Towards General AI: What we can learn from Human Learning

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Child Language as a case study

Study one of the earliest cognitively intense tasks that young children quickly master
Longitudinal Data:

Experimental psychology lab collected longitudinal data
Followed a specific child for 12 consecutive months.
114 children with longitudinal CDIs.
Around 40000 learning examples
Network Growth modeling

Embed cognitive theory into network growth algorithms

Algorithmic assumptions formalize cognitive, learning and attentional mechanisms
Edges: Predefined relationship between words. Here, free associations.
Age 18mo
Intelligent and Invisible Computing

Age 22mo
Model A: Preferential Attachment

**Attractor model** on subset of known words.

**Known words** with a high number of edges are attractors.

Unknown words are learned if they attach to **highly connected words**.

Subset of **known words** *(the child’s current vocabulary knowledge)* plays largest role in acquisition.

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Model B: Preferential Acquisition

**Attractor model** on subset of unknown words.

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Unknown words are learned if they are highly connected in the **learning environment**.

**Independent** of the words a child knows; **language environment** drives learning.

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Experimental setup: Predicting acquisition trajectories

Is semantic relationships or phonological relationships more important to early language acquisition?

- Compare predictive accuracy assuming free association norms
- Or phonological similarity network.

Run network growth model assuming each of the growth processes.

- Preferential Attachment (current vocabulary knowledge)
- Preferential Acquisition (structure of the language environment)

Predict the words to be learned next.

Performance informs our understanding of acquisition
Results: Predictive modeling

Best fitting model for **semantics** is **preferential acquisition**.

Best fitting model for **phonology** is **preferential attachment**.
The dominant mechanism for **semantic** learning is connectivity in the **learning environment**.

The dominant mechanism for **phonological learning** is connectivity of **known vocabulary** words.
Moving beyond incremental insights into robust learning.

We can study learning in young children.

But this is very challenging and requires complex models.

How can we use our understanding of human intelligence to build robust cognitive systems?
Cognitive Architectures: ICARUS

Characteristics:
- Long and short term memories
- Concepts, problems, and goals
- Hierarchical knowledge structure
- Goal reasoning (goal driven but reactive)
ICARUS operation

Operates in cycles

1) Receive sensory input
2) Infer beliefs about current situation
3) Nominates top-level goals relevant to current situation
4) Evaluates skills to achieve the top-level goals
5) If a skill ‘path’ exists, execute the implied actions
6) Otherwise, invoke problem solver
Intelligent and Invisible Computing

Long-term Conceptual Memory → Inference → Belief Memory → Perception

Goal Memory → Skill Retrieval → Environment

Skill Learning → Short-term Goal Memory → Motor Buffer → Execution

Perceptual Buffer → Goal Reasoning
The future of AI

Integration of cognitive science and computer science
Models of AI requires expert knowledge of **humans**
Execution of AI requires expert knowledge of **computation**

Use insights of human acquisition, to extend ICARUS
Exploration **robust learning** and generalization
Development within **Malmo** platform
Thanks!

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AlphaGo: a computer program so close to human intelligence it's far from artificial

As Lee Se-dol, the Go world champion, prepares to face Google DeepMind’s computer program AlphaGo, in a five game match starting Wednesday, his chances look slim. AlphaGo is almost human.

After AlphaGo, what's next for AI?

Deep learning will help us do more than play games
AlphaGo marks stark difference between AI and human intelligence

Google's robot relied on processing power and data storage, writes Daniel Susskind

AlphaGo: beating humans is one thing but to really succeed AI must work with them

Google DeepMind's success is significant, but artificial intelligence practitioners must teach the public there's more to AI than trying to replace them

“Could AI learn to play a team eSports like League of Legends, understanding co-operation and team communication with humans?” Photograph: Ritograppa/Cotton

Microsoft Research Asia
Faculty Summit 2016
Intelligent and Invisible Computing
Focus on predicting words learned next

What are the cognitive mechanisms and developmental processes that support future language learning?

Can we construct computational models that predict learning of *individual words* for individual learners?
Skill evaluation

top-level goals

skill hierarchy

direct actions

Belief inference

higher-level (non-primitive) concepts

primitive concepts

sensory input
ICARUS: recent extensions

Numeric processing
- Ability to perform numeric calculations in concepts and skills
- Ability to plan with numeric effects

Compositional beliefs
- Can create new objects with numeric attributes

Percepts-beliefs unification
- Unified memory for sensory input and beliefs

Episodic memory
- New memory and processing module for storing and retrieving previous events
General Artificial Intelligence?