

# How **AI** UNDERSTANDS LANGUAGE

 Follow @cocoweixu

Wei Xu

Department of Computer Science and Engineering



THE OHIO STATE UNIVERSITY

# THE TURING TEST

VOL. LIX. No. 236.]

[October, 1950]

MIND  
A QUARTERLY REVIEW  
OF  
PSYCHOLOGY AND PHILOSOPHY

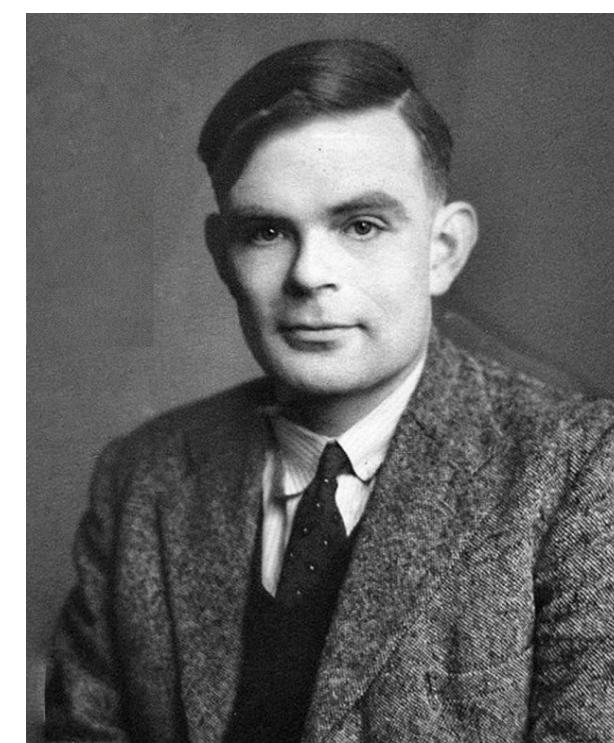
---

I.—COMPUTING MACHINERY AND  
INTELLIGENCE

By A. M. TURING

1. *The Imitation Game.*

I PROPOSE to consider the question, ‘Can machines think ?’ This should begin with definitions of the meaning of the terms ‘machine’ and ‘think’. The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. If the meaning of the words ‘machine’ and ‘think’ are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, ‘Can machines think ?’ is to be sought in a statistical survey such as a Gallup poll. But this is absurd. Instead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words.



Alan Turing (1912-1954) mathematician, world-class Marathon runner, forced to chemical castration for homosexuality conviction.

# THE TURING TEST

VOL. LIX. No. 236.]

[October, 1950]

‘Can machines think?’

MIND  
A QUARTERLY REVIEW  
OF  
PSYCHOLOGY AND PHILOSOPHY

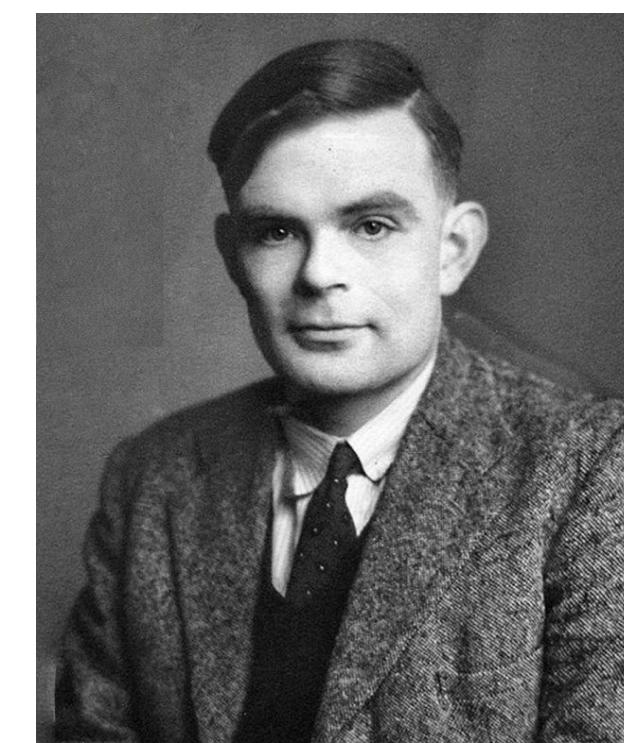
---

I.—COMPUTING MACHINERY AND  
INTELLIGENCE

By A. M. TURING

1. *The Imitation Game.*

I PROPOSE to consider the question, ‘Can machines think?’ This should begin with definitions of the meaning of the terms ‘machine’ and ‘think’. The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. If the meaning of the words ‘machine’ and ‘think’ are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, ‘Can machines think?’ is to be sought in a statistical survey such as a Gallup poll. But this is absurd. Instead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words.



Alan Turing (1912-1954) mathematician, world-class Marathon runner, forced to chemical castration for homosexuality conviction.

# THE TURING TEST

VOL. LIX. No. 236.]

[October, 1950]

‘Can machines think?’

M I N D  
A QUARTERLY REVIEW  
OF  
PSYCHOLOGY AND PHILOSOPHY

---

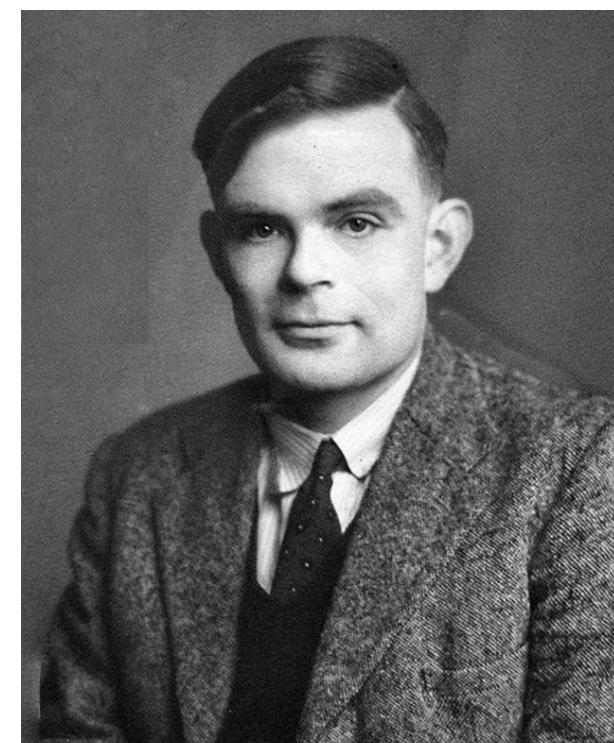
I.—COMPUTING MACHINERY AND  
INTELLIGENCE

By A. M. TURING

1. *The Imitation Game.*

I PROPOSE to consider the question, ‘Can machines think?’ This should begin with definitions of the meaning of the terms ‘machine’ and ‘think’. The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. If the meaning of the words ‘machine’ and ‘think’ are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, ‘Can machines think?’ is to be sought in a statistical survey such as a Gallup poll. But this is absurd. Instead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words.

I shall replace the question by another,



Alan Turing (1912-1954) mathematician, world-class Marathon runner, forced to chemical castration for homosexuality conviction.

# THE TURING TEST

VOL. LIX. No. 236.]

[October, 1950]

‘Can machines think?’

M I N D  
A QUARTERLY REVIEW  
OF  
PSYCHOLOGY AND PHILOSOPHY

---

I.—COMPUTING MACHINERY AND  
INTELLIGENCE

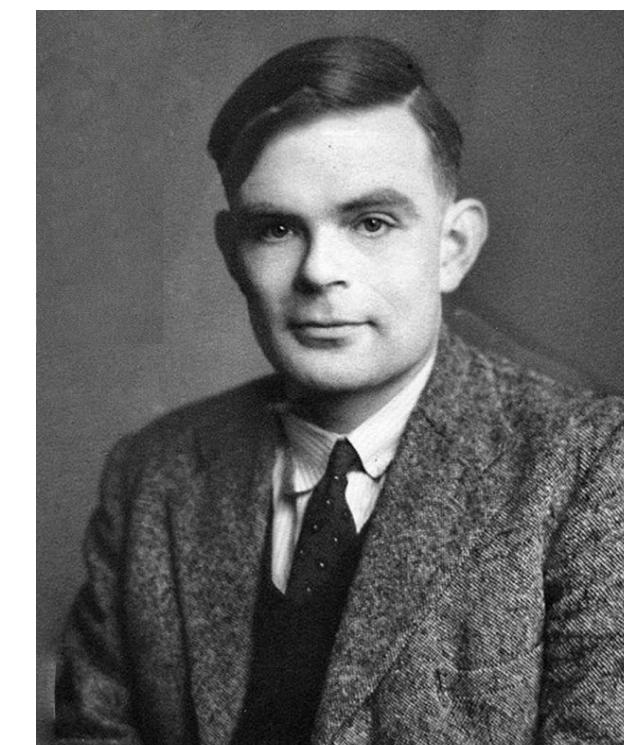
By A. M. TURING

1. *The Imitation Game.*

I PROPOSE to consider the question, ‘Can machines think?’ This should begin with definitions of the meaning of the terms ‘machine’ and ‘think’. The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. If the meaning of the words ‘machine’ and ‘think’ are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, ‘Can machines think?’ is to be sought in a statistical survey such as a Gallup poll. But this is absurd. Instead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words.

I shall replace the question by another,

Can machine conduct natural language  
conversations like a human?



Alan Turing (1912-1954) mathematician, world-class Marathon runner, forced to chemical castration for homosexuality conviction.

# HISTORY OF AI

- 1950 - Turing test

# HISTORY OF AI

## The golden years

- 1950 - Turing test
- 1956 - phrase “Artificial Intelligence” coined
- 1958 - Perceptron (a form of neural networks)
- 1966 - ELIZA (first chatterbots)
- 1974

# HISTORY OF AI

## The golden years

1st AI Winter

- 1950 - Turing test
- 1956 - phrase “Artificial Intelligence” coined
- 1958 - Perceptron (a form of neural networks)
- 1966 - ELIZA (first chatterbots)
- 1974

AI was subject to critiques and funding cuts

# HISTORY OF AI

## The golden years

- 1950 - Turing test
- 1956 - phrase “Artificial Intelligence” coined
- 1958 - Perceptron (a form of neural networks)
- 1966 - ELIZA (first chatterbots)
- 1974

## 1st AI Winter

AI was subject to critiques and funding cuts

## Boom

- 1980 - rise of commercial expert systems
- 1986 - Backpropagation (training neural networks)
- 1987

# HISTORY OF AI

## The golden years

- 1950 - Turing test
- 1956 - phrase “Artificial Intelligence” coined
- 1958 - Perceptron (a form of neural networks)
- 1966 - ELIZA (first chatterbots)
- 1974

## 1st AI Winter

AI was subject to critiques and funding cuts

## Boom

- 1980 - rise of commercial expert systems

- 1986 - Backpropagation (training neural networks)

- 1987

## 2nd AI Winter

market collapse for AI hardware

# HISTORY OF AI

## The golden years

- 1950 - Turing test
- 1956 - phrase “Artificial Intelligence” coined
- 1958 - Perceptron (a form of neural networks)
- 1966 - ELIZA (first chatterbots)
- 1974

## 1st AI Winter

AI was subject to critiques and funding cuts

## Boom

- 1980 - rise of commercial expert systems

- 1986 - Backpropagation (training neural networks)

1987

## 2nd AI Winter

market collapse for AI hardware

## Big Data

1993

- 2011 - **IBM** Watson won Jeopardy!

## Data Science

- 2012 - AlexNet (deep neural networks for image recognition)

## Deep Learning

- 2014 - **amazon.com** released Alexa

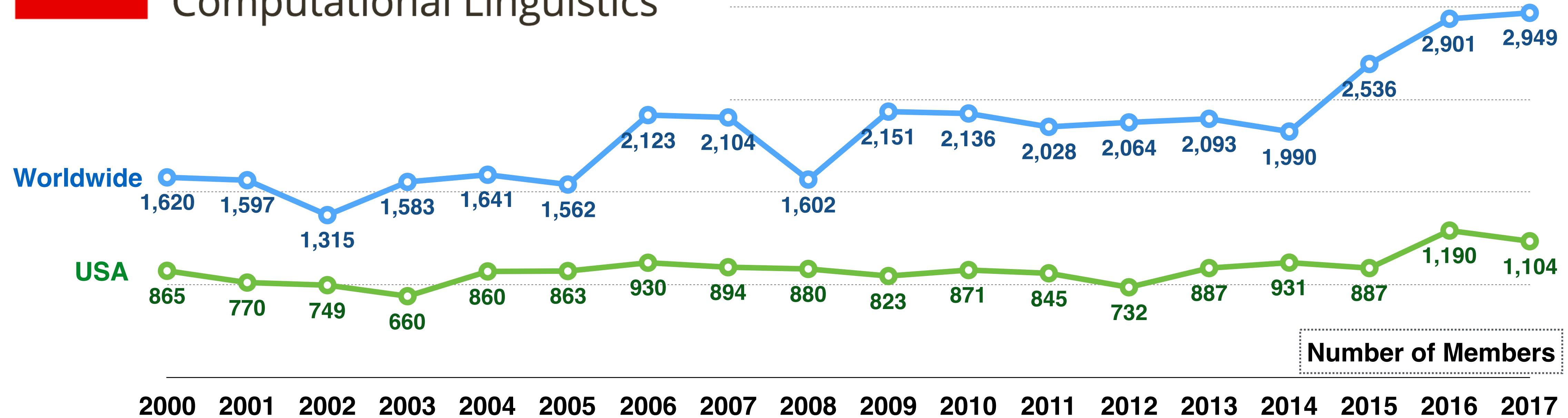
- 2017 - **Google** AlphaGo defeated human go champion

# NATURAL LANGUAGE PROCESSING (NLP)

The goal is to enable computers to understand and generate human language.



Association for  
Computational Linguistics



Number of Members

Human language is **ambiguous**, creative, infinite, and ever evolving.



**Students Cook & Serve Grandparents**

On Thursday, September 9, Gorman School hosted the first annual Grandparent's Day. All Grandparents were invited to a school wide pancake breakfast. Upper grade students served as excellent chefs, as well as taking responsibility for serving the food and the clean up after-

# THE HOLY GRAIL OF AI / NLP

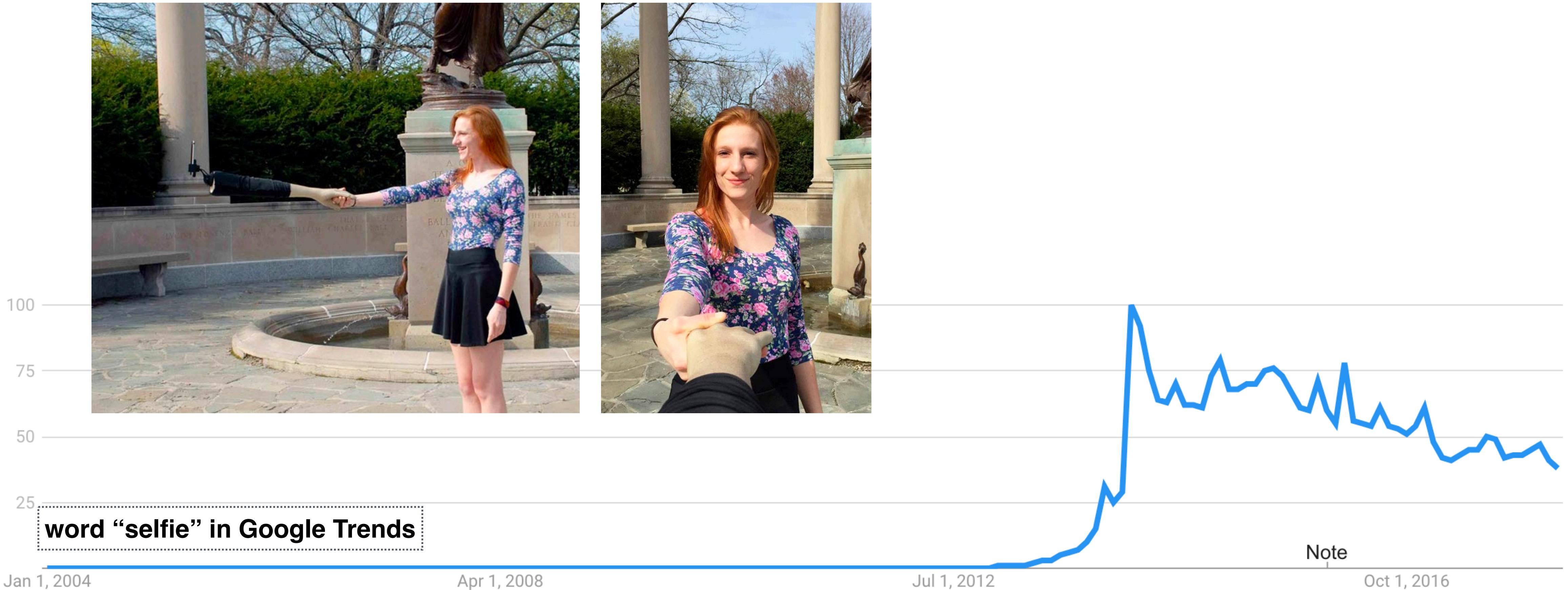
Human language is ambiguous, **creative, infinite**, and ever evolving.

Jeremy Corbyn is a closet Brexiteer. = Mr Corbyn is actually a secret supporter of Brexit.



# THE HOLY GRAIL OF AI / NLP

Human language is ambiguous, creative, infinite, and **ever evolving**.



# THE HOLY GRAIL OF AI / NLP

Human language is ambiguous, creative, infinite, and ever evolving.

**Solution: learning large-scale paraphrases**

# THE HOLY GRAIL OF AI / NLP

Human language is ambiguous, creative, infinite, and ever evolving.

**Solution: learning large-scale paraphrases**

selfie

**word**

photo

Human language is ambiguous, creative, infinite, and ever evolving.

## Solution: learning large-scale paraphrases

selfie      **word**      photo

gets the boot from      **phrase**      has been sacked by

Human language is ambiguous, creative, infinite, and ever evolving.

## Solution: learning large-scale paraphrases

selfie      **word**      photo

gets the boot from      **phrase**      has been sacked by

Jeremy Corbyn is a closet Brexiteer.      **sentence**      Mr Corbyn is actually a secret supporter of Brexit.

# NATURAL LANGUAGE UNDERSTANDING



e.g. Question Answering

Who is the CEO **stepping down** from Boeing?

# NATURAL LANGUAGE UNDERSTANDING



e.g. Question Answering

Who is the CEO **stepping down** from Boeing?



**match**

# NATURAL LANGUAGE UNDERSTANDING



## e.g. Question Answering

Who is the CEO **stepping down** from Boeing?

match

… the forced **resignation** of the CEO  
of Boeing, Harry Stonecipher, for …

# NATURAL LANGUAGE UNDERSTANDING



## e.g. Question Answering

Who is the CEO **stepping down** from Boeing?

match

… the forced **resignation** of the CEO  
of Boeing, Harry Stonecipher, for …

# NATURAL LANGUAGE UNDERSTANDING



## e.g. Question Answering

Who is the CEO **stepping down** from Boeing?

match

… the forced **resignation** of the CEO  
of Boeing, Harry Stonecipher, for …

… after Boeing Co. Chief Executive  
Harry Stonecipher was **ousted** from …

# NATURAL LANGUAGE GENERATION

## e.g. Text Simplification

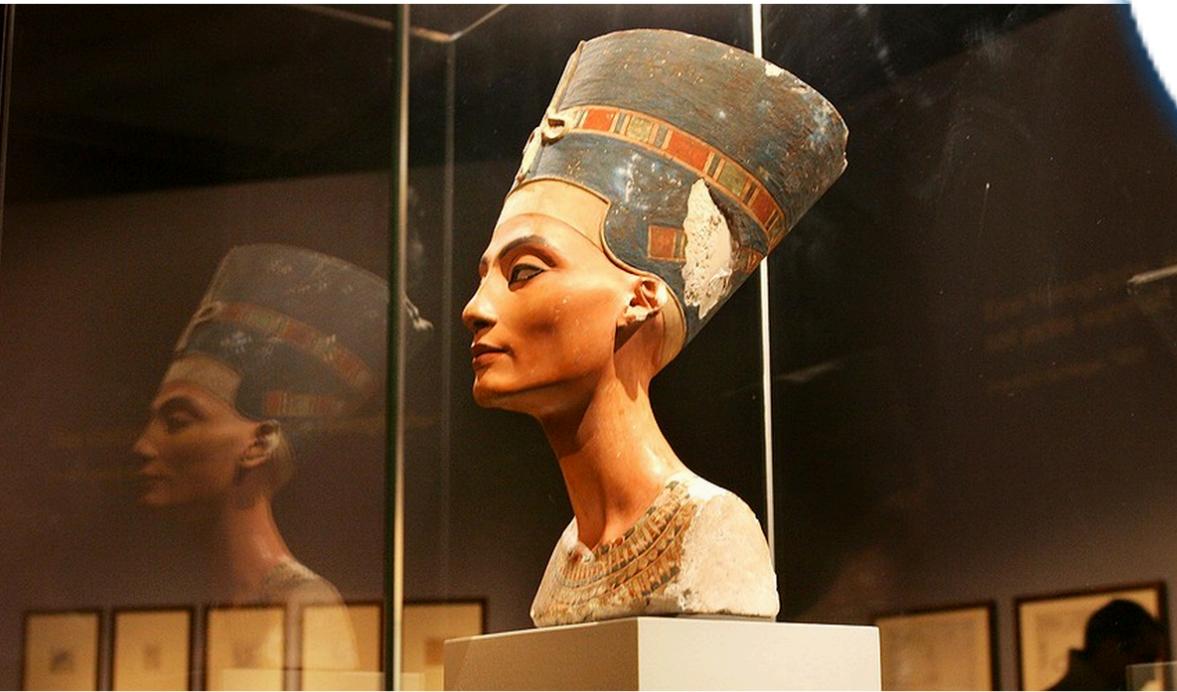
**NEWSela**

WAR & PEACE SCIENCE KIDS MONEY HEALTH

SCIENCE 1738

### Archaeologist may have found remains of ancient Egyptian Queen Nefertiti

By Robert Gebelhoff, Washington Post.  
08.17.15



The 3,330-year-old bust of Nefertiti sits in an exhibition in the Kulturforum in Berlin, Germany, March 1, 2005.  
Photo: AP/Herbert Knosowski

Nefertiti — she's an ancient Egyptian queen and the source of a fantastic mystery regarding the iconic remnants of long-lost royalty.

For decades, archaeologists have speculated on the location of the queen's remains, the last royal mummy missing from the dynasty of the famous King Tutankhamun, better known as King Tut. But now, an archaeologist claims that he has found her

**MAX**  
**1140L**  
960L  
720L  
420L  
 **WRITE**  
 **QUIZ**

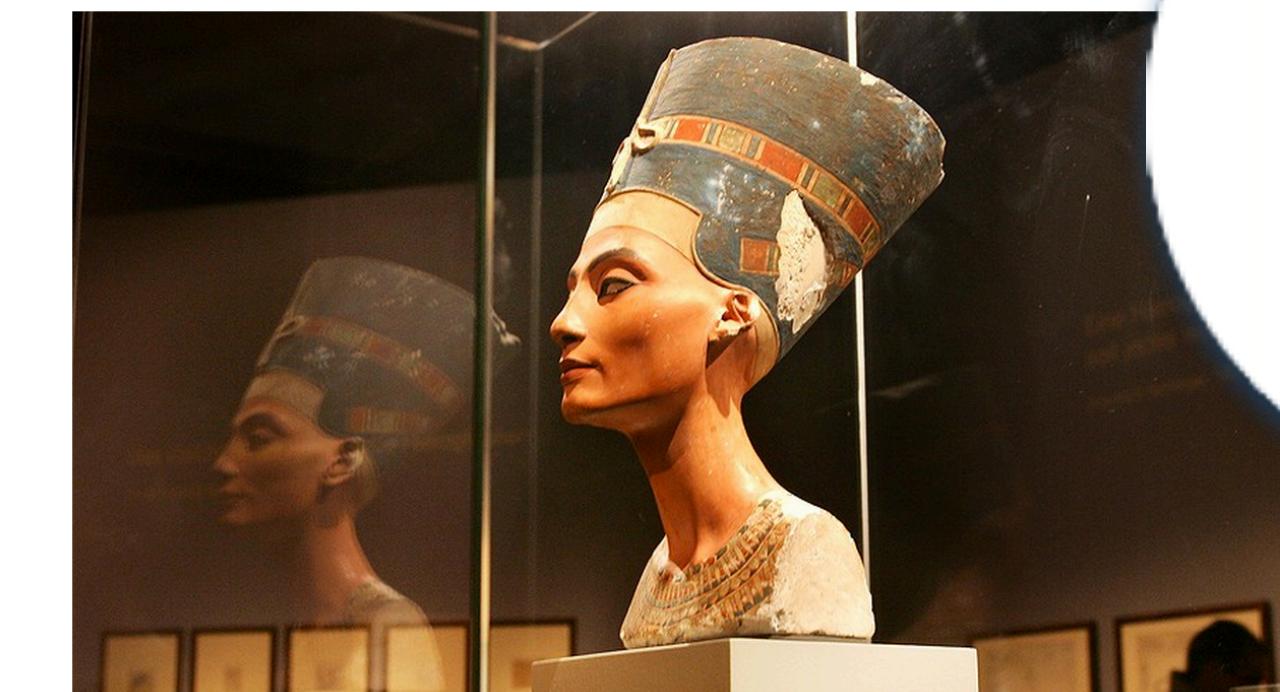
**NEWSela**

WAR & PEACE SCIENCE KIDS MONEY LAW HEALTH

SCIENCE 1738

### Mystery of ancient Egypt solved? Tomb of queen may be hidden near King Tut

By Washington Post, adapted by Newsela staff  
08.17.15



The 3,330-year-old bust of Nefertiti sits in an exhibition in the Kulturforum in Berlin, Germany, March 1, 2005.  
Photo: AP/Herbert Knosowski

The ancient Egyptian Queen Nefertiti has long been at the center of a mystery. For years, archaeologists have wondered where her tomb might be hidden. Nefertiti belonged to the family line of the famous King Tutankhamun, better known as King Tut. Indeed, some believe she was Tut's mother. While the other royals in her line are

**1140L**  
**960L**  
**720L**  
420L  
 **WRITE**  
 **QUIZ**

(adapting machine translation techniques)

# MINING SEMANTIC KNOWLEDGE FROM [BIG DATA]



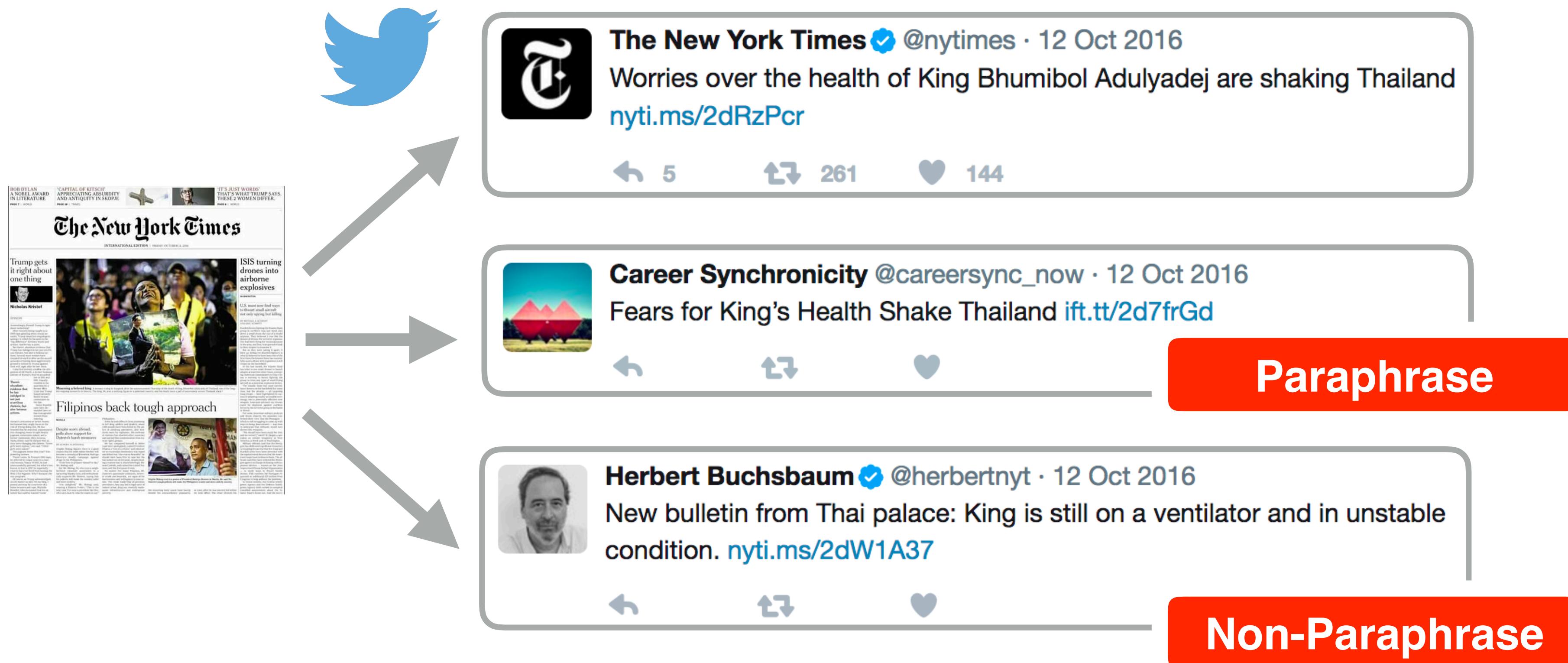
# MINING SEMANTIC KNOWLEDGE FROM [BIG DATA]



# MINING SEMANTIC KNOWLEDGE FROM [BIG DATA]



# MINING SEMANTIC KNOWLEDGE FROM [BIG DATA]



# DESIGNING VARIOUS [MACHINE LEARNING] MODELS

# DESIGNING VARIOUS [MACHINE LEARNING] MODELS

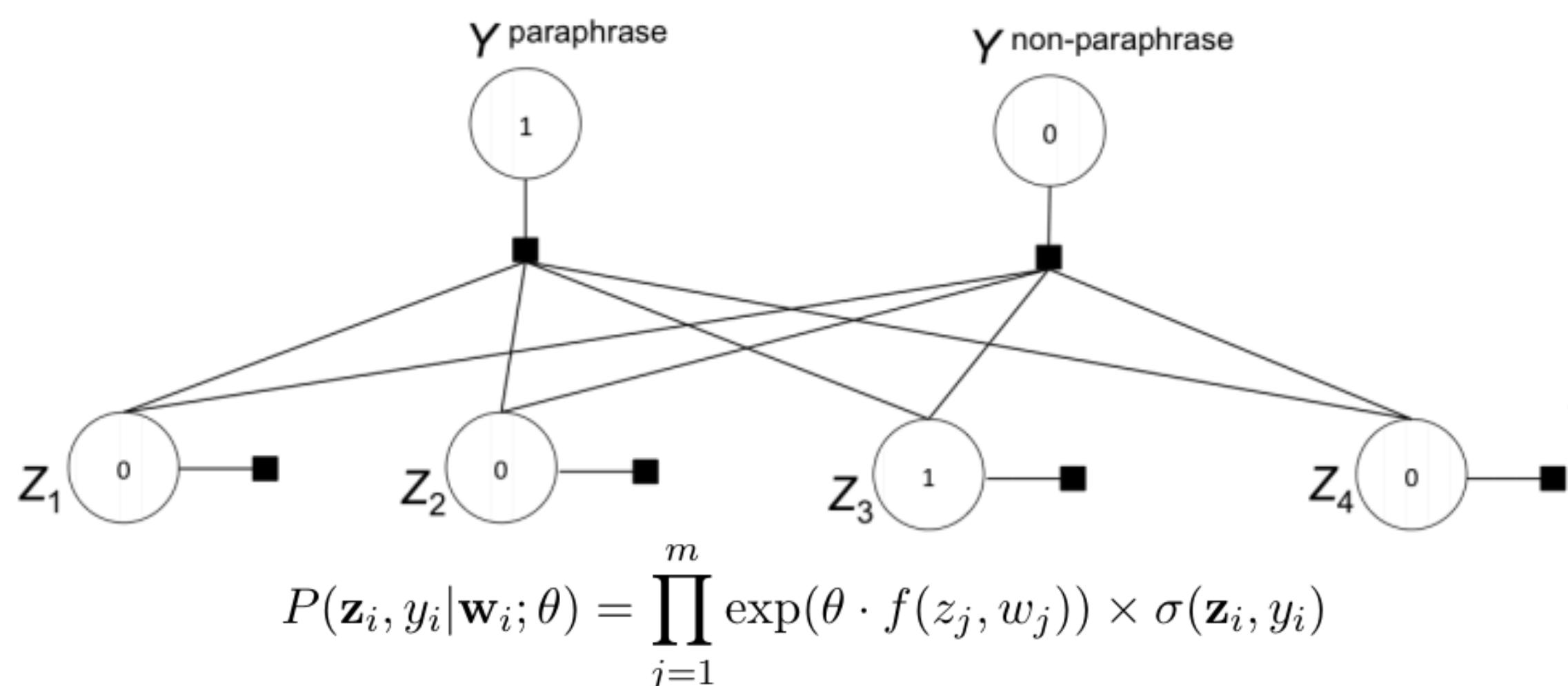
$$\begin{matrix} \square \\ X \end{matrix} \approx \begin{matrix} P \\ \times \end{matrix} \begin{matrix} Q^T \end{matrix}$$

- **LEX-OrMF** (Orthogonal Matrix Factorization) [Guo and Diab 2012]

# DESIGNING VARIOUS [MACHINE LEARNING] MODELS

$$\begin{matrix} \square \\ X \end{matrix} \approx \begin{matrix} P \\ \times \\ Q^T \end{matrix}$$

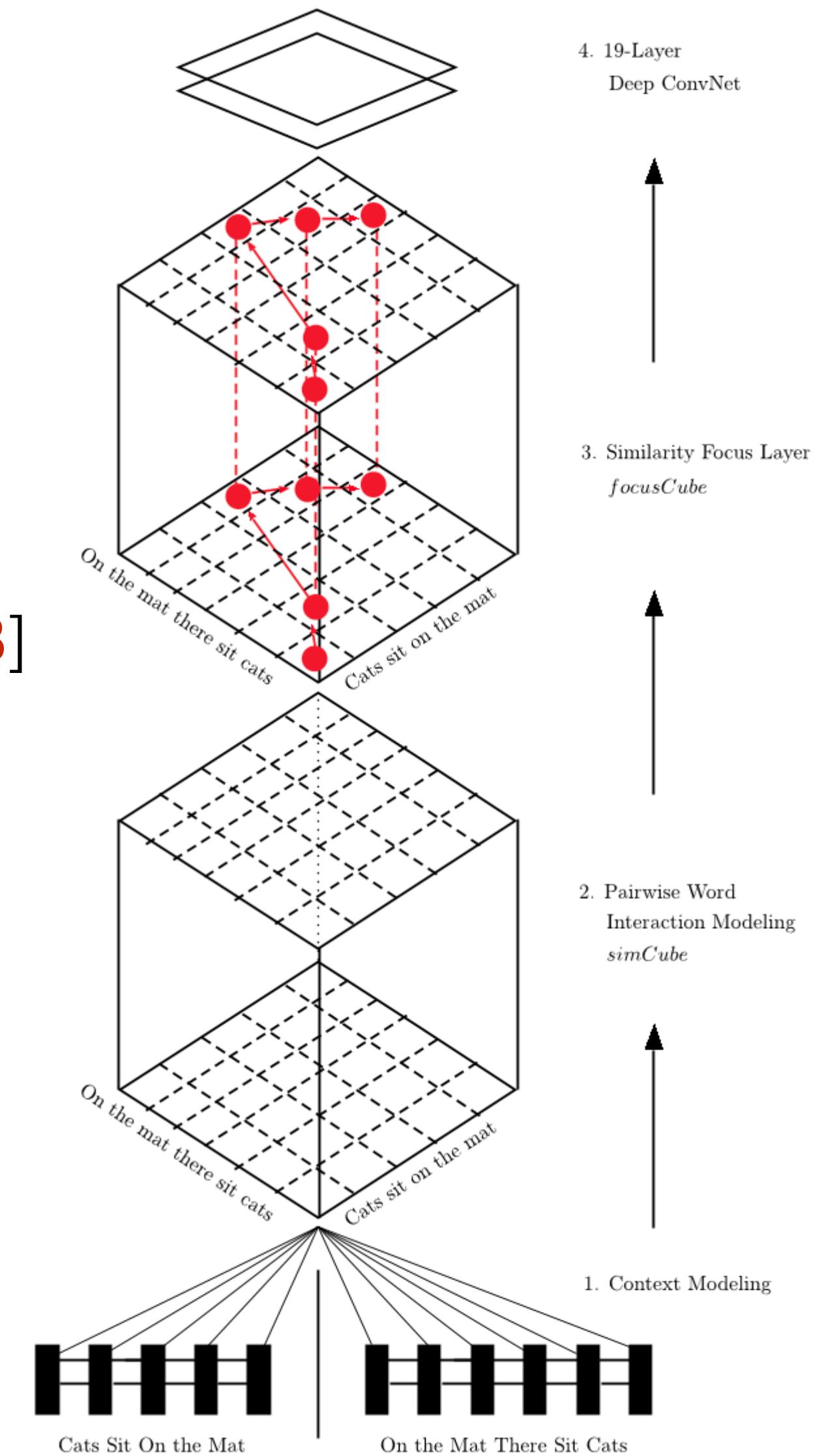
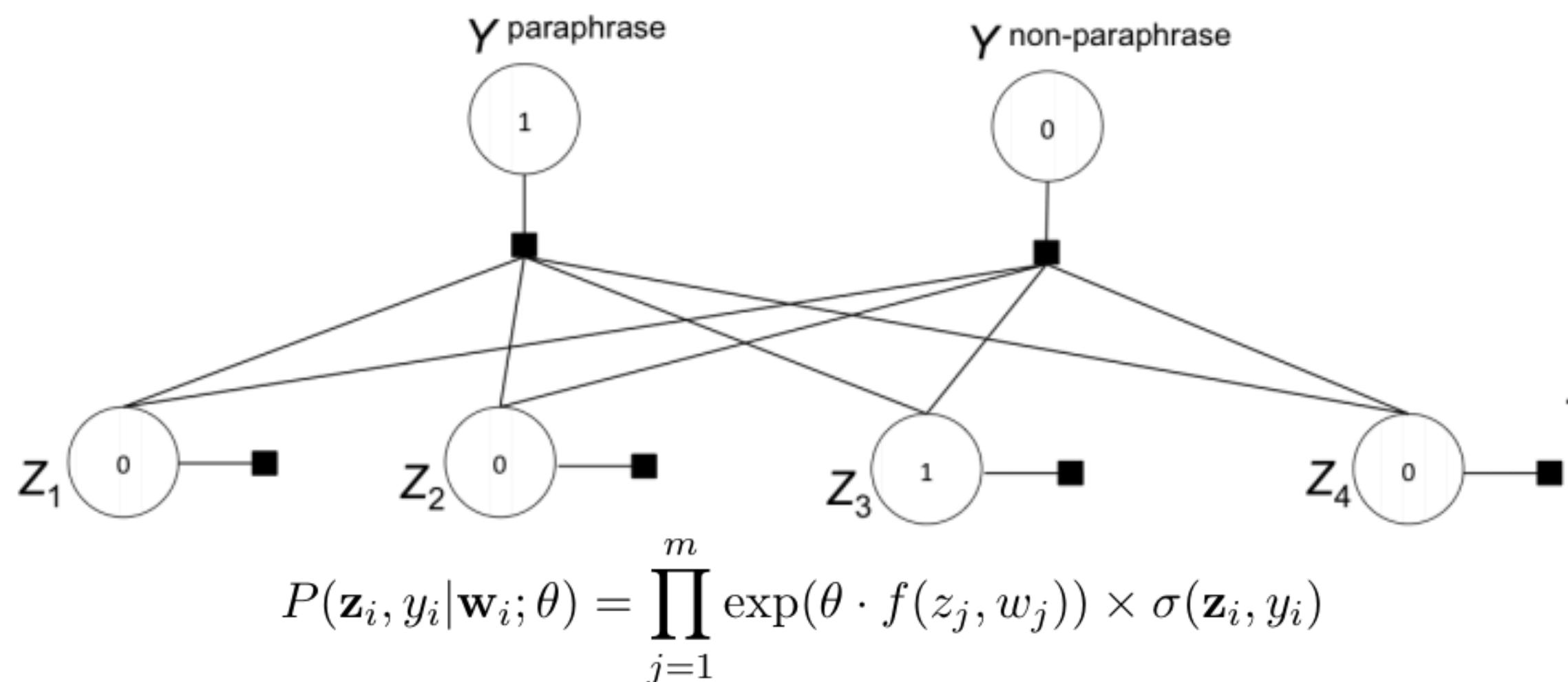
- **LEX-OrMF** (Orthogonal Matrix Factorization) [Guo and Diab 2012]
- **MultiP** (Multiple Instance Learning) [Xu et al. 2014; Tabassum et al. 2016]



# DESIGNING VARIOUS [MACHINE LEARNING] MODELS

$$X \approx P \times Q^T$$

- **LEX-OrMF** (Orthogonal Matrix Factorization) [Guo and Diab 2012]
- **DeepPairwiseWord** (Deep Neural Networks) [He et al. 2015; Lan and Xu 2018]
- **MultiP** (Multiple Instance Learning) [Xu et al. 2014; Tabassum et al. 2016]



# [DATA SCIENCE] FOR LINGUISTIC STYLES

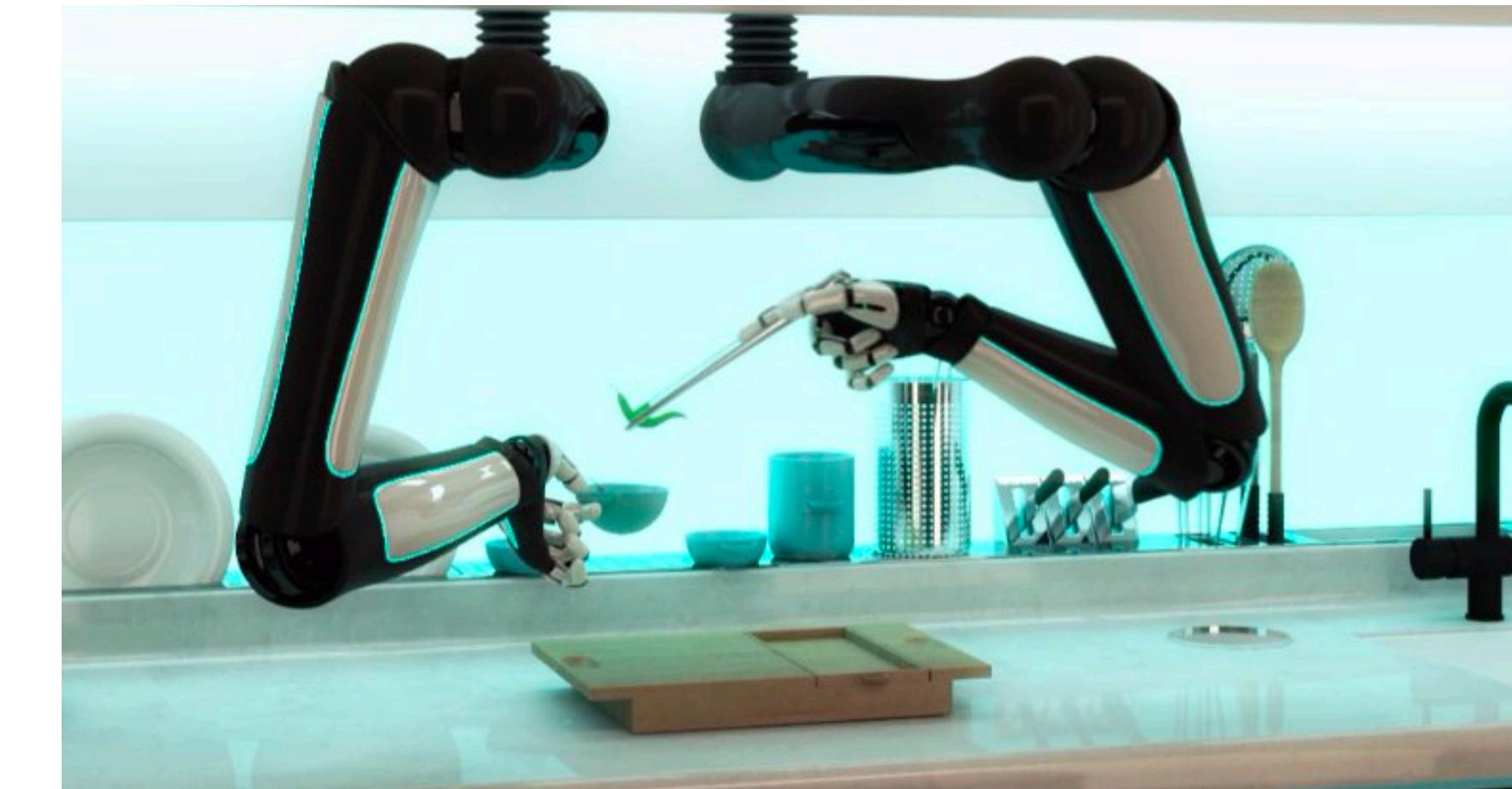
(also studied age & income)

# [DATA SCIENCE] FOR LINGUISTIC STYLES

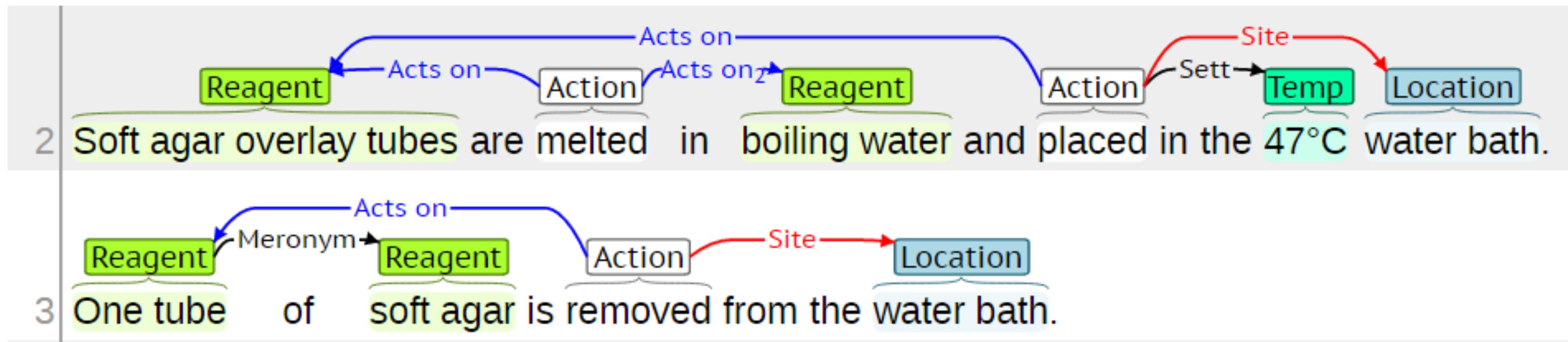


(also studied age & income)

# MACHINE READING OF INSTRUCTIONS



## Wet Lab Protocols:



# THANK YOU

I can no other answer make but thanks,  
And thanks, and ever thanks.

# THANK YOU

thanku

thank u 4 ur time

thankning you

gramercies

thanks a lot

gratitude

appreciate it

thx

thanks

3x

thnx

say thanks

thank you very much

I can no other answer make but thanks,  
And thanks, and ever thanks.

thanks a ton

wawwww thankkkkkkkkkkk you alottttttttt!

I am grateful