANIC,	357-449
IV. INTELLECT,	1. FORMATION OF IDEAS,	450-515
	2. COMMUNICATION OF IDEAS,	516-599
V. VOLITION,	1. INDIVIDUAL,	600-736
	2. INTERSOCIAL,	737-819
VI. AFFECTIONS,	1. GENERALLY,	820-826
	2. PERSONAL,	827-887
	3. SYMPATHETIC,	888-921
	4. MORAL,	922-975
	5. RELIGIOUS,	976-1000

Structure
of the
index

CLASS I.

WORDS EXPRESSING ABSTRACT RELATIONS.

SECTION I. EXISTENCE.

1. BEING, IN THE ABSTRACT.

1 **EXISTENCE**, being, entity, subsistence: — coexistence, *see* 120.

Reality, actuality, positiveness, absoluteness, fact, matter of fact; *see* Truth, 494.

Science of existence, Ontology. Existence in space; *see* 186.

V. To be, to exist, have being, subsist, live, breathe, stand, obtain, occur.

To consist in, lie in.

To come into existence, 141, to arise, come out, come forth, appear, 448.

To bring into existence; 161.

Adj. Existing, being, subsisting, in being, in existence, ex-

2. **INEXISTENCE**, non-existence, nonentity, no such thing, negativeness; vacuity, 4.

Annihilation, abeyance, extinction, *see* Destruction, 162, and Disappearance, 449.

V. Not to be, not to exist, &c., to have no existence.

To cease to be, pass away, vanish, fade, dissolve, melt away, perish, disappear, 449, to be annihilated, extinct, &c., to be no more, to die, 360.

Adj. Inexistent, non-existent, non-existing, (that which does not exist, has no existence, or is without existence,) &c., negative, blank.

Ontology

* The heavy figures indicate the articles to which the figures in the index refer.

Problem

You will find the term 'ontology' only iff you know that it is grouped under the label science of being, but you will not find it via 'hierarchy', 'order' or 'classification'.

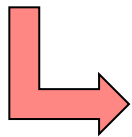
Other problems

- 1. Metalanguage** : not very intuitive
Under what label to find the target word ?
- 2. Grouping** not always very consistent;
- 3.** Not **corpus** based;
- 4.** No provision for accessing terms via **association** :
 - elephant-memory;
 - monkey-banana;
 - dog-bone
- 5.** Hierarchy fairly **flat** and the lists very **long** (insufficient clustering)

Possible solution to the word access problem

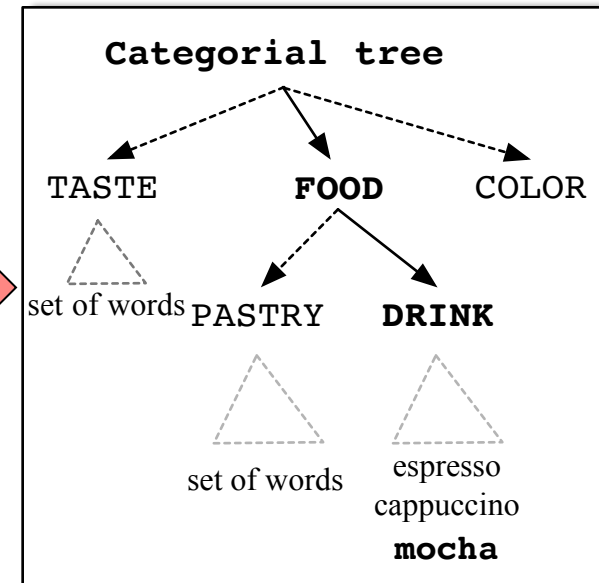
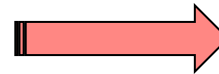
Use *categories* or *relational* information like the ones found in **WordNet** or **Roget's Thesaurus**, but, no doubt, we need many more.

Input : coffee
Target: mocha



TEA 39 0.39	BISCUITS 1 0.01
CUP 7 0.07	BITTER 1 0.01
BLACK 5 0.05	DARK 1 0.01
BREAK 4 0.04	DESERT 1 0.01
ESPRESSO 40.0.4	DRINK 1 0.01
POT 3 0.03	FRENCH 1 0.01
CREAM 2 0.02	GROUND 1 0.01
HOUSE 2 0.02	INSTANT 1 0.01
MILK 2 0.02	MACHINE 1 0.01
CAPPUCINO 20.02	MOCHA 1 0.01
STRONG 2 0.02	MORNING 1 0.01
SUGAR 2 0.02	MUD 1 0.01
TIME 2 0.02	NEGRO 1 0.01
BAR 1 0.01	SMELL 1 0.01
BEAN 1 0.01	TABLE 1 0.01
BEVERAGE 1 0.01	

List of directly associated words
(internal, intermediate result)



Tree for navigation

Some typical links in WordNet

	Type of relation	Description of the relation	prime-target
1	<i>Hypernym</i>	a more general word	pie-pastry
2	<i>Hyponym</i>	a more specific word	fruit-nut
3a	<i>Meronym_substance</i>	a concept being a substance of another concept	blood-body
3b	<i>Meronym_part_of</i>	a concept being part of another concept	ship-fleet
3c	<i>Meronym_member_of</i>	a concept being a member of another concept	kid-family
4a	<i>Holonym_substance</i>	a concept having another concept as substance	sea-salt
4b	<i>Holonym_part_of</i>	a concept having another concept as part	tree-leave
4c	<i>Holonym_member_of</i>	a concept having another concept as member	team-player
5	<i>Cause to</i>	a verb expressing the cause of a result	kill-die
6	<i>Entailment</i>	a verb expressing an unavoidable result	buy-have

Some other links

	Type of relation	Description of the relation	prime-target
7	<i>Troponym</i>	a specific way to perform an action	drink-sip
8	<i>Part_of_meaning</i>	part of the target word's definition	butter - milk
9	<i>Quality</i>	typical quality, or inherent feature	snow - cold
10	<i>Co-occurrence</i>	two concepts occurring frequently together	blue - sky
11	<i>Topically related</i>	two concepts related by topic	sea - tide
12	<i>Used_for</i>	instrumentally related words	fork - eating
13	<i>Made_of</i>	substance or element used to make <object>	glass - sand

Some other links

	Type of relation	Description of the relation	prime-target
14	<i>Free association</i>	any kind of link between two words (often hard to name, i.e. make explicit)	door - open
15	<i>Synonym</i>	word expressing basically the same meaning	cup-mug
16	<i>Antonym</i>	<i>a word meaning the opposite</i>	dry-wet
17	<i>Sound (rhyme)</i>	two similar sounding words	bad - mad/sad
18	<i>Homophones</i>	words sounding alike, but spelled differently	right - write
19	<i>Anagrams</i>	composed of same or similar components	cheater - teacher

Summary and conclusion

Since **Semantic networks** (SNs) or **knowledge graphs** come in many forms we could mention here only some of them. Obviously, there are many more.

While these tools have great potential for supporting (not only machines, but also) human users in their quest of processing data (ideas and language), they are not the brain, eventhough they may look like it (or an externalized version of it). If you don't trust me, ask the neuroscientists or take a look at their work.

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Good discussions

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- ▶ Harley, T. A. (2013). *The psychology of language: From data to theory*. Psychology press.

Some useful stuff in French

- ▶ Denhière, G. (1975). *Mémoire sémantique, conceptuelle ou lexicale ?* Langages, n° 40, 41-73 (good discussion concerning the work done in psychology, but in French)
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- ▶ Lieury, A. (2005). *Psychologie de la mémoire: histoire, théories, expériences*. Dunod.

Some relevant links for classification

Work in the past

- ▶ [http://www.wikiwand.com/en/Categories_\(Aristotle\)](http://www.wikiwand.com/en/Categories_(Aristotle))
- ▶ http://www.wikiwand.com/en/Porphyrion_tree
- ▶ http://www.wikiwand.com/en/Ramon_Llull
- ▶ http://www.wikiwand.com/en/De_Arte_Combinatoria
- ▶ http://www.wikiwand.com/en/Alphabet_of_human_thought
- ▶ http://www.wikiwand.com/en/Universal_language
- ▶ http://www.wikiwand.com/en/An_Essay_towards_a_Real_Character_and_a_Philosophical_Language
- ▶ <http://www.wikiwand.com/en/Thesaurus>
- ▶ http://www.wikiwand.com/en/Peter_Mark_Roget

More recent work

- ▶ http://www.wikiwand.com/en/Mind_map
- ▶ http://www.wikiwand.com/en/Concept_map
- ▶ http://www.wikiwand.com/en/Topic_Maps

Conceptual editing

Mindmaps

- ▶ Buzan, T., and Buzan, B. (1996). *The Mind Map Book: How to Use Radiant Thinking to Maximize Your Brain's Untapped Potential*.
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- ▶ Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn*. Cambridge University Press.
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- ▶ Hallett, C., Scott, D., & Power, R. (2007). *Composing questions through conceptual authoring*. *Computational Linguistics*, 33(1), 105-133.
- ▶ Tennant, H. R., Ross, K. M., Saenz, R. M., Thompson, C. W., and Miller, J. R. (1983). *Menu-based natural language understanding*. In Proceedings of the 21st annual meeting on Association for Computational Linguistics (pp. 151-158).
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Composition and discourse planning

State of the art in automatic text production

- ▶ Andriessen J., deSmedt K. and Zock, M. (1996) *Discourse Planning: Empirical Research and Computer Models*. In T. Dijkstra & K. de Smedt (Eds). *ComputationalPsycholinguistics: AI and Connectionist Models of Human Language processing*, Taylor & Francis, London, pp. 247-278
- ▶ Bateman J and M. Zock. (2017) *Natural Language Generation*. In R. Mitkov (Ed.) *Handbook of Computational Linguistics* (2nd edition), Oxford University Press.

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Thanks a lot

MERCI POUR
VOTRE
ATTENTION!



PARCE QUE TOUT
LE MONDE PEUT
SE TROMPER!

