The Emergentist Approach To Language

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The Standard Approach: Units and Rules

• Sentences • Clauses and phrases • Words • Morphemes • Phonemes • Phonological features	• S -> NP VP • V + {past} -> V+ed

Sentences and Past Tenses

- The boy kicks the ball.
- The baby is sleeping.
- The wind toppled the tree.

- like-liked
- love-loved
- hate-hated

Some possible sentences

- ‘It is cold.’
- ‘It is very cold.’
- ‘It is very very cold.’
- ‘It is very very very cold.’

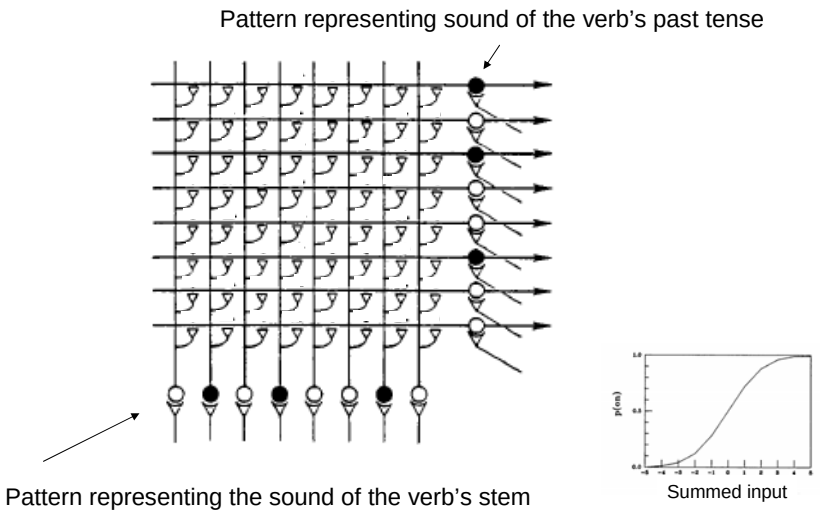
The Emergentist Approach

- Language arises from the interactions of simple processing units that operate according to simple principles of processing, representation and learning.
- Units and rules are useful to *approximately describe* what emerges from these interactions but have no mechanistic or explanatory role in language processing, language change, or language learning.

An Emergentist Theory: Natural Selection

- No grand design.
- Forces of nature select those best prepared to survive.
- Survivors leave more offspring.
- The full range of the animal kingdom including all the capabilities of the human mind emerge from these very basic principles.

A Pattern Associator Network

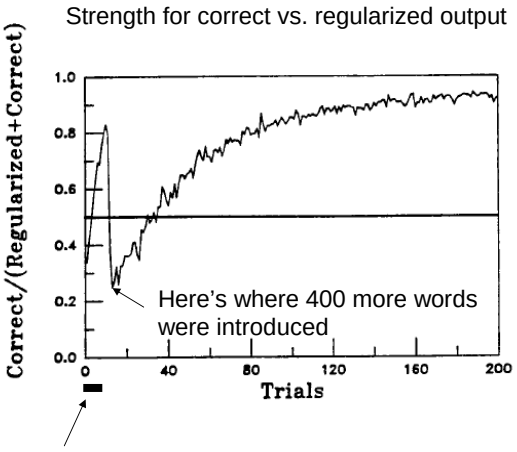


Learning rule for the Pattern Associator network

- For each output unit:
  - Determine activity of the unit based on its input.
  - If the unit is inactive when the target is active:
    - Increase the weight coming into the unit from each active input unit.
  - If the unit is active when target is not:
    - Reduce each weight coming into the unit from each active input unit.

Ten most frequent past tenses in English

- Felt
- Had
- Made
- Got
- Gave
- Took
- Came
- Went
- Looked
- Needed



Some features of the model

- Regulars co-exist with exceptions.
- The model produces the regular past for most unfamiliar test items.
- The model captures the different subtypes among the regulars:
  - like-liked
  - love-loved
  - hate-hated
- The model is sensitive to the no-change pattern among irregulars:
  - hit-hit
  - cut-cut
  - hide-hid

REGULAR AND NO CHANGE RESPONSES TO *t/d* AND OTHER VERBS
(Data from Bybee & Slobin, 1982)

Verb Ending	Regular Suffix	No Change
Not *t/d*	203	34
t/d	42	157

Additional characteristics

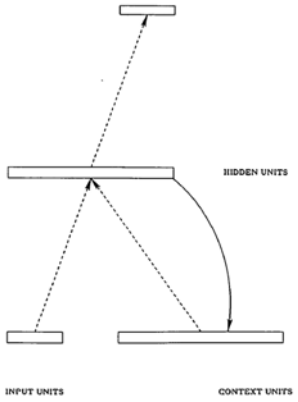
- The model exploits gangs of related exceptions.
  - dig-dug
  - cling-clung
  - swing-swung
- The ‘regular pattern’ infuses exceptions as well as regulars:
  - say-said, do-did
  - have-had
  - keep-kept, sleep-slept
  - Burn-burnt
  - Teach-taught

Key features of the Past Tense model

- No lexical entries and no rules
- No problem of rule selection

Elman's Simple Recurrent Network

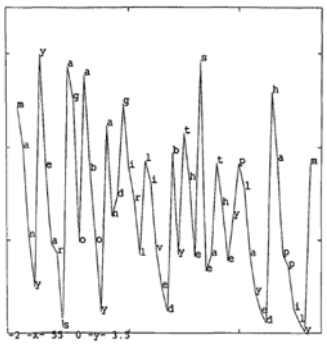
- Task is to predict the next element of a sequence on the output, given the current element on the input units.
- Each element is represented by a pattern of activation.
- Each box represents a set of units.
- Each dotted arrow represents all-to-all connections.
- The solid arrow indicates that the previous pattern on the hidden units is copied back to provide context for the next prediction.
- Learning occurs through connection weight adjustment using an extended version of the error correcting learning rule.



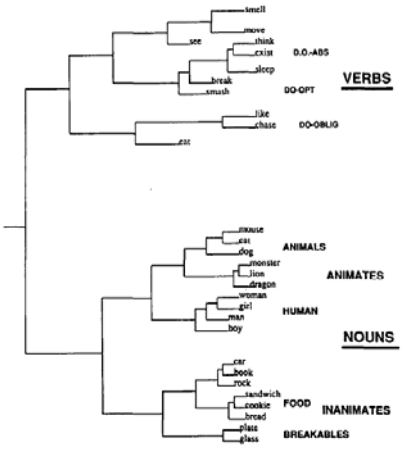
Results for Elman net trained with letter sequences

TABLE 2
Fragment of Training Sequence for Letters-in-Words Simulation

Input		Output	
01101	(*m*)	00001	(*a*)
00001	(*a*)	01110	(*n*)
01110	(*n*)	11001	(*y*)
11001	(*y*)	11001	(*y*)
11001	(*y*)	00101	(*e*)
00101	(*e*)	00001	(*a*)
00001	(*a*)	10010	(*r*)
10010	(*r*)	10011	(*s*)
10011	(*s*)	00001	(*a*)
00001	(*a*)	00111	(*g*)
00111	(*g*)	01111	(*o*)
01111	(*o*)	00001	(*a*)
00001	(*a*)	00010	(*b*)
00010	(*b*)	01111	(*o*)
01111	(*o*)	11001	(*y*)
11001	(*y*)	00001	(*a*)
00001	(*a*)	01110	(*n*)
01110	(*n*)	00100	(*d*)
00100	(*d*)	00111	(*g*)
00111	(*g*)	01001	(*i*)
01001	(*i*)	10010	(*r*)
10010	(*r*)	01100	(*l*)
01100	(*l*)	01100	(*i*)
11001	(*i*)		



Hidden Unit Patterns for Elman Net Trained on Word Sequences



Some whole and partial sentences

- The dog likes ice cream.
- The boys who chased the dog like ice cream.
- He hit the ball out of the …
- The wheezing old man looked like he was about to kick the …

Key Features of the Both Models

- No lexical entries and no rules
- No problem of rule selection