Connectionist Models of Situated Language Processing
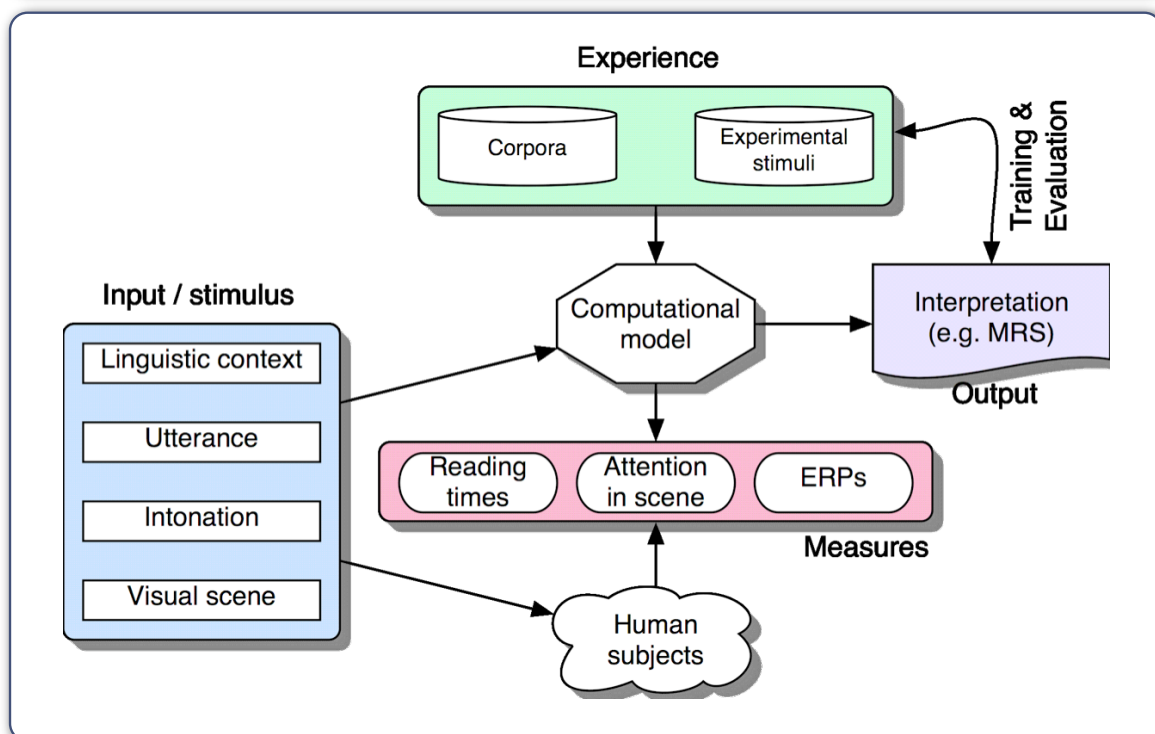## Lecture 10 (part II)
Introduction to Psycholinguistics

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Adaptive models of language

Why use SRNs?

Goals of model behavior:

- Incremental interpretation

- Anticipation of role fillers

- Influence of scene events

- Processing without the scene

- Resolution of multiple/conflicting constraints

- Relative importance of the scene

Adaptation to, and seemless integration of, multiple information sources.

Connectionist models
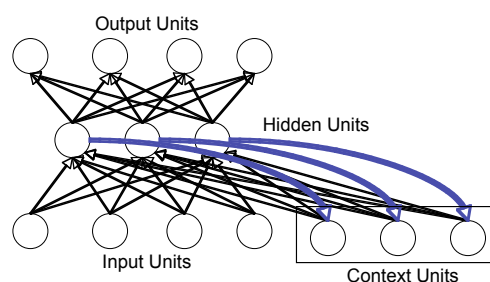
Purely connectionist models: Simple Recurrent Networks

- Learn based on experience

  - Supervised: trained to output a meaning representation

  - Unsupervised: trained to predict the next word

- Good a learning a range of linguistic constraints, and integrating multiple information sources
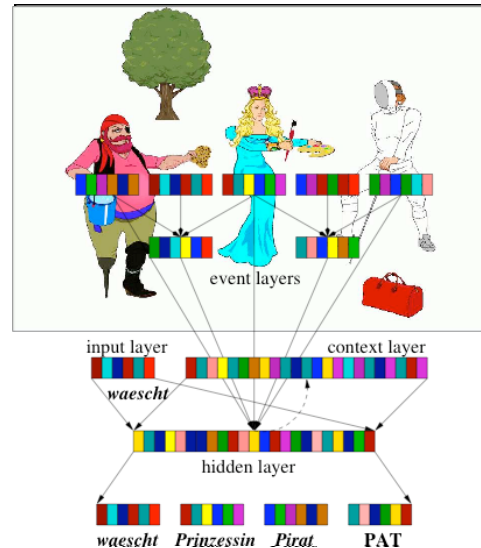
Network Architecture

Simple Recurrent Network trained with BPTT

- Enhanced with encoding of scene

Entities: (characters)

Events: (agent-action-patient)

Simulation 1

One network to model four experiments simultaneously

Exp 1a & 1b: Linguistic and Stored knowledge

- No event information available

- 32 verbs, 48 nouns

- 96 extra nouns (avoid overfitting)

Exp 3a & 3b: Depicted actions

- Depicted events encoded

- 48 verbs, 72 nouns

- Extra unambiguous sentences

Training

Training data

- Generated from experimental materials as templates

- All combinations of referents

Test data

- Actual experimental sentences are held out

- All test sentences have matching scene

Training Regime

- Trained on final interpretation

- Scene provided as context 50% of time

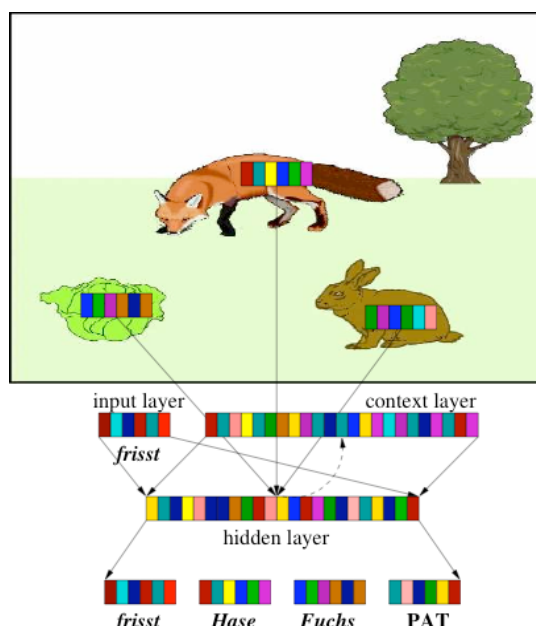 - reflect experience, and adaption to availability of scene

Den Hasen frisst gleich der Fuchs

⇒ Fox-like Agent

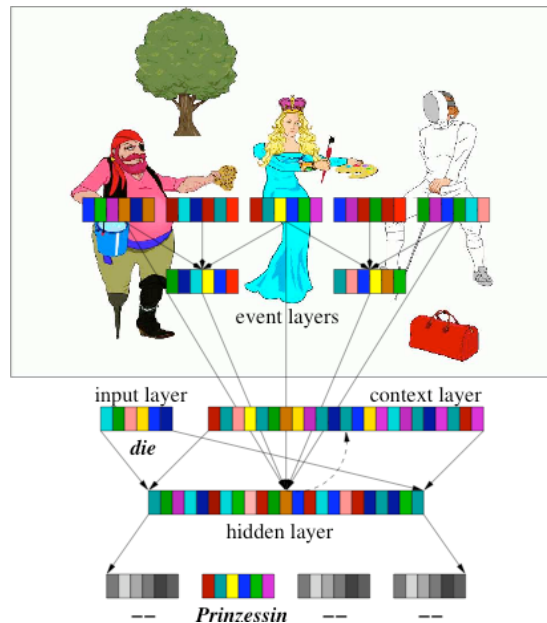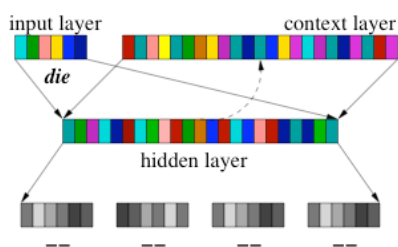anticipated based on <u>experience</u> and <u>stereotypicality</u>

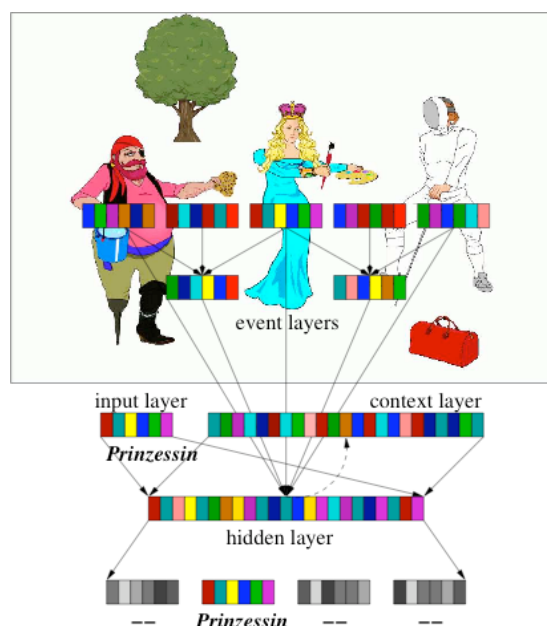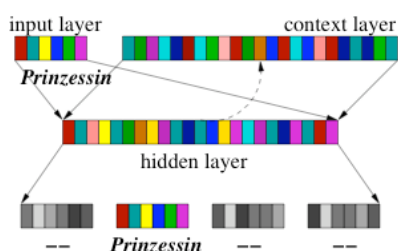⇒ Fox Agent

anticipated based on <u>experience</u> and <u>scene</u>

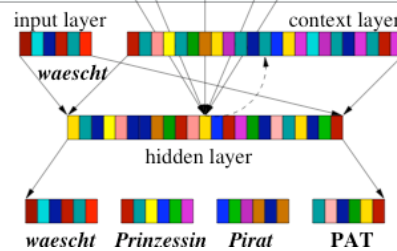# die *Prinzessin waescht der Pirat*

⇒ Princess

anticipated because it is the only feminine object depicted

die *Prinzessin waescht der Pirat*

die Prinzessin *waescht* der Pirat

⇒ Processing of

washes
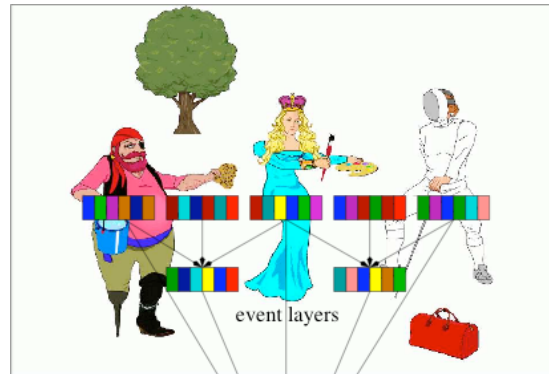enables recovery of all
event information
from depicted event
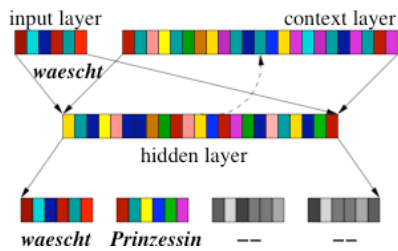
die Prinzessin waescht *der* Pirat

⇓ Processing of
nominative article *der*
establishes role of
Princess as Patient
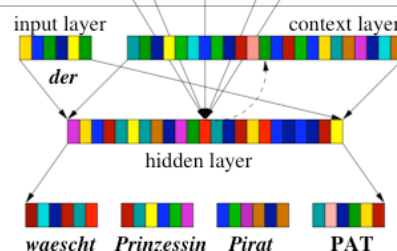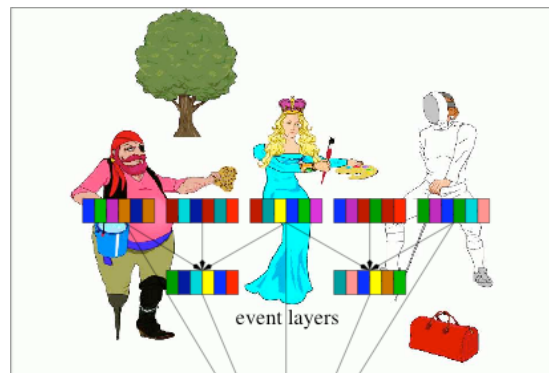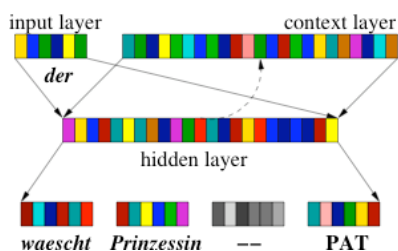
die Prinzessin waescht der Pirat

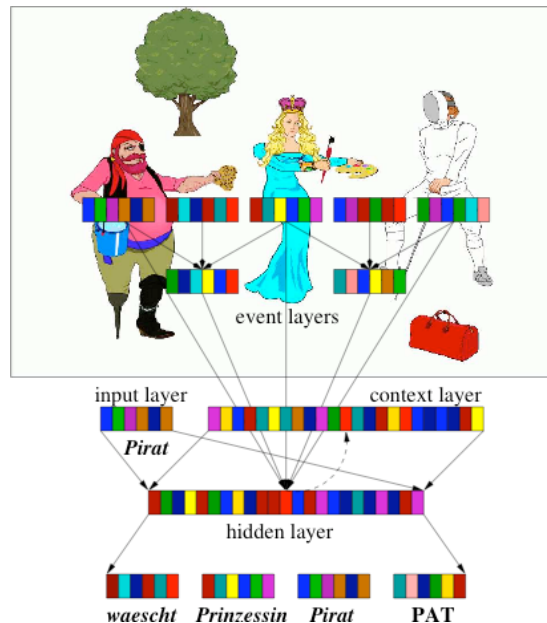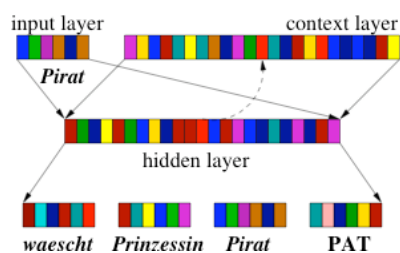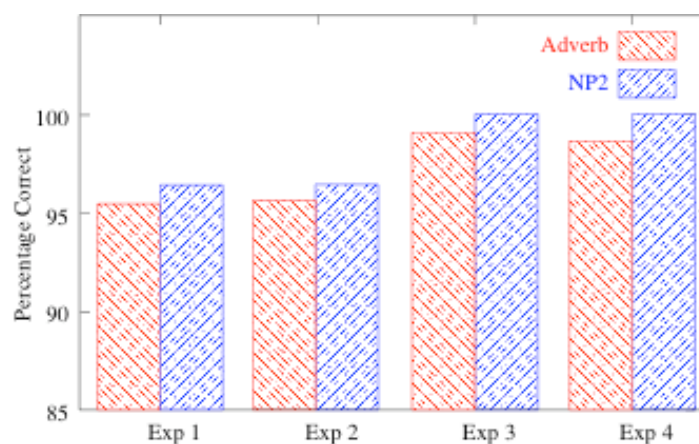# Simulation 1: Performance

Over 95% accuracy on verb (anticipation) and NP2
- Exp 1 & 2: stored knowledge; no depicted events
- Exp 3 & 4: depicted events; no stored knowledge

A Connectionist Model of Scene & Sentence

Trained to model materials from 5 visual world studies

- SRN + Scene

Successfully models the use of:

- experience
- immediate scene
- sentence alone
- priority of the scene

Exhibits anticipatory behaviour
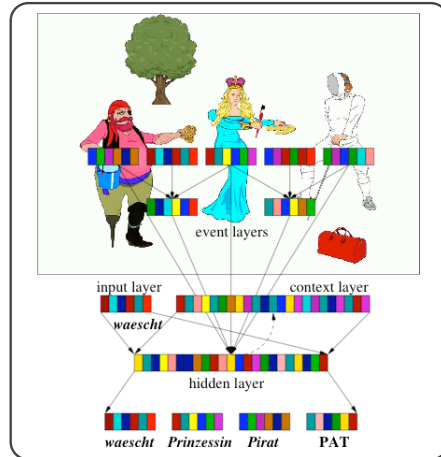
> What about modeling attention in the scene?

event layers

input layer   context layer

waescht

hidden layer

waescht   Prinzessin   Pirat   PAT

Coordinated Interplay Account

Utterance

Incremental Interpretation:
- Prosodic, lexical, syntactic, semantic constraints

Forward Inferencing:
- <u>knowledge-driven</u> expectations
- <u>scene-driven</u> by events and affordances

> Priority of scene events over stored knowledge

Coordinated Interplay Account

Attention

Referential:
- rapid (180ms) looks to depicted <u>noun</u> and <u>verb</u> referents
- parallel lexical access

Anticipatory:
- looks to object likely to be mentioned based on <u>scene</u> or <u>knowledge</u>

> Priority of anticipatory over lexical identification

Visual Scene

Referential Context:
- objects in the scene

Scene events:
- depicted actions and participants

Affordances:
- events and relationships supported by the scene

Revised Architecture

Flatter representation of scenes/events

- Objects and events input directly to the hidden layer

Attentional Mechanism:

- Gating units mask the scene inputs

- Bind arguments and events

Predicting Human Behavior

Model use of knowledge, events and scene priority.

- Single corpus covers two experiments
  - 16 verbs and 16 nouns
  - 7008 unique input sentences
  - Scenes feature 3840 unique events yielding
  - ~250,000 joint events obeying above constraints
- Network never trained on conflict conditions of Exp 5
- 50/50: SVO/OVS, Scene/NoScene
- Depicted:stereotypical ratio is 4:1

Use of Stored Knowledge

Depict: *Den Piloten <u>verköstigt</u> gleich **der Detektiv***
"The pilot <u>serves</u> soon the detective"
Typical: *Den Piloten <u>verzaubert</u> gleich **der Zauberer***
"The pilot <u>jinxes</u> soon the magician"

msk.tcl

| STEP | CLEAR | ZAPWIN | BACK | QUIT | gram4 |

| P0 | P1 | P2 | | P3 | P4 | P5 |
| Detektiv | verkoestigt | Pilot | | Zauberer | bespitzelt | Pilot |

Inp
Zauberer

| verzaubert | Pilot | Zauberer | PAT | |

| den | Pilot | verzaubert | gleich | der | Zauberer | |

| Snapshot | Epoch | Sent | Word |
| z18222.wgts008650 | 0 | 0 | 6 |

Use of Scene Knowledge

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| Detektiv | verkoestigt | Pilot | | Zauberer | bespitzelt | Pilot |

Inp
Detektiv

| verkoestigt | Pilot | Detektiv | PAT | |

| den | Pilot | verkoestigt | gleich | der | Detektiv | |

| Snapshot | Epoch | Sent | Word |
| z18222.wgts008650 | 0 | 3 | 6 |

Priority of the Scene over Knowledge

Typical: *Den Piloten <u>bespitzelt</u> gleich **der Detektiv***
"The pilot spies on soon the magician"
Depict: *Den Piloten <u>bespitzelt</u> gleich **der Zauberer***
"The pilot spies on soon the magician"