

Introduction to Statistical Machine Translation

Adam Lopez

Including content and jokes borrowed from / inspired
by: Chris Callison-Burch, Philipp Koehn, Kevin Knight,
and Martin Kay

Introduction to Statistical Machine Translation

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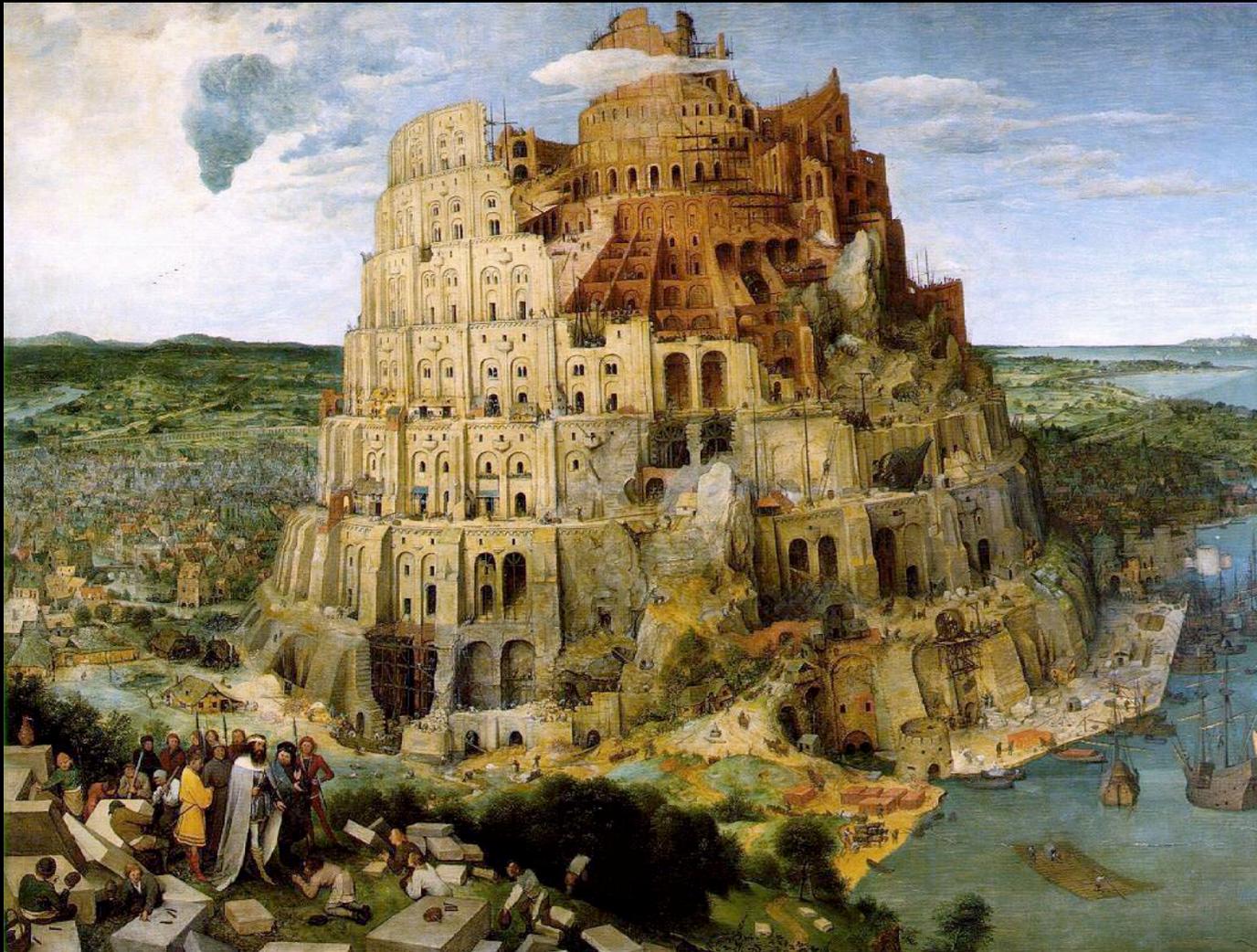
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and Martin Kay

Errors and bad timing are all mine, though.

虽然北风呼啸，但天空依然十分清澈。

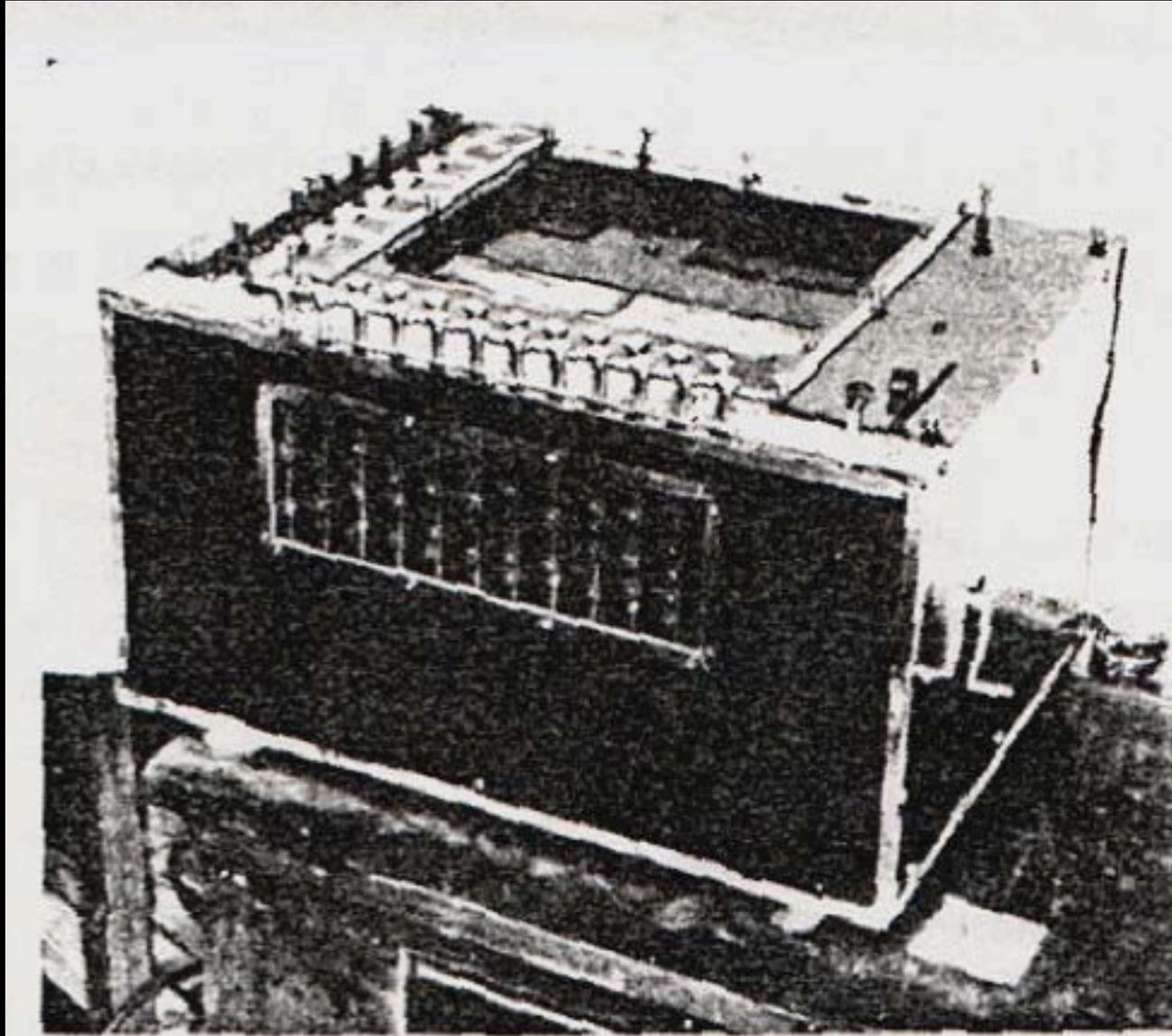
虽然北风呼啸，但天空依然十分清澈。

However, the sky remained clear under
the strong north wind .



The Tower of Babel

Pieter Bruegel the Elder (1563)



Georges Artsrouni's "mechanical brain",
patented 1933 (France)

COMIT
METAL
Systran
TITUS
SPANAM
ENGSPAN
CUKT
Ariane
GETA
SUSY
AMPAR
NERPA
FRAP
Logos

LUTE
KANT
Candide
SDL
Eurotra
CATALYST
UNITRAN
Rewrite
Pharoah
Moses
Hiero
SAMT
Joshua
Google Translate

Related fields:

artificial intelligence

cognitive science

computer science

linguistics

logic

machine learning

mathematics

philosophy

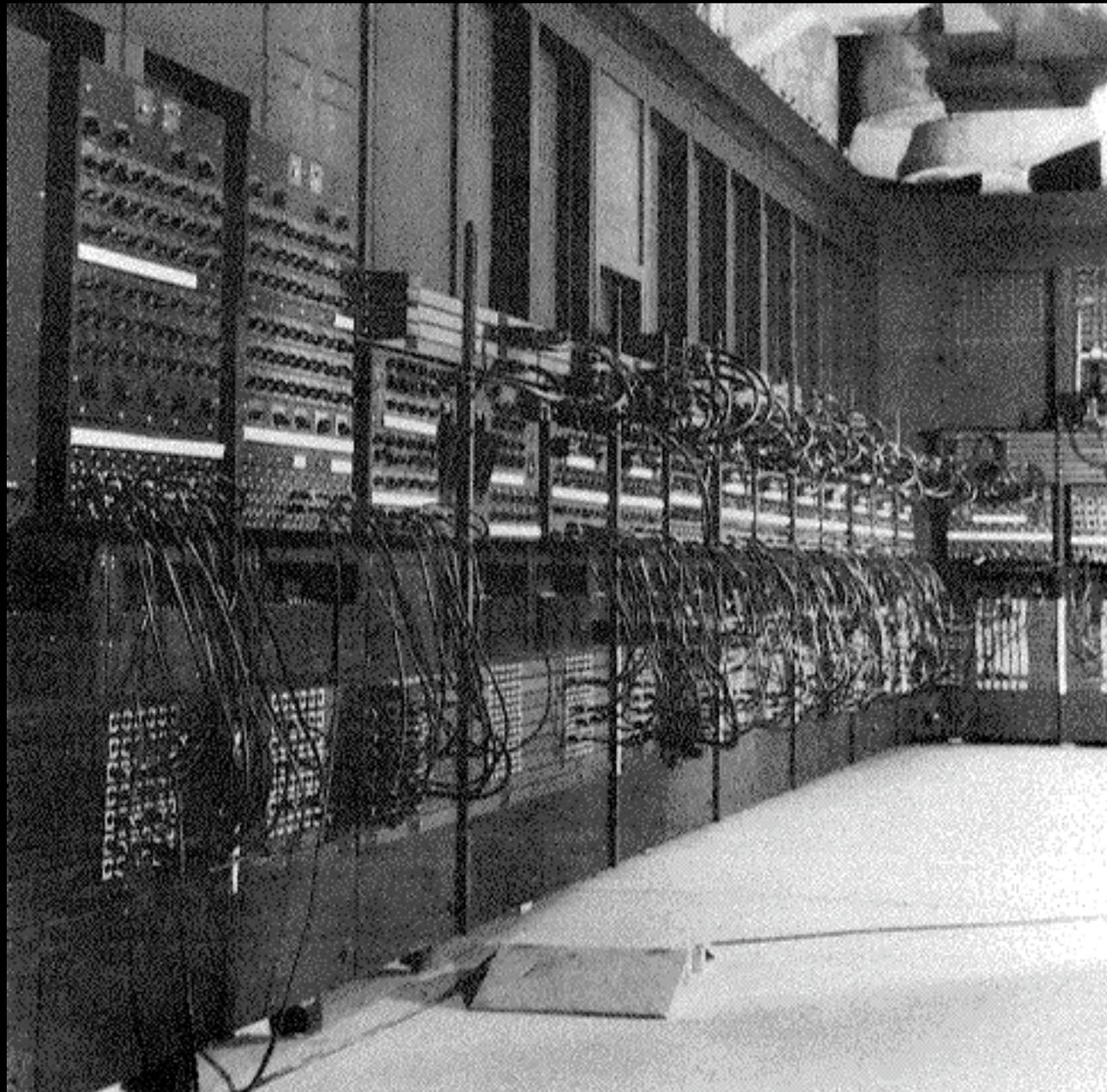
signal processing

statistics

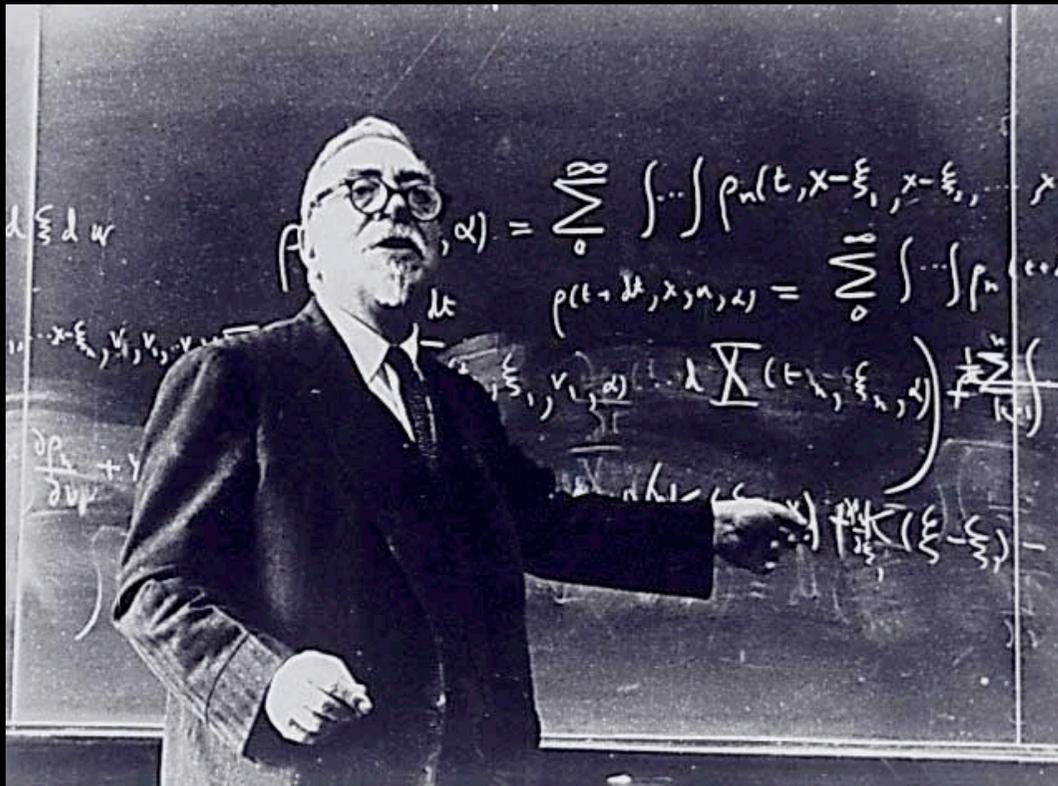
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Constraint-Based MT
Knowledge-Based MT
Lexical-Based MT
Rule-Based MT
Principle-Based MT
Shake-and-Bake MT
Statistical MT
Example-Based MT
Memory-Based MT
Dialogue-Based MT
Neural-Network-Based MT
Context-Based MT



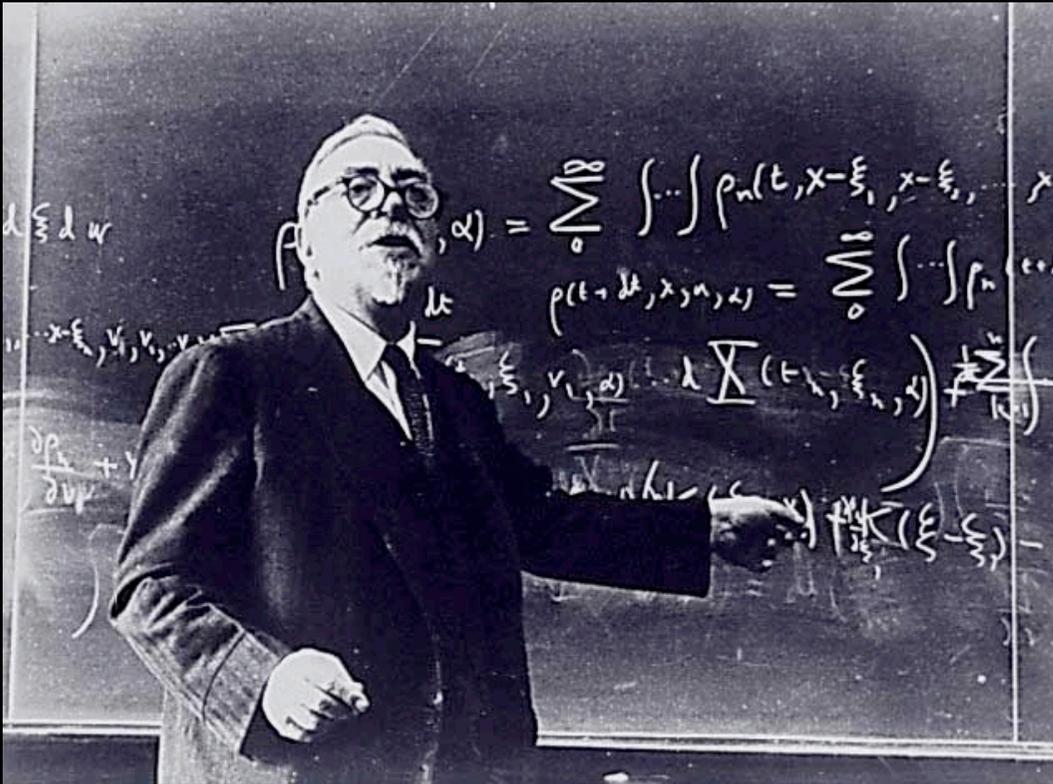
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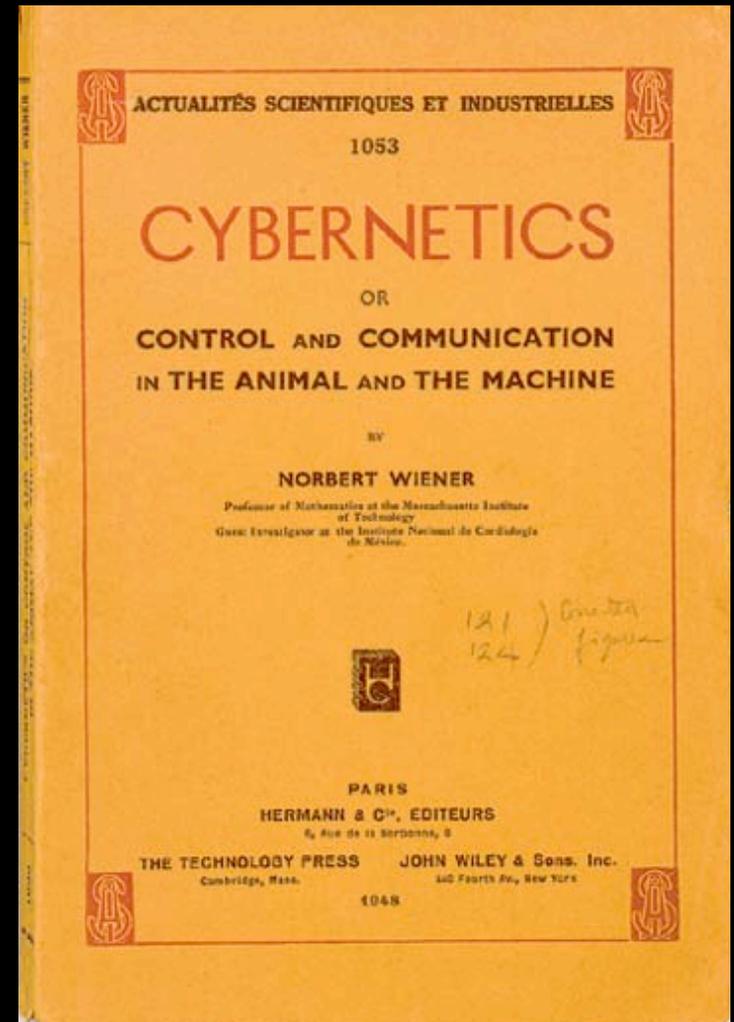
ENIAC (1946)



Norbert Wiener

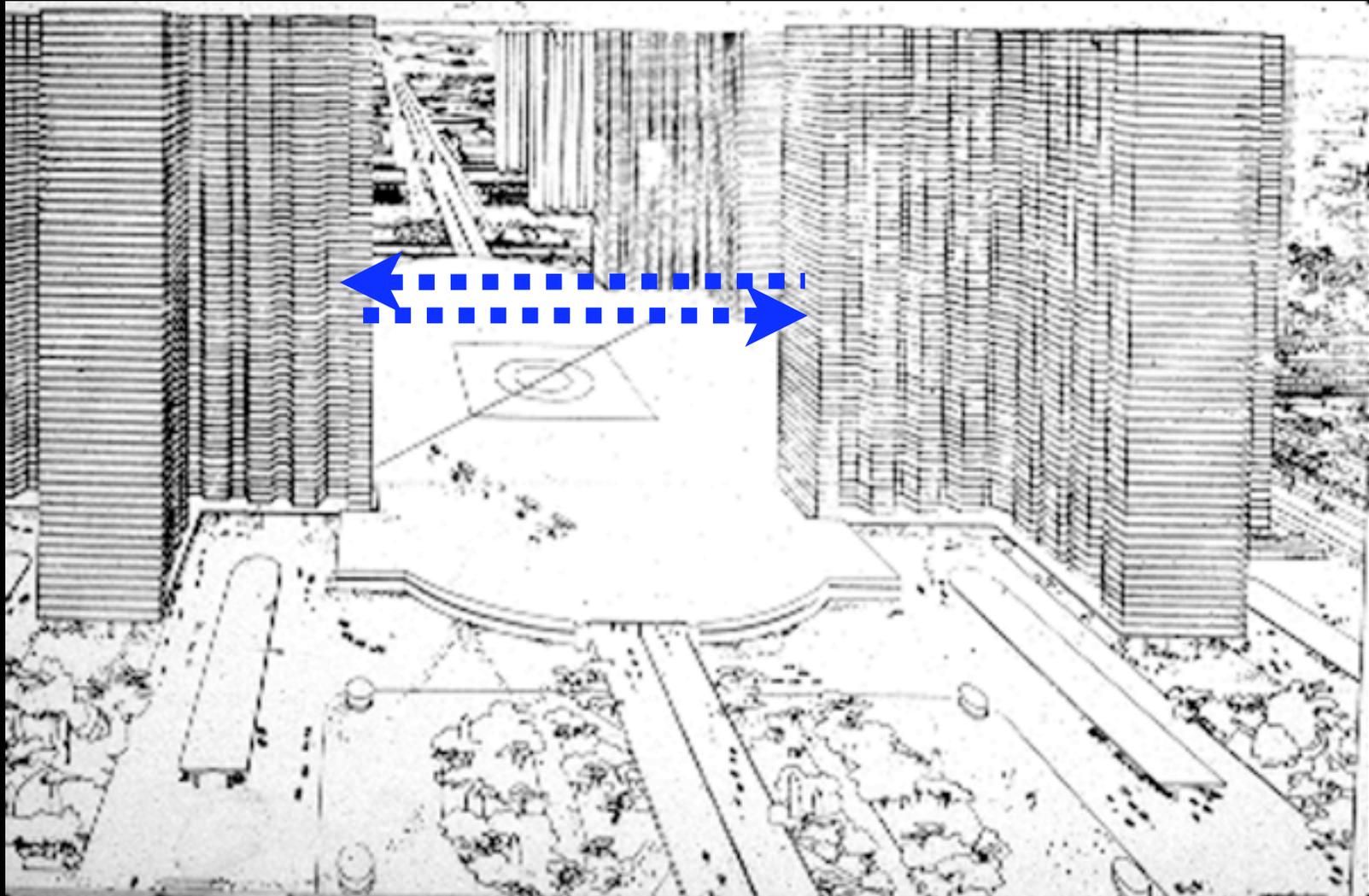


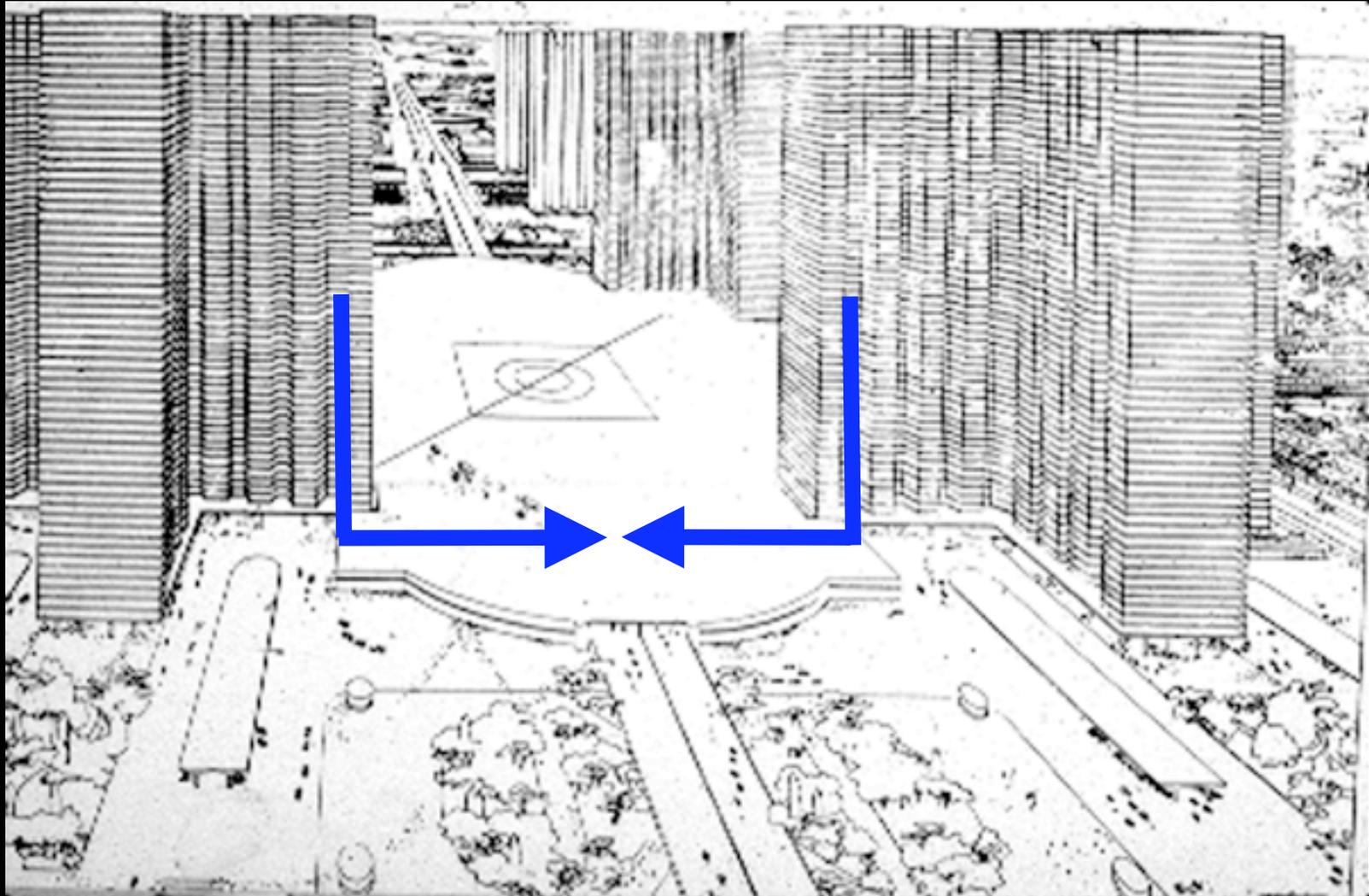
Norbert Wiener





(C) FLC



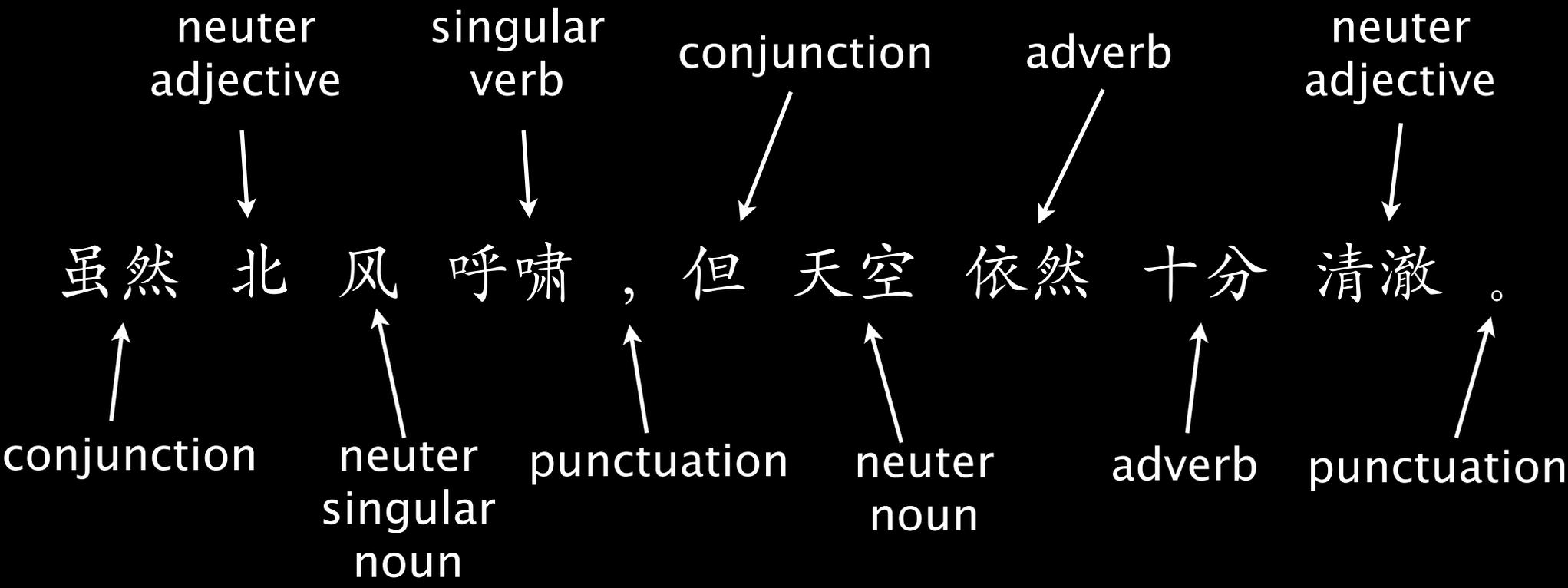


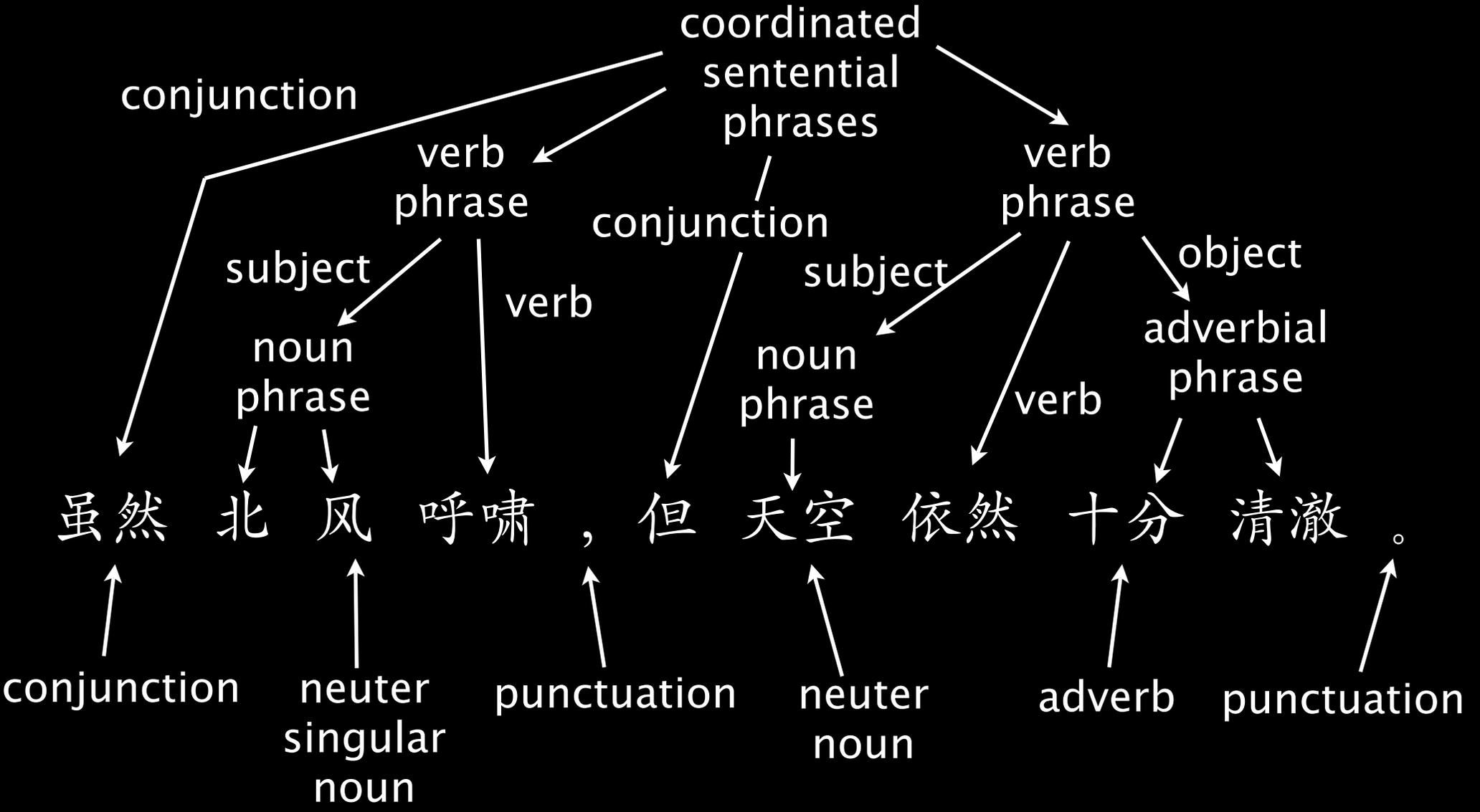
Thus it may be true that the way to translate from Chinese to Arabic, or from Russian to Portuguese, is not to attempt the direct route, shouting from tower to tower. Perhaps the way is to descend, from each language, down to the common base of human communication — the real but as yet undiscovered universal language — and — then re-emerge by whatever particular route is convenient.

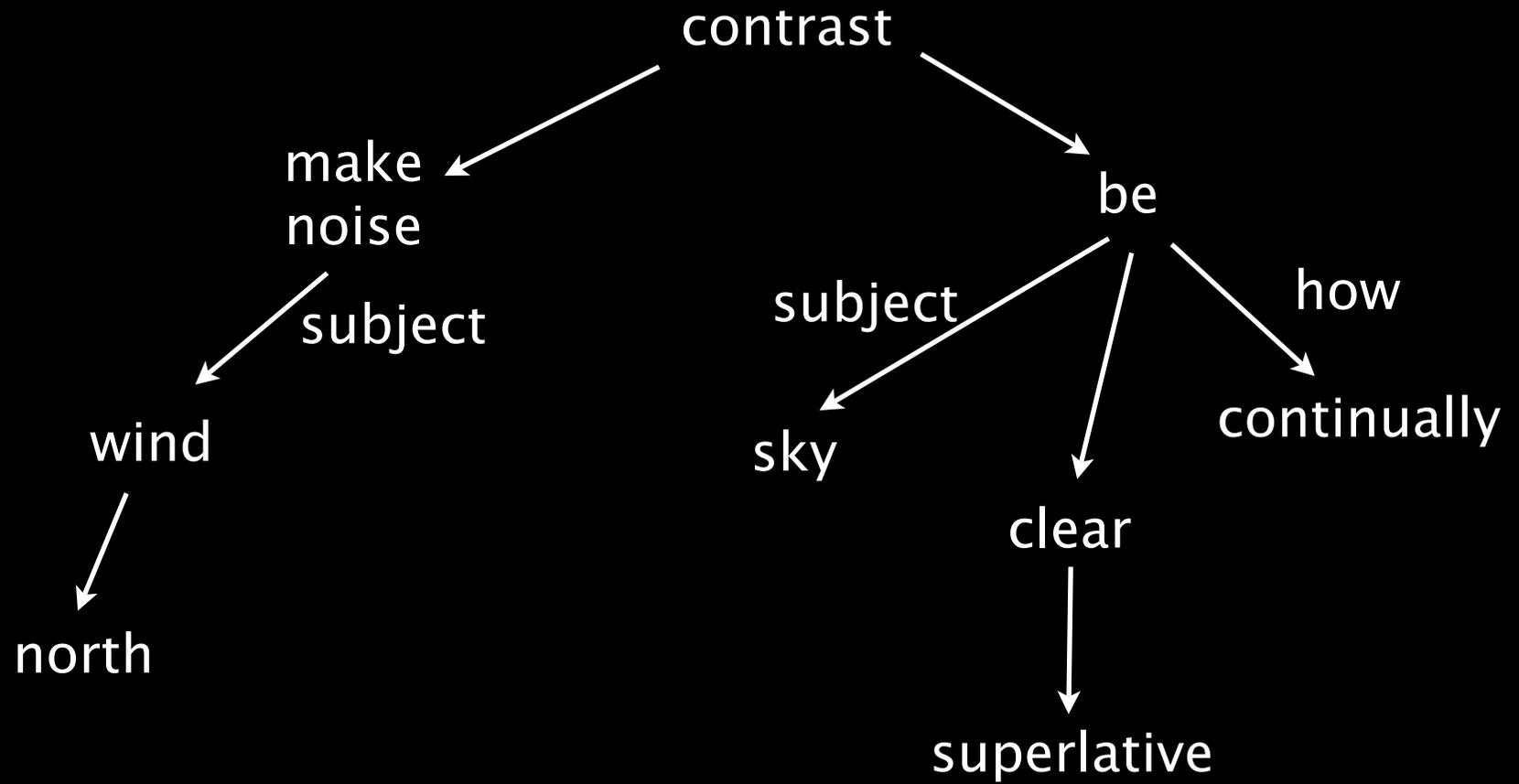
Warren Weaver

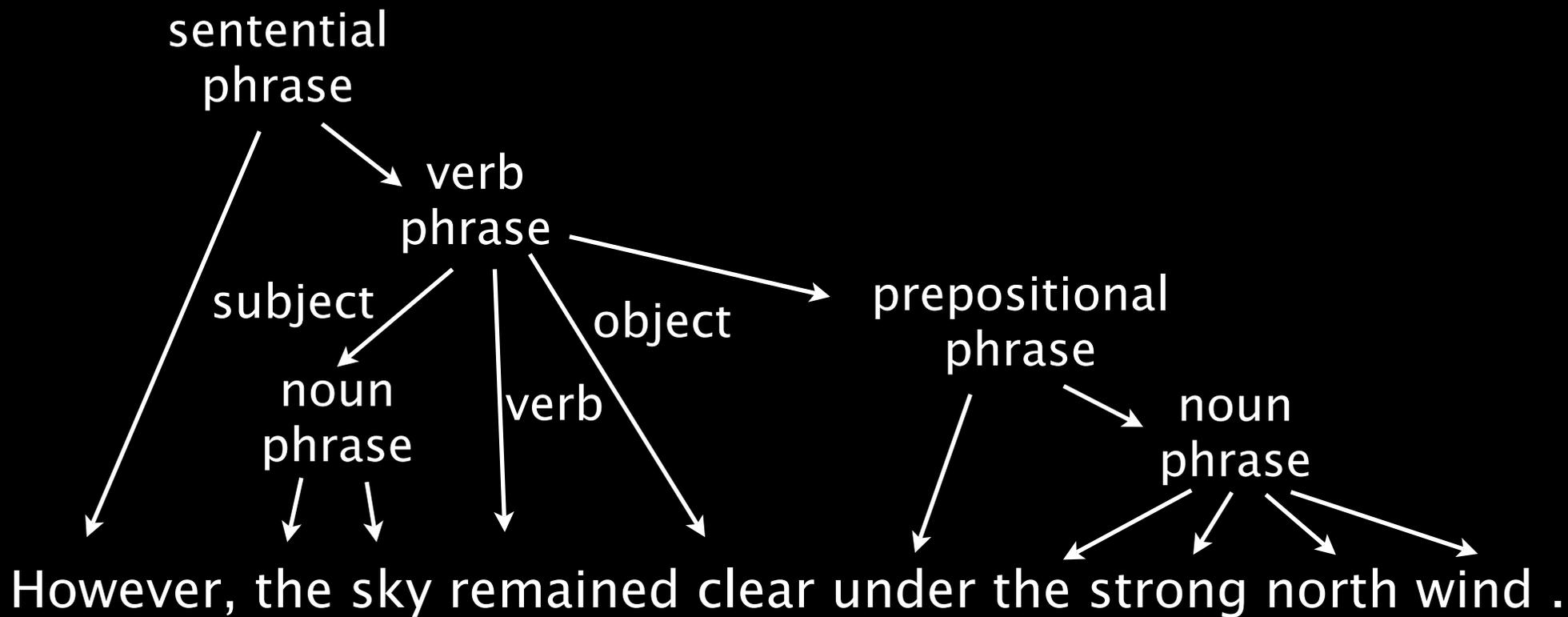


虽然北风呼啸，但天空依然十分清澈。









NINGSUKOL ang duha ka mga tulisan hinungdan nga napusilan hinuon sila ug napatay sa mirespon-ding kapulisan sa milabayng gabii.

Ang kalayo nga niga-was gikan sa sombohan sa armas sa suspetsado maoy ngihimong guide sa kapulisan sa ilang pagba-wos hangtud nga ilang napatay ang usa sa suspetsado alas says sa milabayng gabi sa Ybañez Compound, sitio Alaska Barangay Mambaling, Siyudad sa Sugbo.



Language Tools

Search across languages

Type a search phrase in your own language to easily find pages in another language. We'll translate the results for you to

Search for:

My language: Search pages written in:

Tip: Use [advanced search](#) to restrict your search by language and country without translating your search phrase.

Translate text



Language Tools

Search across languages

Type a search phrase in your own language to easily find pages in another language. We'll translate the results for you to

Search for:

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- Catalan
- Chinese
- Croatian
- Czech
- Danish
- Dutch
- English
- Filipino**
- Finnish
- French
- German
- Greek
- Hebrew
- Hindi
- Indonesian
- Italian
- Japanese
- Korean

English

Search pages written in:

Spanish

Translate and Search

[Advanced search](#) to restrict your search by language and country without translating your search phrase.

Filipino



English

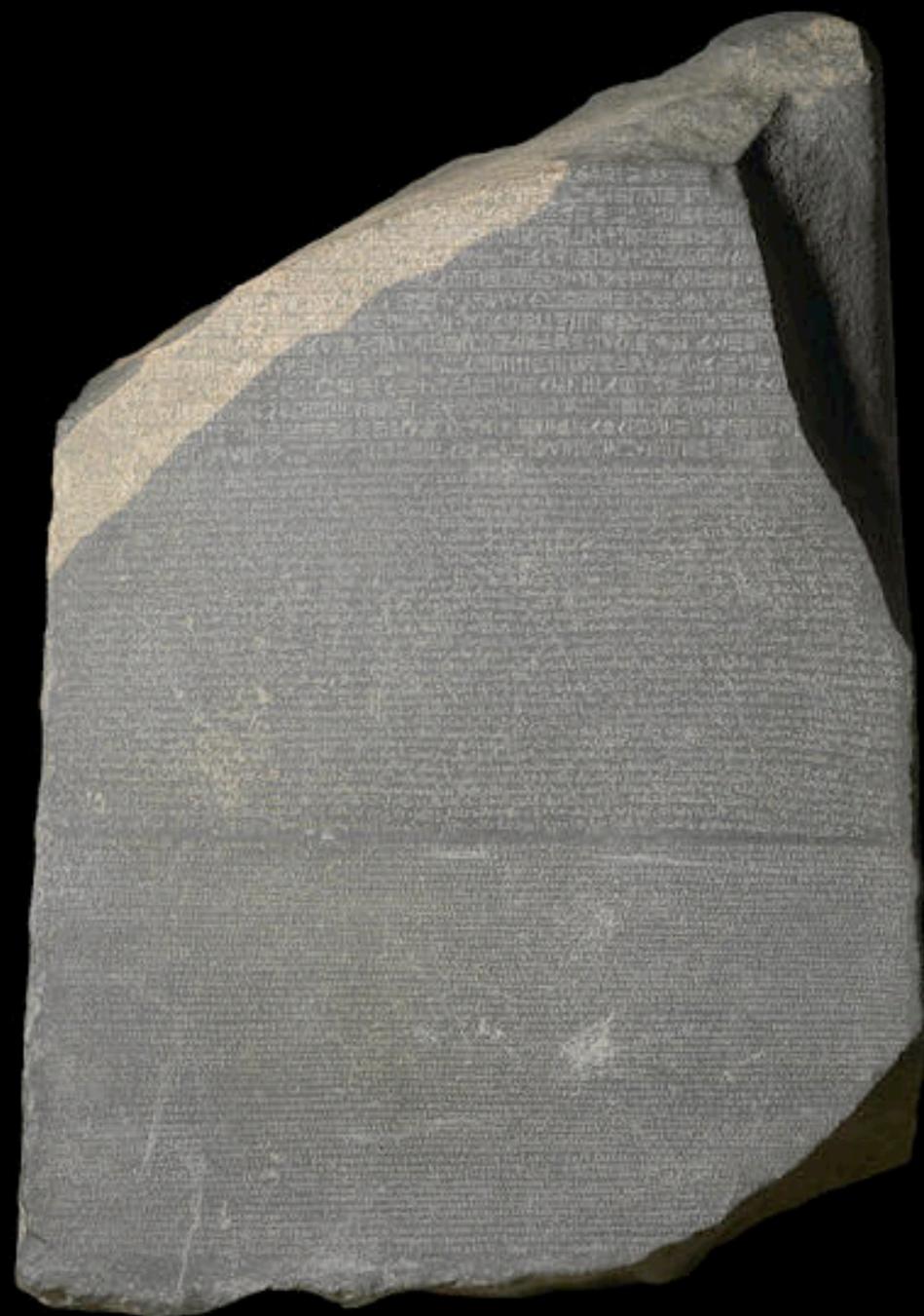
Translate

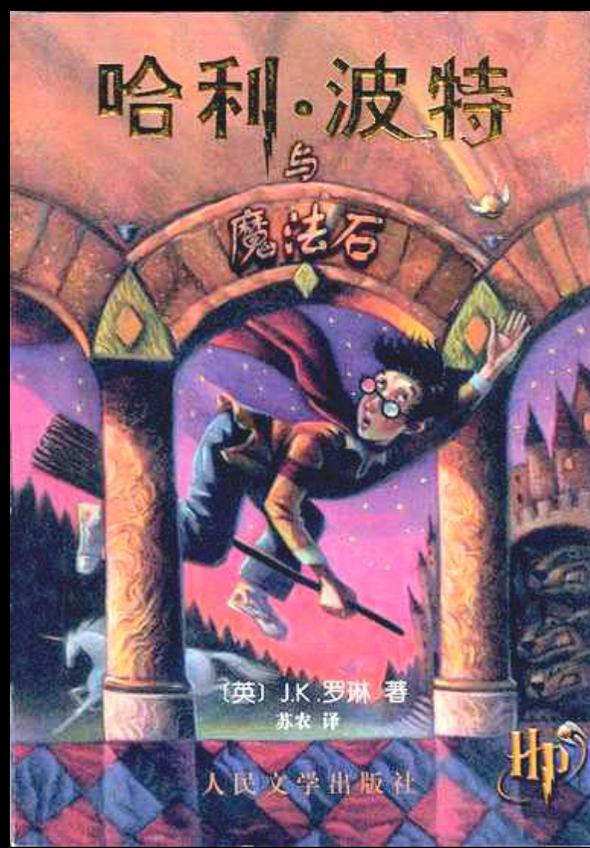
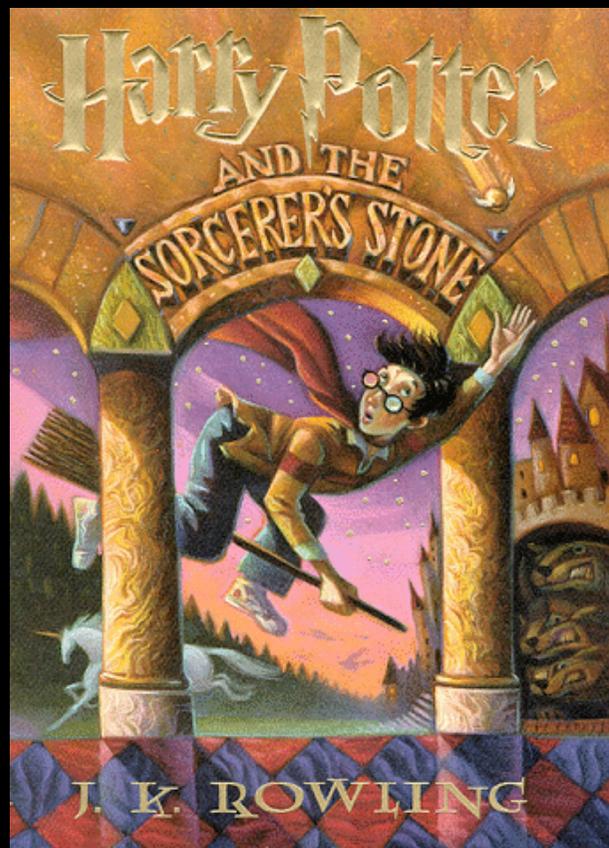


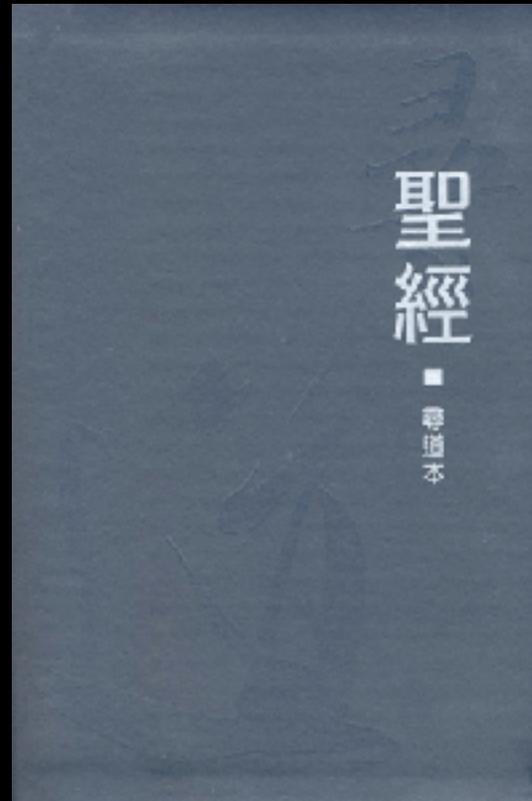
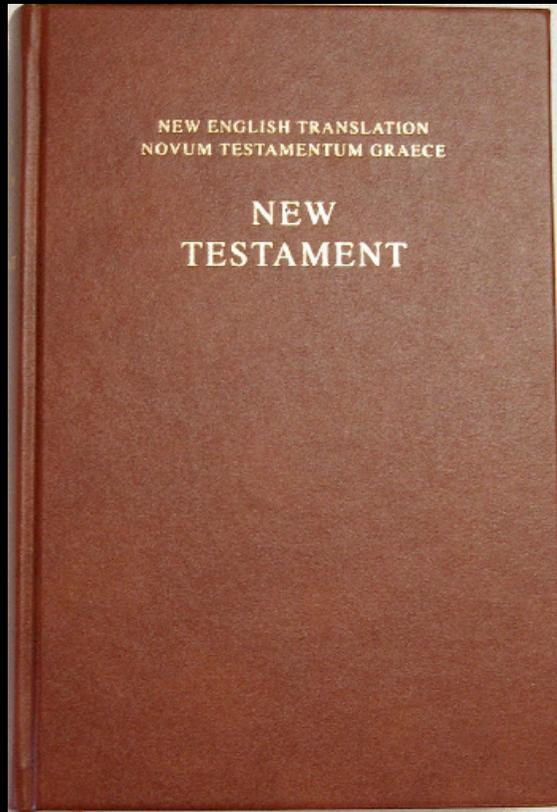
Statistical Machine Translation Live

4/28/2006 03:40:00 PM
Franz Och

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联合国大会主席

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- Memorial Ceremony for Late Deputy Commissioner Zhu Xiangdong Held in Beijing(09.16)
- The Urban Investment in Fixed Assets Continued Increasing in August(09.16)
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- The Value-added of Industry up by 16 Percent in August(09.15)
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- Global Manager of ICP of World Bank Visited Beijing(09.08)

Producers' Price Index For Manufactured Goods

Statistical Data
 Monthly Yearly
 Census Others

Related links
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 Others

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- Monthly Data Updated(09.15)
- Statistical Data: Women and Men in China----Facts and Figures 2004(09.08)
- Monthly Data Updated(09.07)
- Monthly Data Updated(08.29)
- Monthly Data Updated(08.23)

中华人民共和国国家统计局
 National Bureau of Statistics of China
 www.stats.gov.cn

105年9月18日 星期日
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- 株洲: 商品房预售制度对房地产市场的影响浅析 (09.16)
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工业品出厂价格指数

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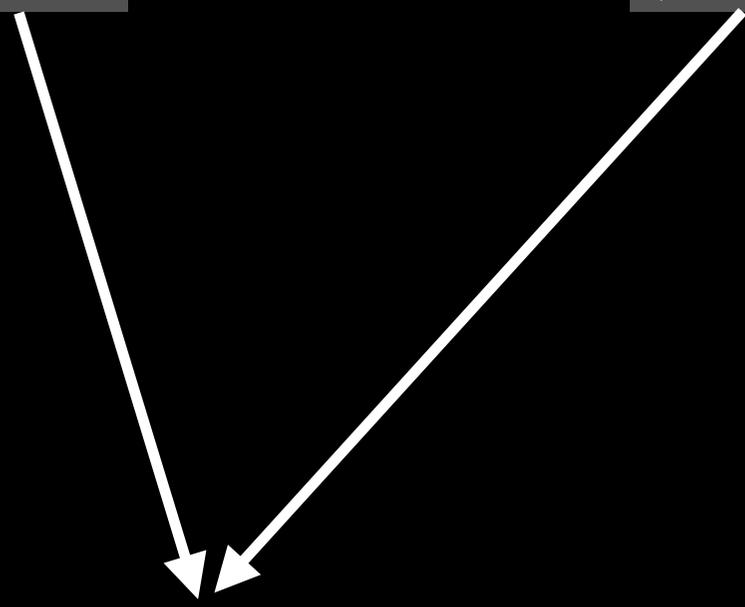
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However, the sky remained clear under the strong north wind .

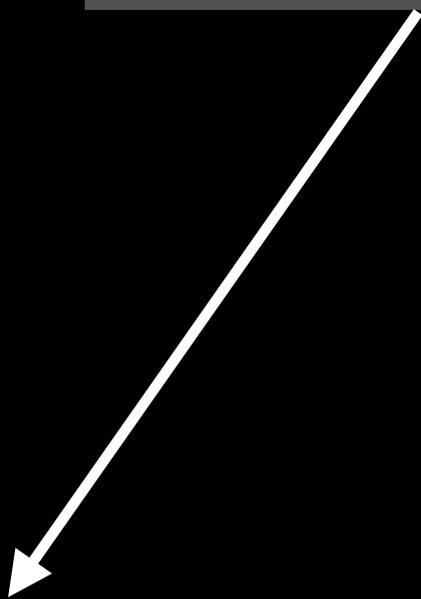
虽然北风呼啸，但天空依然十分清澈。

虽然 北 风 呼 啸 ， 但 天 空 依 然 十 分 清 澈 。



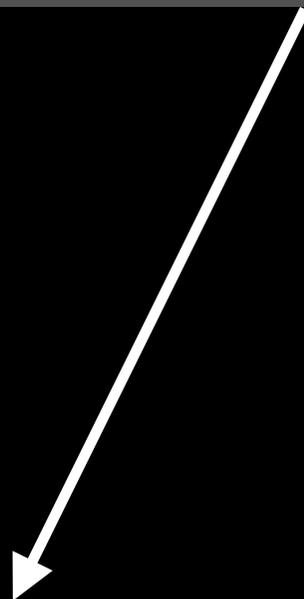
However,

虽然 北风呼啸，但天空 依然 十分 清澈。



However, the sky

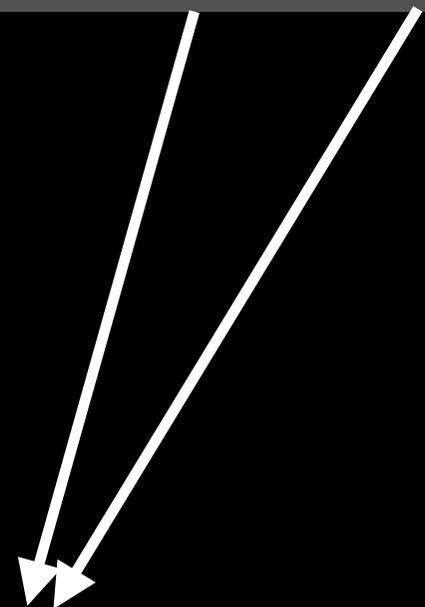
虽然 北风呼啸，但天空依然十分清澈。



However, the sky remained

虽然北风呼啸，但天空依然十分清澈。

However, the sky remained clear



虽然北风呼啸，但天空依然十分清澈。

However, the sky remained clear under
the strong north wind .

虽然北风呼啸，但天空依然十分清澈。

However, the sky remained clear under
the strong north wind .

CLASSIC SOUPS

				Sm.	Lg.			
清	燉	雞	湯	57.	House Chicken Soup (Chicken, Celery, Potato, Onion, Carrot)	1.50	2.75	
雞	飯	湯	58.	Chicken Rice Soup	1.85	3.25		
雞	麵	湯	59.	Chicken Noodle Soup	1.85	3.25		
廣	東	雲	吞	60.	Cantonese Wonton Soup.....	1.50	2.75	
蕃	茄	蛋	湯	61.	Tomato Clear Egg Drop Soup	1.65	2.95	
雲	吞	湯	62.	Regular Wonton Soup	1.10	2.10		
酸	辣	湯	63.	Hot & Sour Soup	1.10	2.10		
蛋	花	湯	64.	Egg Drop Soup.....	1.10	2.10		
雲	蛋	湯	65.	Egg Drop Wonton Mix.....	1.10	2.10		
豆	腐	菜	湯	66.	Tofu Vegetable Soup	NA	3.50	
雞	玉	米	湯	67.	Chicken Corn Cream Soup	NA	3.50	
蟹	肉	玉	米	湯	68.	Crab Meat Corn Cream Soup.....	NA	3.50
海	鮮	湯	69.	Seafood Soup.....	NA	3.50		

CLASSIC SOUPS

				Sm.	Lg.			
清	燉	雞	湯	57.	House Chicken Soup (Chicken, Celery, Potato, Onion, Carrot)	1.50	2.75	
雞	飯	湯	58.	Chicken Rice Soup	1.85	3.25		
雞	麵	湯	59.	Chicken Noodle Soup	1.85	3.25		
廣	東	雲	吞	60.	Cantonese Wonton Soup.....	1.50	2.75	
蕃	茄	蛋	湯	61.	Tomato Clear Egg Drop Soup	1.65	2.95	
雲	吞	湯	62.	Regular Wonton Soup	1.10	2.10		
酸	辣	湯	63.	Hot & Sour Soup	1.10	2.10		
蛋	花	湯	64.	Egg Drop Soup.....	1.10	2.10		
雲	吞	湯	65.	Egg Drop Wonton Mix.....	1.10	2.10		
豆	腐	菜	湯	66.	Tofu Vegetable Soup	NA	3.50	
雞	玉	米	湯	67.	Chicken Corn Cream Soup	NA	3.50	
蟹	肉	玉	米	湯	68.	Crab Meat Corn Cream Soup.....	NA	3.50
海	鮮	湯	69.	Seafood Soup.....	NA	3.50		

CLASSIC SOUPS

				Sm.	Lg.			
清	燉	雞	湯	57.	House Chicken Soup (Chicken, Celery, Potato, Onion, Carrot)	1.50	2.75	
雞	飯	湯	58.	Chicken Rice Soup	1.85	3.25		
雞	麵	湯	59.	Chicken Noodle Soup	1.85	3.25		
廣	東	雲	吞	60.	Cantonese Wonton Soup.....	1.50	2.75	
蕃	茄	蛋	湯	61.	Tomato Clear Egg Drop Soup	1.65	2.95	
雲	吞	湯	62.	Regular Wonton Soup	1.10	2.10		
酸	辣	湯	63.	Hot & Sour Soup	1.10	2.10		
蛋	花	湯	64.	Egg Drop Soup.....	1.10	2.10		
雲	蛋	湯	65.	Egg Drop Wonton Mix.....	1.10	2.10		
豆	腐	菜	湯	66.	Tofu Vegetable Soup	NA	3.50	
雞	玉	米	湯	67.	Chicken Corn Cream Soup	NA	3.50	
蟹	肉	玉	米	湯	68.	Crab Meat Corn Cream Soup.....	NA	3.50
海	鮮	湯	69.	Seafood Soup.....	NA	3.50		

CLASSIC SOUPS

				Sm.	Lg.			
清	燉	雞	湯	57.	House Chicken Soup (Chicken, Celery, Potato, Onion, Carrot)	1.50	2.75	
雞	飯	湯	58.	Chicken Rice Soup	1.85	3.25		
雞	麵	湯	59.	Chicken Noodle Soup	1.85	3.25		
廣	東	雲	吞	60.	Cantonese Wonton Soup.....	1.50	2.75	
蕃	茄	蛋	湯	61.	Tomato Clear Egg Drop Soup	1.65	2.95	
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海	鮮	湯	69.	Seafood Soup.....	NA	3.50		

CLASSIC SOUPS

				Sm.	Lg.			
清	燉	雞	湯	57.	House Chicken Soup (Chicken, Celery, Potato, Onion, Carrot)	1.50	2.75	
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CLASSIC SOUPS

				Sm.	Lg.			
清	燉	雞	湯	57.	House Chicken Soup (Chicken, Celery, Potato, Onion, Carrot)	1.50	2.75	
雞	飯	湯	58.	Chicken Rice Soup	1.85	3.25		
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雞	玉	米	湯	67.	Chicken Corn Cream Soup	NA	3.50	
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清 燉 雞	湯	57.	House Chicken Soup (Chicken, Celery, Potato, Onion, Carrot)	1.50 2.75
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廣 東 雲 吞		60.	Cantonese Wonton Soup.....	1.50 2.75
蕃 茄 蛋	湯	61.	Tomato Clear Egg Drop Soup	1.65 2.95
雲 吞	湯	62.	Regular Wonton Soup	1.10 2.10
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蛋 花	湯	64.	Egg Drop Soup.....	1.10 2.10
雲 吞	湯	65.	Egg Drop Wonton Mix.....	1.10 2.10
豆 腐 菜	湯	66.	Tofu Vegetable Soup	NA 3.50
雞 玉 米	湯	67.	Chicken Corn Cream Soup	NA 3.50
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$p(\textit{heads}) ?$

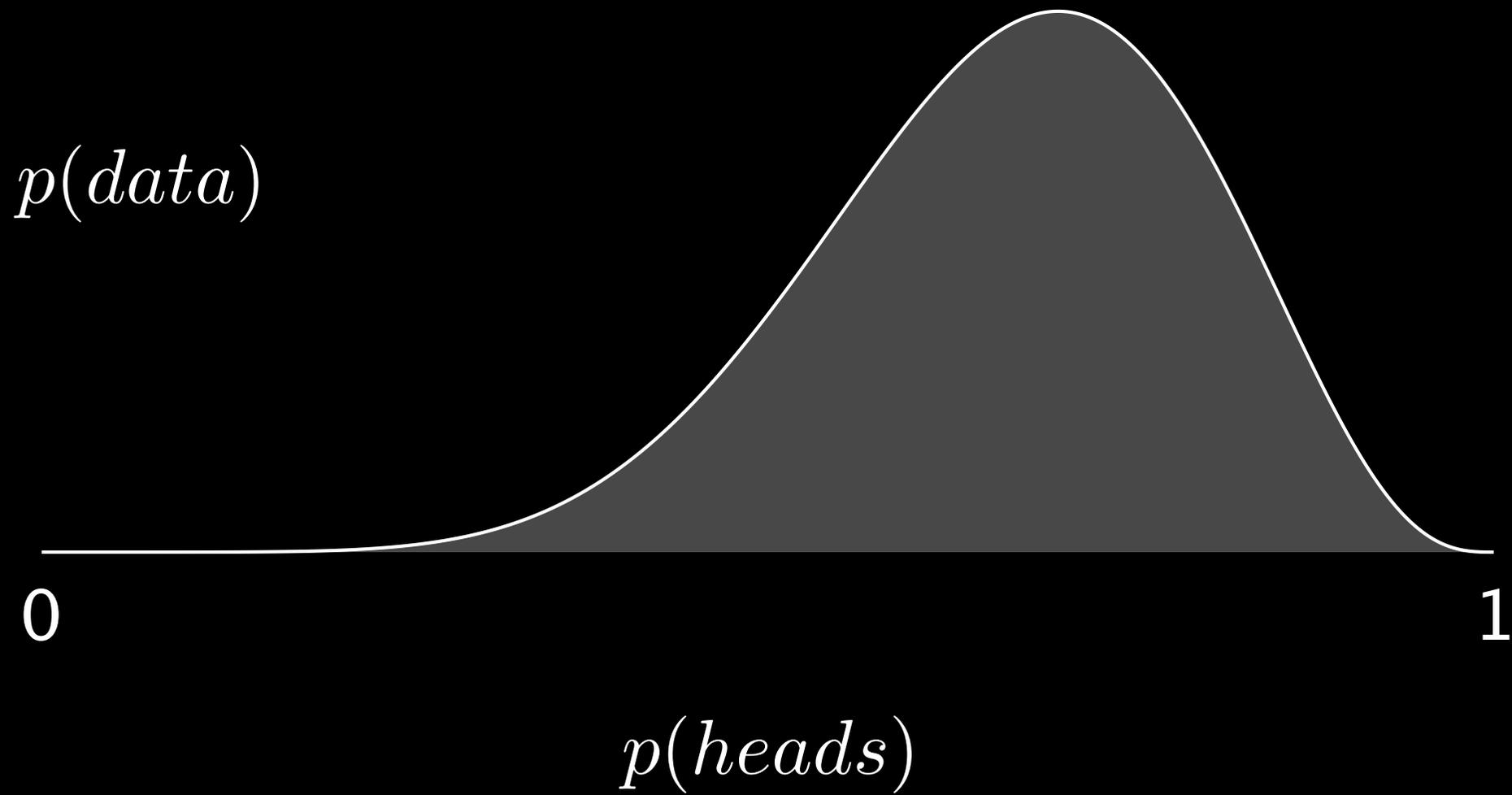


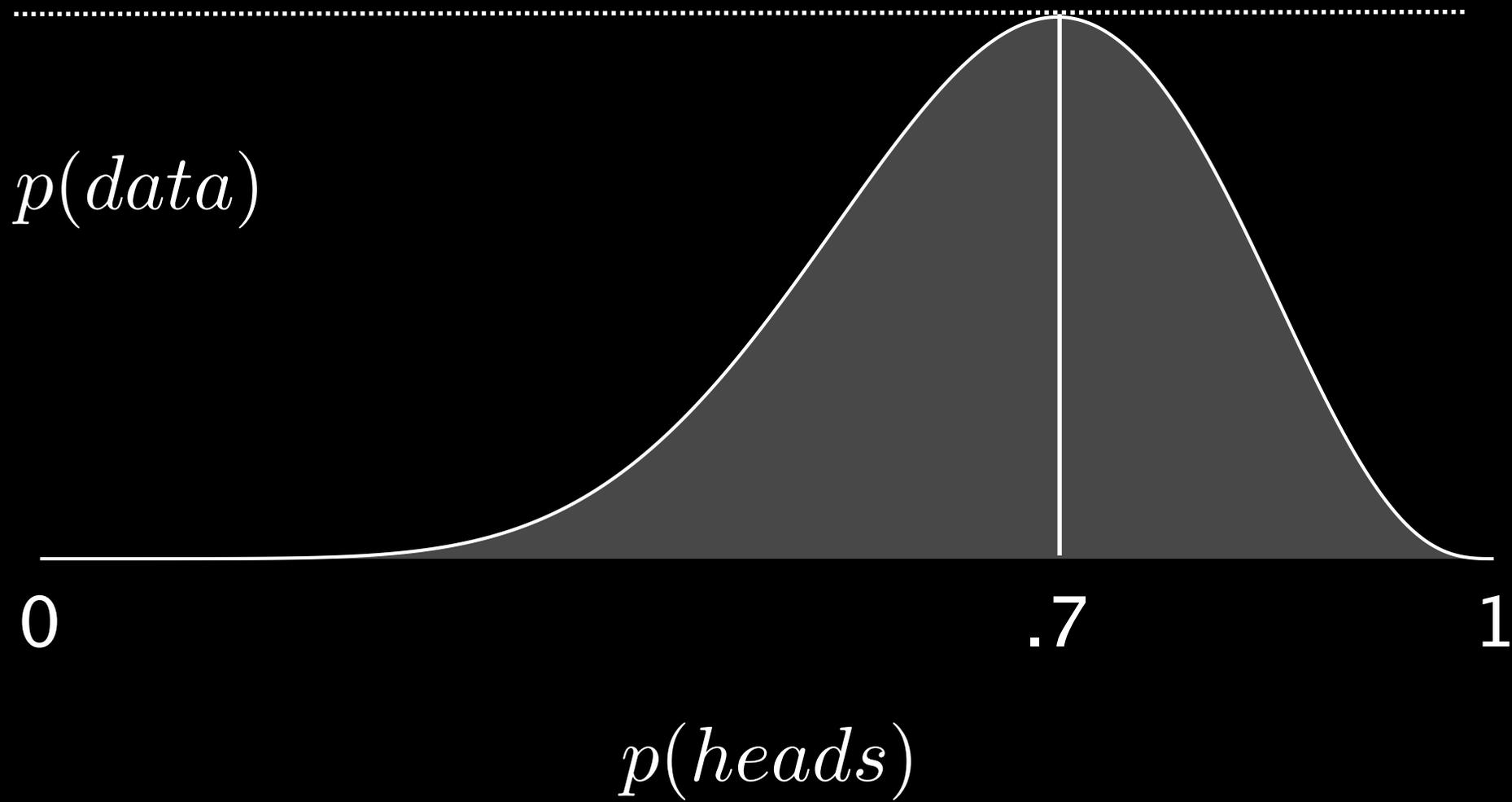


$$p(\text{data}) = p(\text{heads})^7 \times p(\text{tails})^3$$

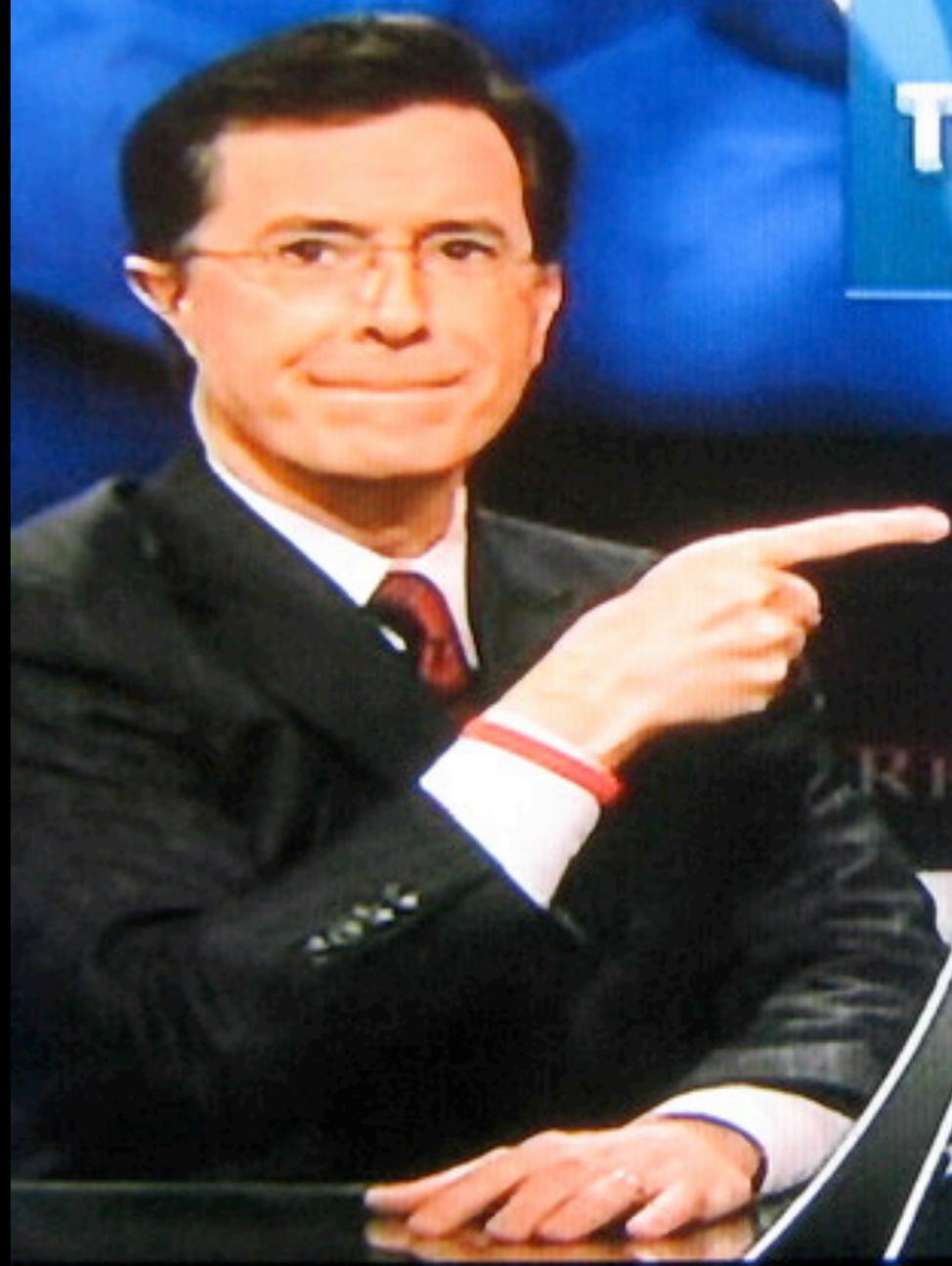


$$p(\text{data}) = p(\text{heads})^7 \times [1 - p(\text{heads})]^3$$

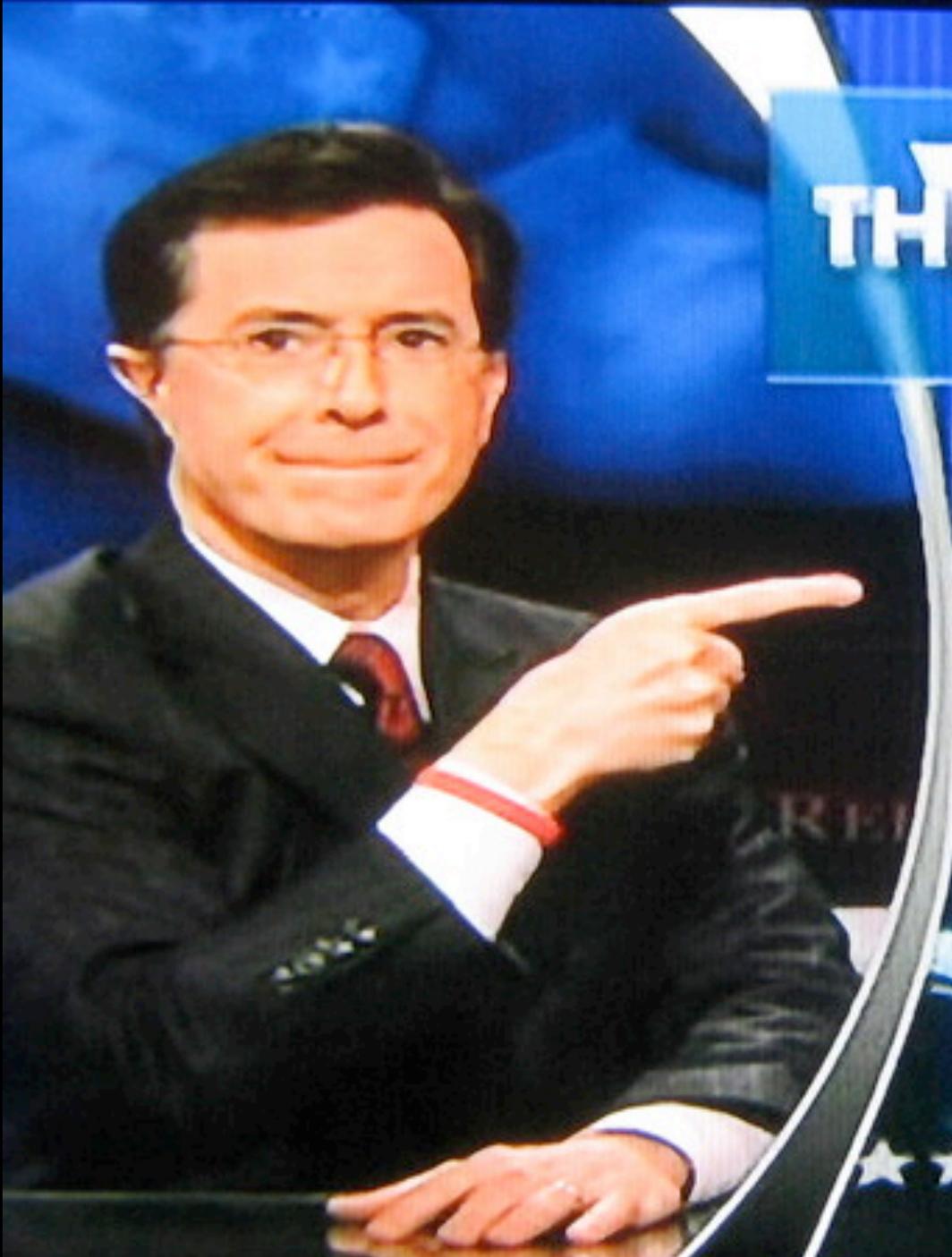




THE ~~W~~ORD



COM
CENT

A man in a dark suit, white shirt, and red tie, wearing glasses, is pointing his right index finger towards the right. He is positioned on the left side of the image. The background is a blue studio set with a world map and a row of stars at the bottom. The title 'THE WORD' is displayed in large, white, 3D block letters on a blue rectangular background in the upper right.

THE WORD

Optimization



$p(\textit{heads}) ?$

$p(\textit{heads}) ?$

虽然北风呼啸，但天空依然十分清澈。

However, the sky remained clear under
the strong north wind .

虽然 北 风 呼 啸 ， 但 天 空 依 然 十 分 清 澈 。

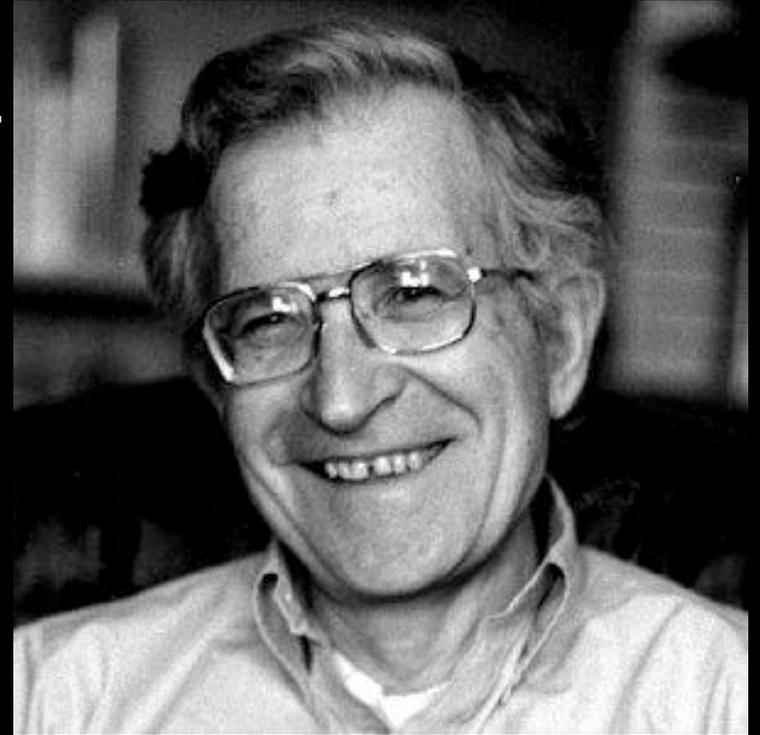
However, the sky remained clear under
the strong north wind .

$$p(\textit{English}|\textit{Chinese}) = \prod_{rule} p(rule)$$

$$\operatorname{argmax}_{\text{English}} p(\text{English}|\text{Chinese}) = \prod_{\text{rule}} p(\text{rule})$$

It must be recognized that the notion of a probability of a sentence is an entirely useless one, under any interpretation of this term.

Noam Chomsky

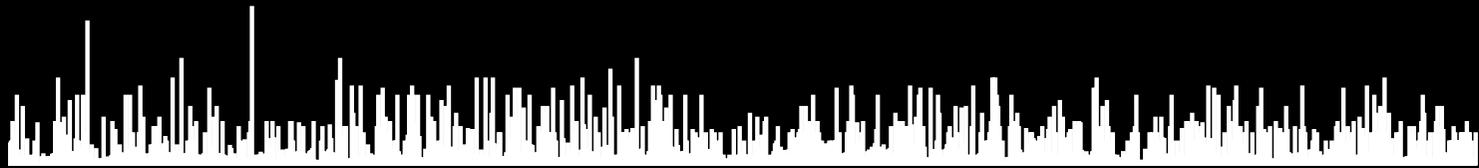


Every time I fire a linguist,
the performance of the
recognizer goes up.

Fred Jelinek (1988)



$p(\textit{English}|\textit{Chinese})$

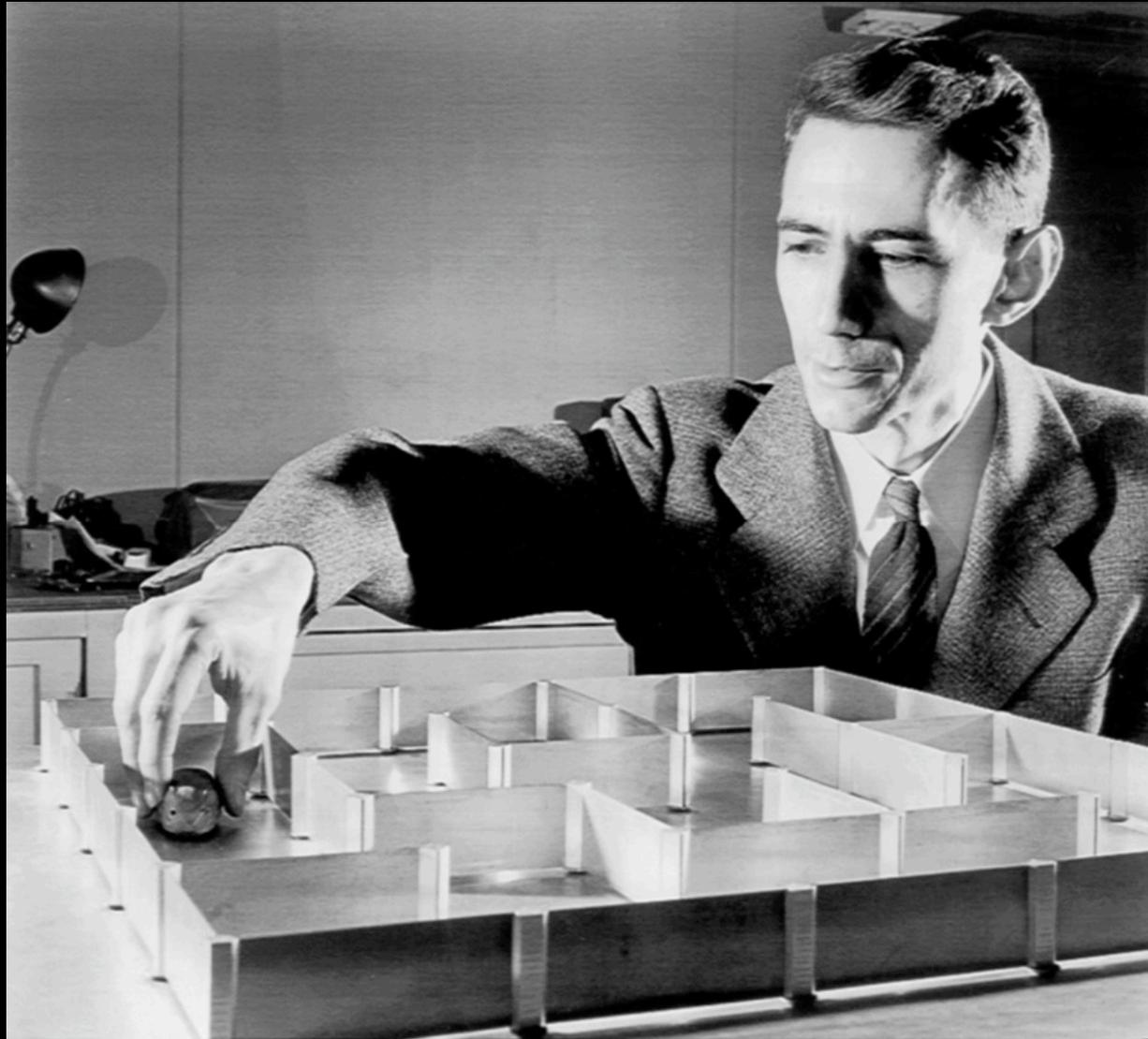


English



THE MATHEMATICAL THEORY OF COMMUNICATION

by Claude E. Shannon and Warren Weaver



Claude Shannon



When I look at an article in Russian, I say: “This is really written in English, but it has been coded in some strange symbols. I will now proceed to decode.”

Warren Weaver

...But the probability that an event has happened is the same as the probability I have to guess right if I guess it has happened.

Wherefore the following proposition is evident: If there be two subsequent events, the probability of the 2d b/N and the probability both together P/N , and it being 1st discovered that the 2d event has also happened, the probability I am right is P/b .



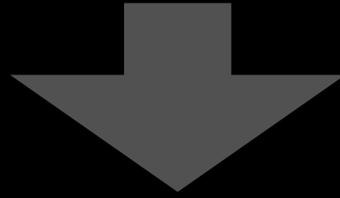
Thomas Bayes

$$p(\textit{English}|\textit{Chinese}) =$$

$$\frac{p(\textit{English}) \times p(\textit{Chinese}|\textit{English})}{p(\textit{Chinese})}$$

$$p(\textit{English}|\textit{Chinese}) \sim$$

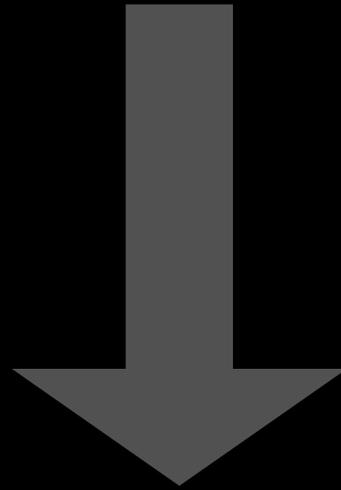
$$p(\textit{English}) \times p(\textit{Chinese}|\textit{English})$$



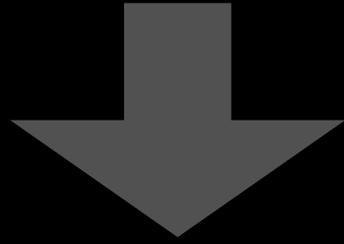
However, the sky remained clear under
the strong north wind .



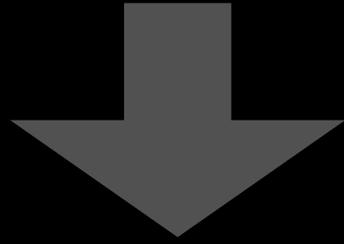
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the strong north wind .



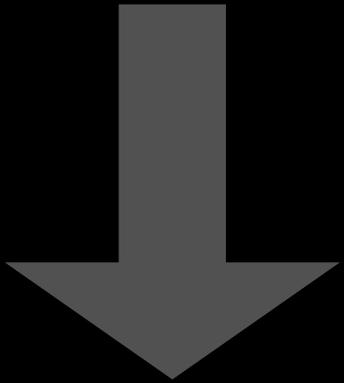
虽然 北 风 呼 啸 ， 但 天 空 依 然 十 分 清 澈 。



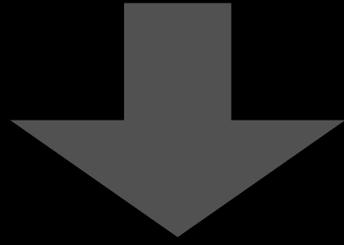
configuration



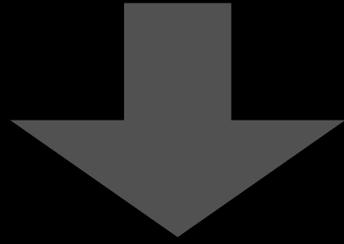
configuration



configuration

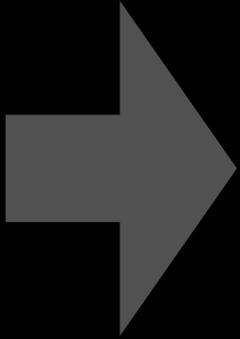


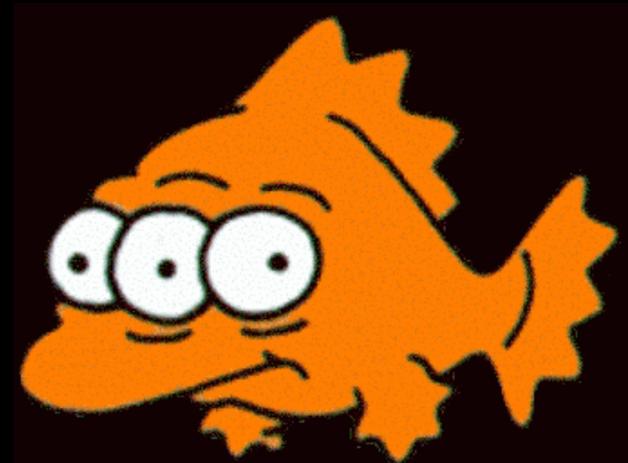
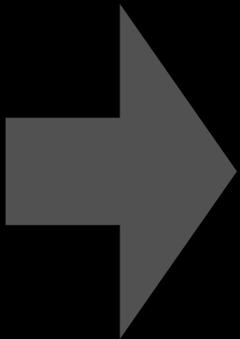
Our enemies are innovative and resourceful, and so are we. They never stop thinking about new ways to harm our country and our people, and neither do we.



Our enemies are innovative and resourceful, and so are we. They never stop thinking about new ways to harm our country and our people, and neither do we.







However

$$p(\textit{However} | \textit{START})$$

However ,

$p(, | \textit{However})$

However , the

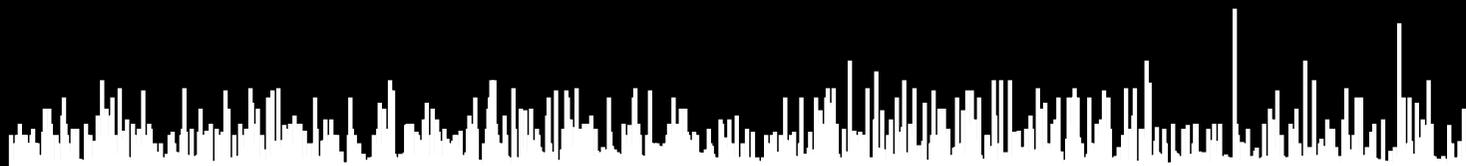
$$p(\textit{the} | ,)$$

However , the sky

$$p(\textit{sky}|\textit{the})$$

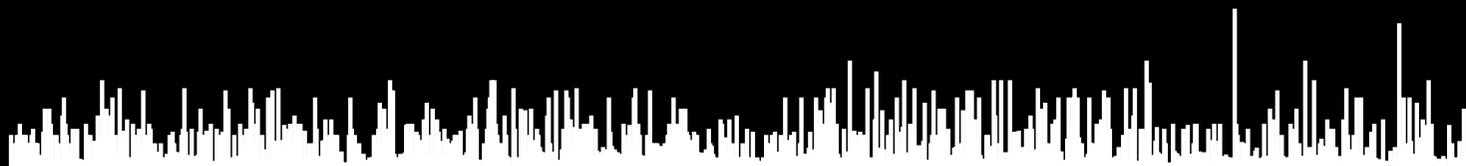
$$p(\textit{English}) = \prod_{i=1}^{\textit{length}(\textit{English})} p(\textit{word}_i | \textit{word}_{i-1})$$

$p(\textit{Chinese}|\textit{English})$

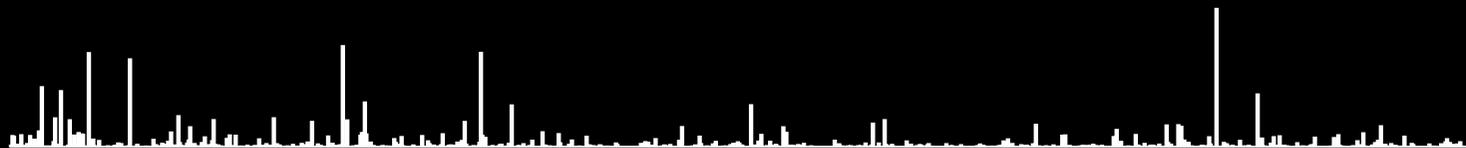


English

$p(\textit{Chinese}|\textit{English})$



$\times p(\textit{English})$

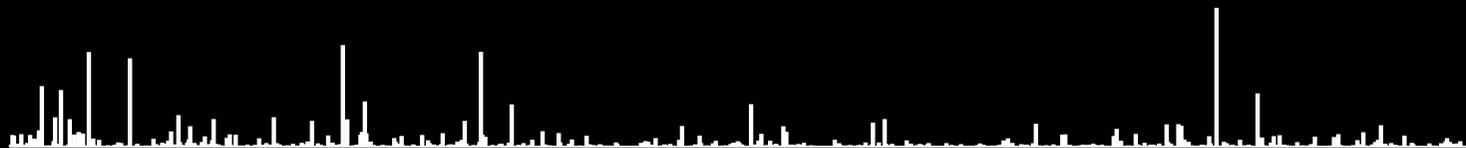


English

$p(\textit{Chinese}|\textit{English})$



$\times p(\textit{English})$

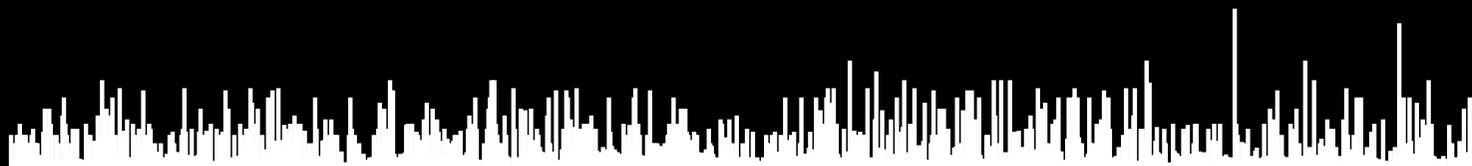


$= p(\textit{English}|\textit{Chinese})$

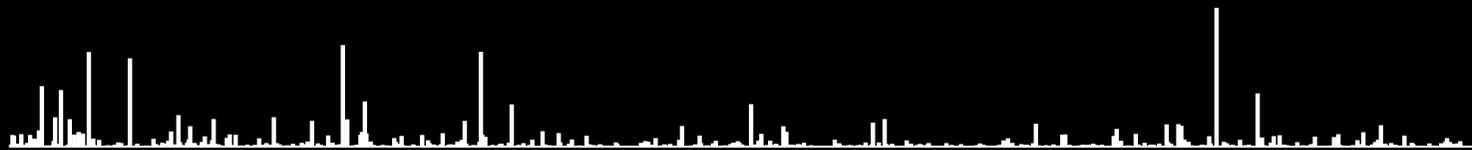


English

$$p(\textit{Chinese}|\textit{English})^1$$



$$\times p(\textit{English})^1$$

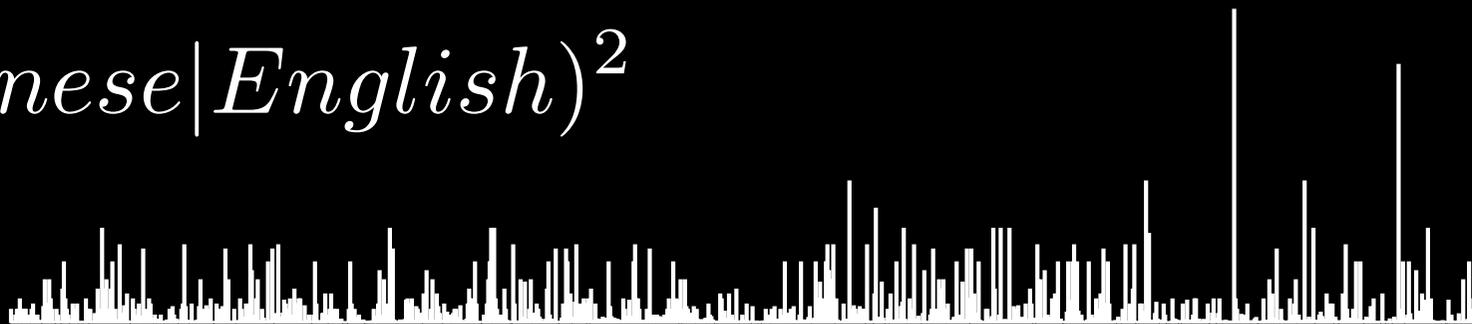


$$= p(\textit{English}|\textit{Chinese})$$

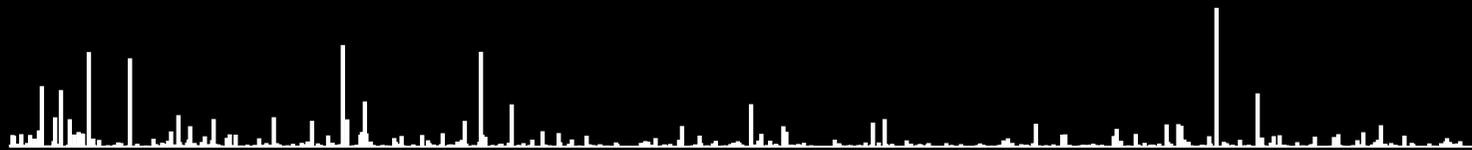


English

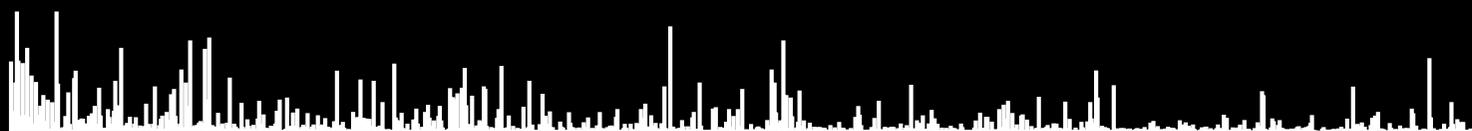
$$p(\textit{Chinese}|\textit{English})^2$$



$$\times p(\textit{English})^1$$



$$= \textit{score}(\textit{English}|\textit{Chinese})$$

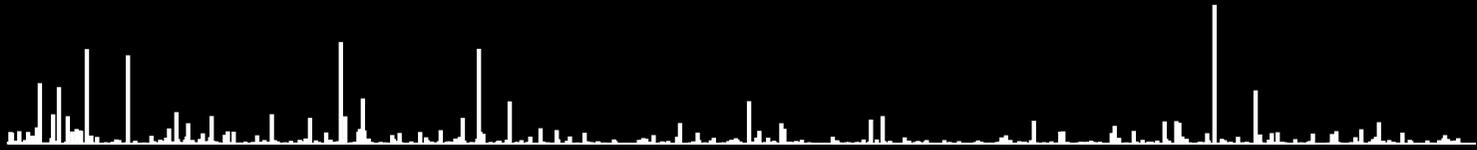


English

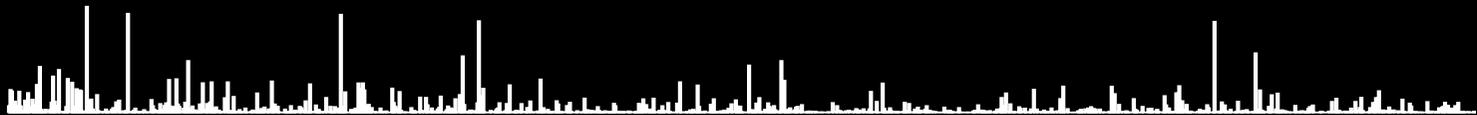
$$p(\textit{Chinese}|\textit{English})^{1/2}$$



$$\times p(\textit{English})^1$$



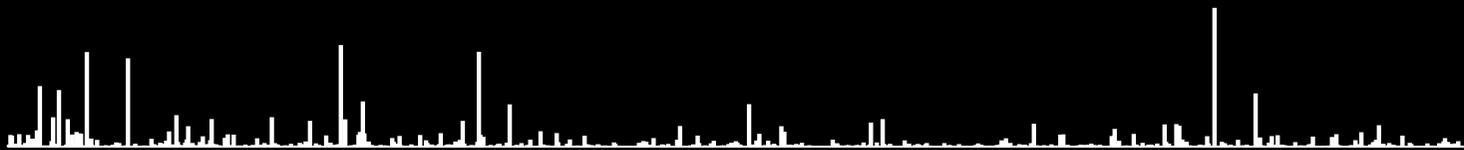
$$= \textit{score}(\textit{English}|\textit{Chinese})$$



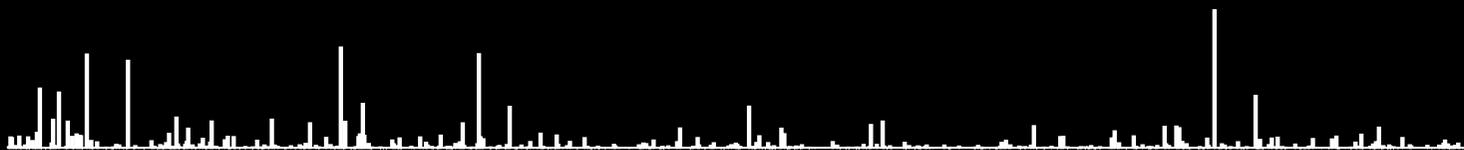
English

$$p(\textit{Chinese}|\textit{English})^0$$

$$\times p(\textit{English})^1$$



$$= \textit{score}(\textit{English}|\textit{Chinese})$$

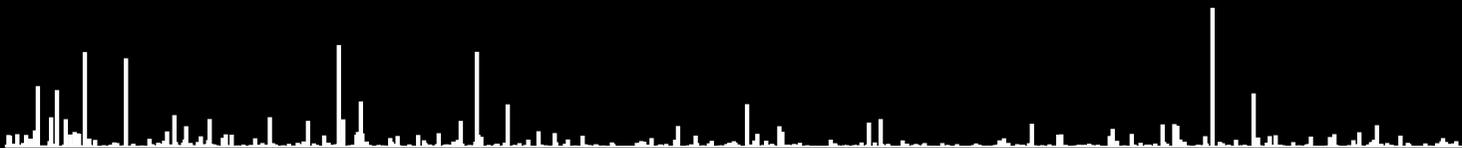


English

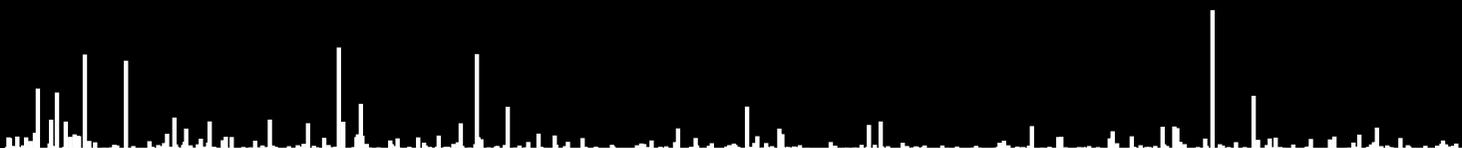
$$0 \cdot \log p(\textit{Chinese}|\textit{English})$$



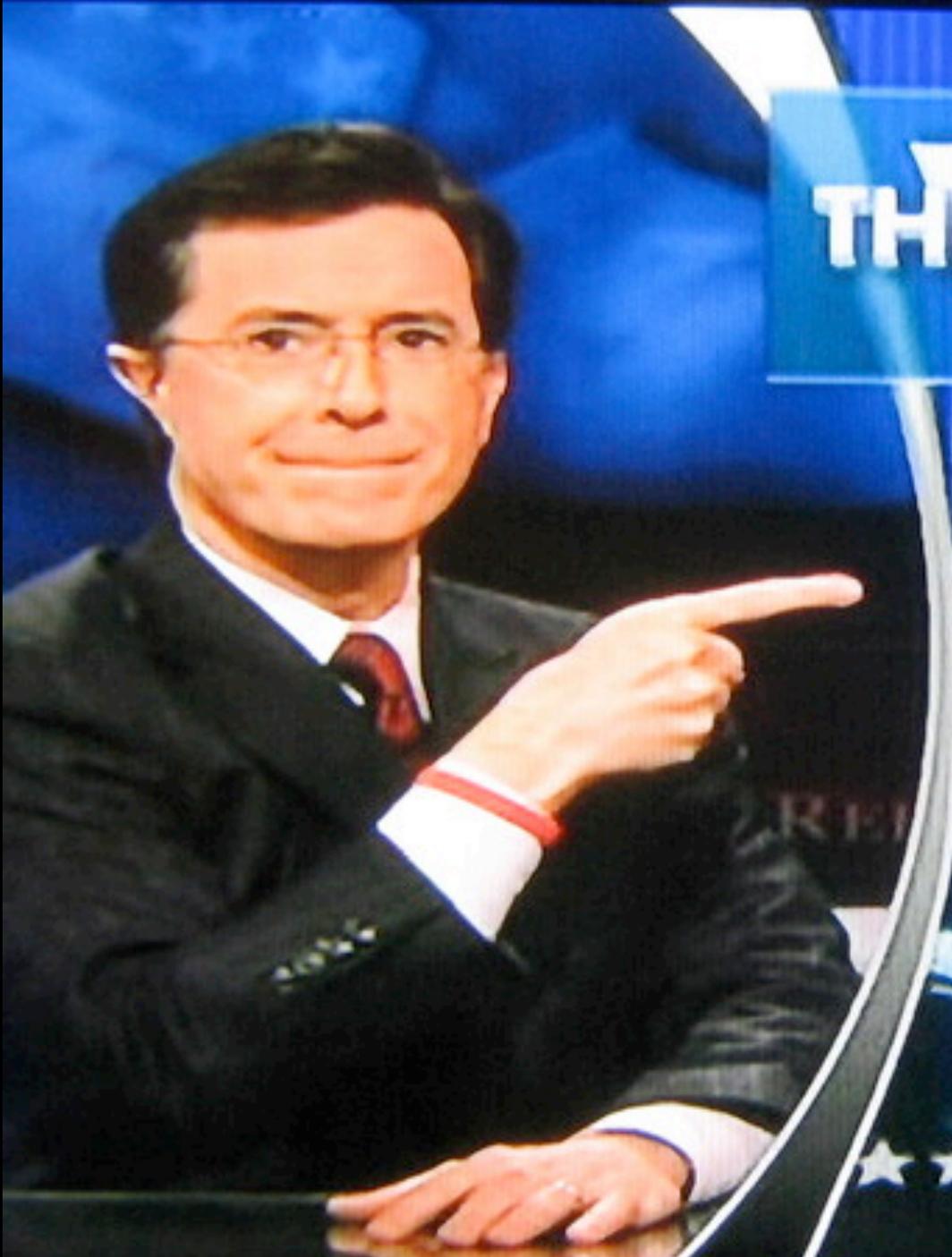
$$+1 \cdot \log p(\textit{English})$$



$$= \textit{score}(\textit{English}|\textit{Chinese})$$



English

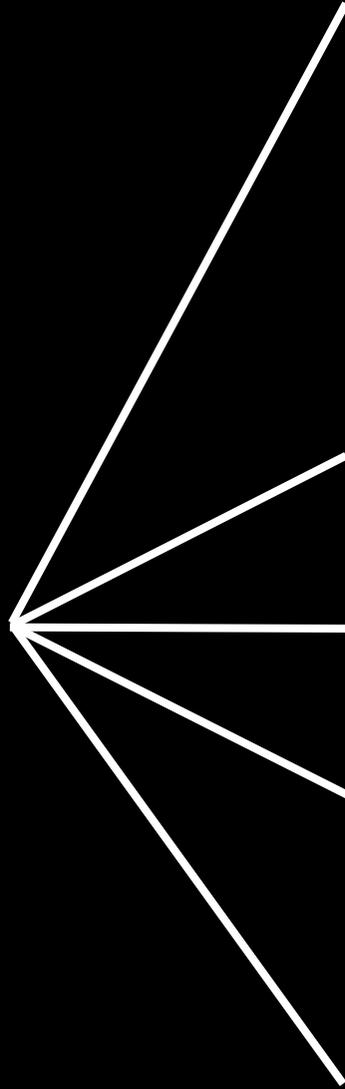
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THE WORD

Optimization

虽然北风呼啸，但天空依然十分清澈。

虽然北风呼啸，但天空依然十分清澈。



However

虽然北风呼啸，但天空依然十分清澈。

Although

虽然北风呼啸，但天空依然十分清澈。

The sky was still crystal clear

虽然北风呼啸，但天空依然十分清澈。

However

虽然北风呼啸，但天空依然十分清澈。

Although

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The sky was still crystal clear

虽然北风呼啸，但天空依然十分清澈。

Although the north wind screamed

虽然北风呼啸，但天空依然十分清澈。

Although the northern wind shrieked

虽然北风呼啸，但天空依然十分清澈。

Although a north wind

虽然北风呼啸，但天空依然十分清澈。

Although the north wind screamed

虽然北风呼啸，但天空依然十分清澈。

Although the northern wind shrieked

虽然北风呼啸，但天空依然十分清澈。

Although a north wind

虽然北风呼啸，但天空依然十分清澈。

Although the northern wind shrieked,

虽然北风呼啸，但天空依然十分清澈。

Although the northern wind shrieked across the sky

虽然北风呼啸，但天空依然十分清澈。

Although the northern wind shrieked, yet

虽然北风呼啸，但天空依然十分清澈。

Although the northern wind shrieked,

虽然北风呼啸，但天空依然十分清澈。

Although the northern wind shrieked across the sky

虽然北风呼啸，但天空依然十分清澈。

Although the northern wind shrieked, yet

虽然北风呼啸，但天空依然十分清澈。

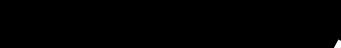
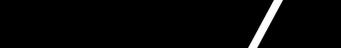
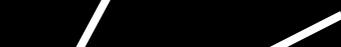
Although the northern wind shrieked across the sky,

→ 虽然北风呼啸，但天空依然十分清澈。



Although the northern wind shrieked across the sky,

虽然北风呼啸，但天空依然十分清澈。



Although the northern wind shrieked
across the sky, still quite

虽然北 风呼啸，但天空依然十分清澈。

Although the northern wind shrieked
across the sky, but was still very clear.

虽然北 风呼啸，但天空依然十分清澈。

Although the northern wind shrieked
across the sky, it remained crystal clear.

虽然北 风呼啸，但天空依然十分清澈。

Although the northern wind shrieked
across the sky, but was still very clear.



虽然北风呼啸，但天空依然十分清澈。

Although the northern wind shrieked
across the sky, but was still very clear.

虽然北风呼啸，但天空依然十分清澈。

A man with glasses, wearing a dark suit, white shirt, and red tie, is pointing his right index finger towards the right. He is positioned on the left side of the image. The background is a blue studio set with a world map and a row of stars at the bottom. The text 'THE WORD' is prominently displayed in the upper right quadrant.

THE WORD

Optimization



More has been written
about machine
translation evaluation
than about machine
translation itself.

Yorick Wilks

- Why evaluate?
 - Rank systems
 - Evaluate incremental changes
 - Assess new ideas objectively

美国愿和北韩谈判但拒绝再付出报酬

US willing to negotiate with North Korea
but not to pay more compensation.

美国愿和北韩谈判但拒绝再付出报酬

US willing to negotiate with North Korea
but not to pay more compensation.

The United States is willing to hold
talks with North Korea but refused to
pay remuneration.

“奋进”号因机械手故障推迟到升空

Launch of “Endeavour” delayed by
robotic arm problems.

“奋进”号因机械手故障推迟到升空

Launch of “Endeavour” delayed by
robotic arm problems.

“Progress” postponed because of
mechanical hand into the sky.

与此同时,欧陆各地和以外地区的民防单位都表示,降雪已使道路封闭、火车误点和机场瘫痪。

In the meantime, civil defense services across the European continent and beyond all indicated that snowfalls have blocked roads, delayed trains, and paralyzed airports.

与此同时,欧陆各地和以外地区的民防单位都表示,降雪已使道路封闭、火车误点和机场瘫痪。

In the meantime, civil defense services across the European continent and beyond all indicated that snowfalls have blocked roads, delayed trains, and paralyzed airports.

Meanwhile, land and other regional civil defense units have all said to down the road closure and train mistakenly points and the airport.

Chinese people in the traditional Spring Festival is approaching, the CPC Central Committee this afternoon in Zhongnanhai on the 22nd non-Party personages to convene a forum in Spring Festival, invited the central committees of democratic parties, the leadership of the National Federation of Industry and Commerce and personages without party affiliation on behalf of comrades gathered together State yes, talked in length about the friendship, to greet the Chinese New Year. CPC Central Committee General Secretary and State President and Central Military Commission Chairman Hu Jintao on behalf of the CPC Central Committee, the State Council, to the central committees of democratic parties, leaders of the National Federation of Industry and Commerce and personages without party affiliation, to members of the united front, to extend my New Year's blessing.

Although the northern wind shrieked across
the sky , it was still very clear .

Although the northern wind shrieked across the sky , it was still very clear .

However , the sky remained clear under the strong north wind .

Although the northern wind shrieked across the sky, it was still very clear.

However, the sky remained clear under the strong north wind.

Although the northern wind shrieked across the sky , it was still very clear .

However , the sky remained clear under the strong north wind .

Although a north wind was howling , the sky remained clear and blue .

The sky was still crystal clear , though the north wind was howling .

Despite the strong northerly winds , the sky remains very clear .

Although the northern wind shrieked across the sky , it was still very clear .

However , the sky remained clear under the strong north wind .

Although a north wind was howling , the sky remained clear and blue .

The sky was still crystal clear , though the north wind was howling .

Despite the strong northerly winds , the sky remains very clear .

Although the northern wind shrieked across the sky , it was still very clear .

unigram: 11/15 bigram: 4/14 trigram: 1/13

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unigram: 3/3 bigram: 2/2 trigram: 1/1

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brevity penalty: 3/12

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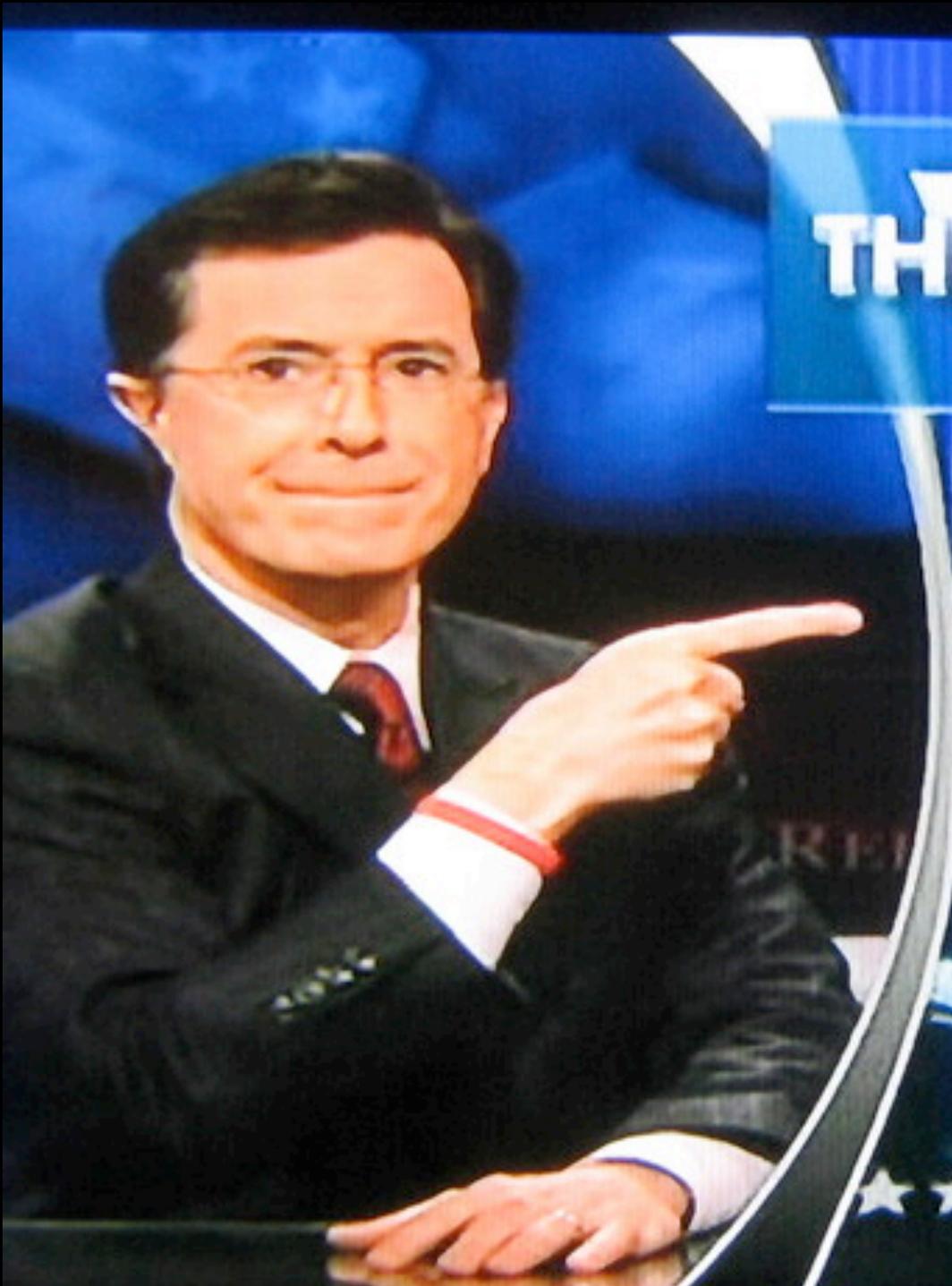
BiLingual Evaluation Understudy

BLEU-1	BEwT-E	RTE
BLEU-4	Badger	RTE-MT
BLEU-v11b	BadgerLite	SEPIA1
BLEU-v12	Bleu-sbp	SEPIA2
METEOR-v0.6	BleuSP	SNR
NIST-v11b	CDer	SR-Or
TER-v0.7.254-GRR	DP-Or	SVM-Rank
ATEC1	DP-Orp	TERp
ATEC2	DR-Or	ULCh
ATEC3	EDPM	ULCopt
ATEC4	LET	invWer
Meteor-v0.7	METEOR-ranking	mBLEU
	MaxSim	mTER

BLEU(MT output)

$BLEU(\operatorname{argmax}_{English} \operatorname{score}(English|Chinese))$

$$\sum_{\text{Chinese} \in \text{Test}} BLEU(\operatorname{argmax}_{\text{English}} \text{score}(\text{English} | \text{Chinese}))$$

A man in a dark suit, white shirt, and red tie, wearing glasses, is pointing his right index finger towards the right. He is positioned on the left side of the image. The background is a blue studio set with a world map and a row of stars at the bottom. The text 'THE WORD' is prominently displayed in the upper right.

THE WORD

Optimization



Max Blues Training

Evaluation drives MT research

- Metrics can drive the research for the topics that they evaluate
- NIST MT Eval / DARPA Sponsorship
- Bleu has lead to a focus on phrase-based translation
- Maximum BLEU training
- Other metrics may similarly change the community's focus

When writing a paper

- If you're writing a paper that claims that
 - one approach to machine translation is better than another, or that
 - some modification you've made to a system has improved translation quality
- Then you need to back up that claim
- Evaluation metrics can help, but good experimental design is also critical

Experimental Design

- Separating training / test / development sets
- Standardized data sets
- Standardized evaluation metric
- Error analysis
- Statistical significance



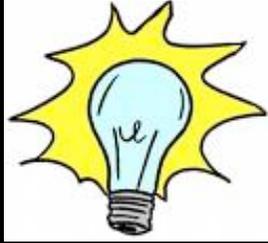
idea



idea



implementation



idea



implementation



32.6

experiment



?

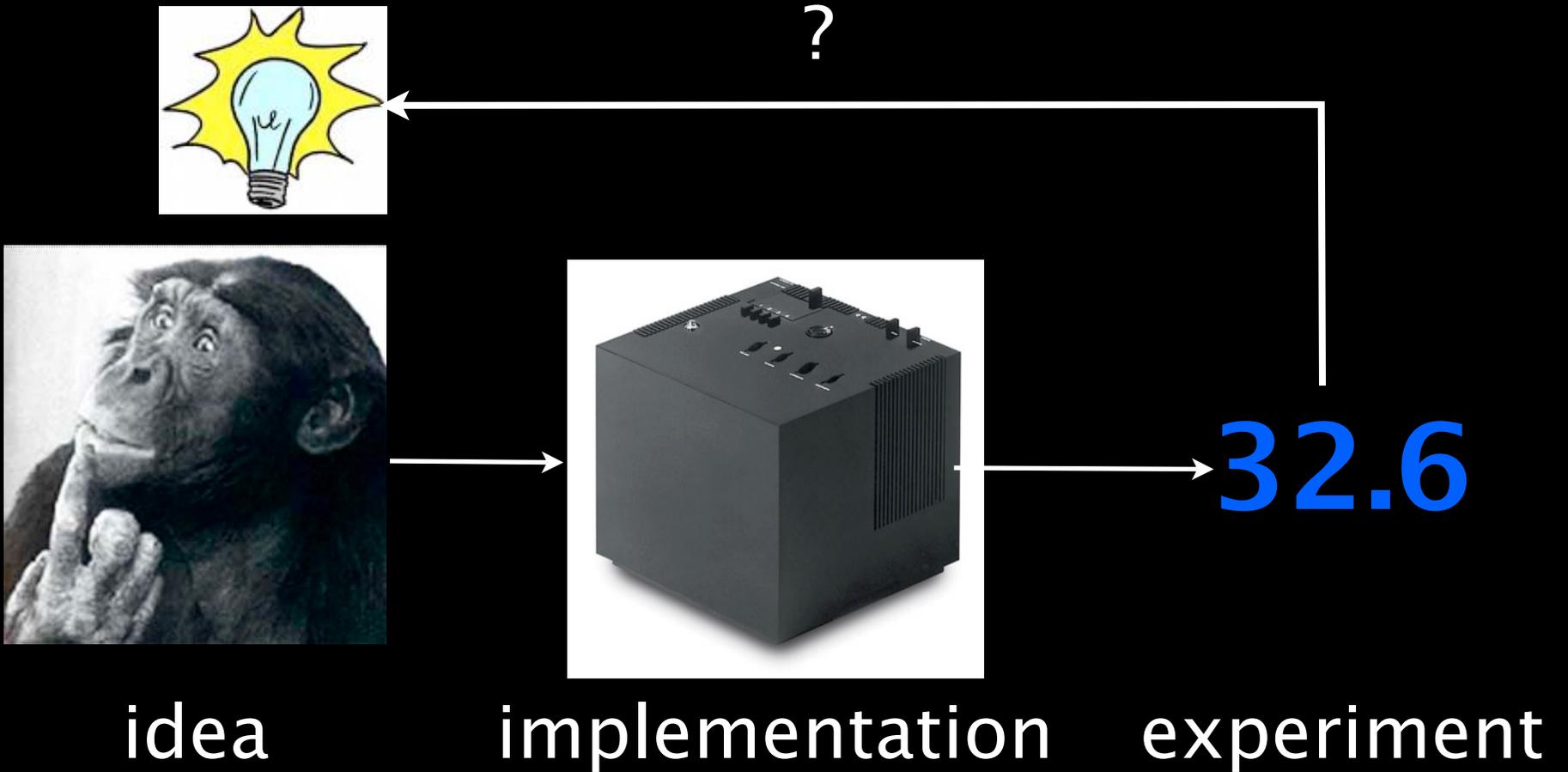


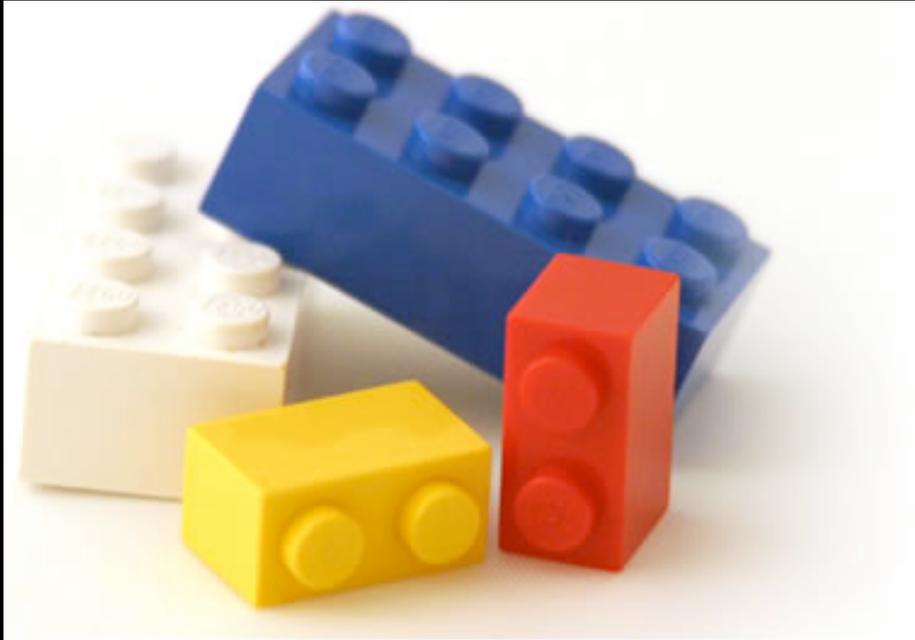
32.6

idea

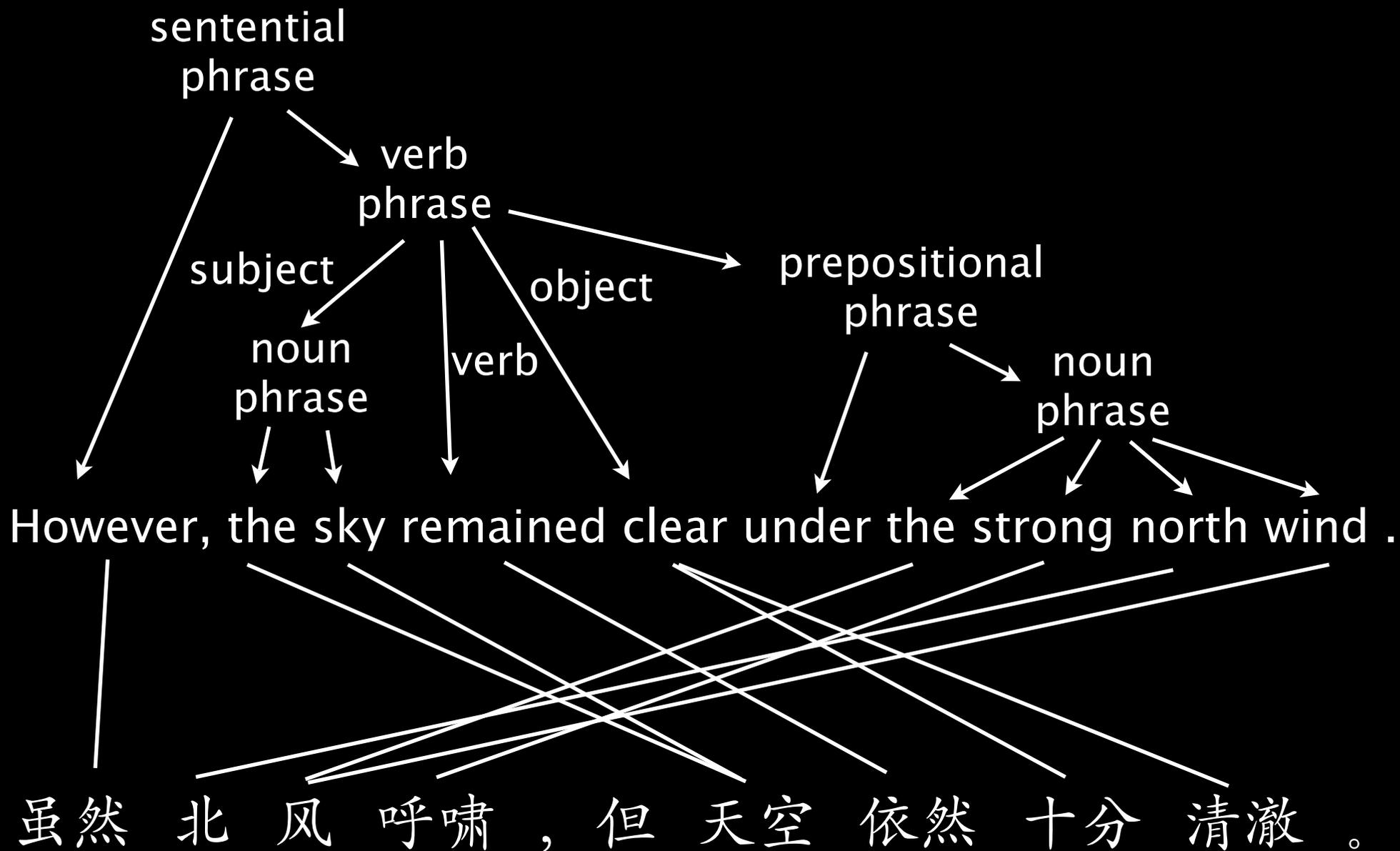
implementation

experiment





- www.statmt.org/euoparl/
- www.fjoch.com/GIZA++.html
- www.statmt.org/moses/
- Open source tools from this week.



Some of my best
friends are linguists.

Fred Jelinek (2004)



Open Problems

- What do we do when there's not enough (or any) parallel data?
- What do we do for out-of-domain data?
- What is the best learning algorithm?
- What is the best model?
- What is the best evaluation function?

- <http://www.statmt.org> - papers, tutorials, etc.
- Statistical Machine Translation. In *ACM Computing Surveys* 40(3), Aug 2008.

At <http://homepages.inf.ed.ac.uk/alopez>

BibTeX at <http://github.com/alopez/smtbib>