Linguistic properties of multi-word passphrases

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Passphrases an increasingly attractive approach

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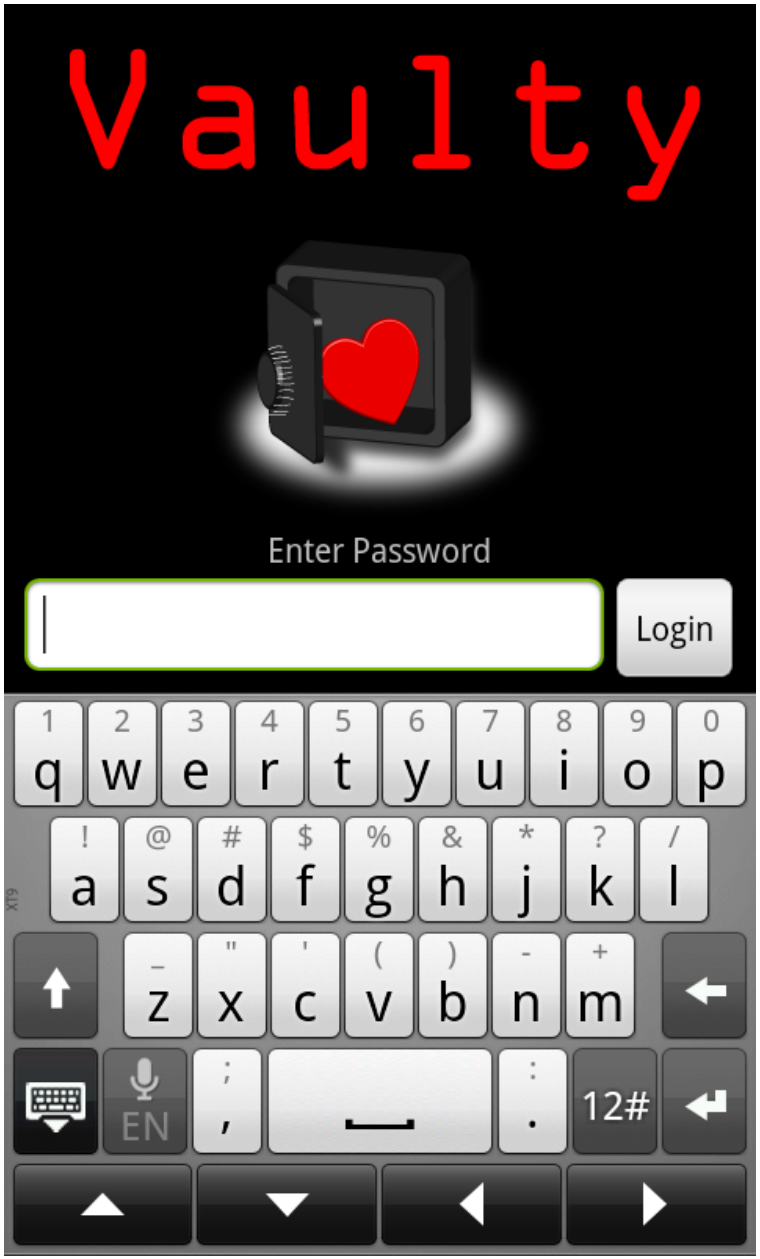
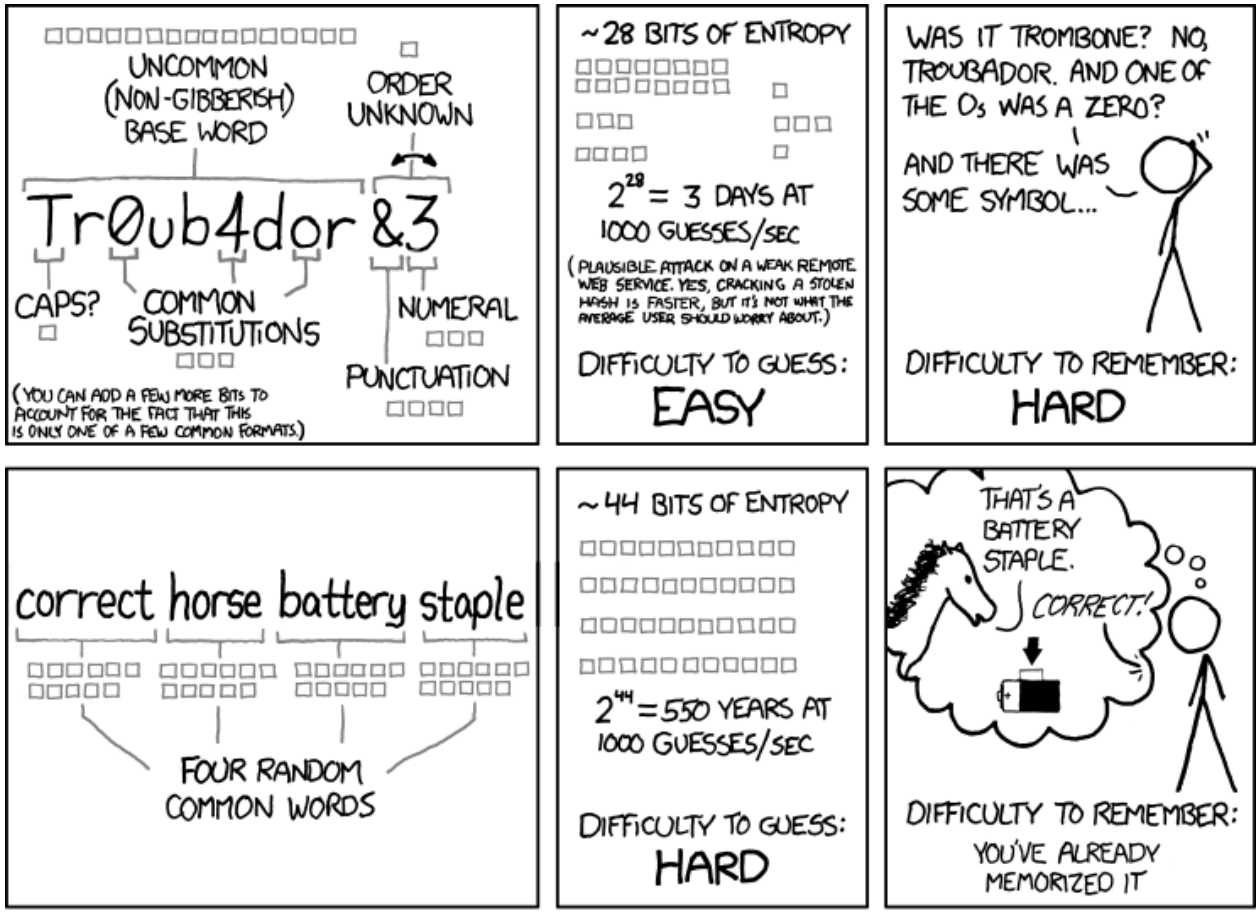


Passphrases an increasingly attractive approach



xkcd #936

What do we know about passphrase guessing?

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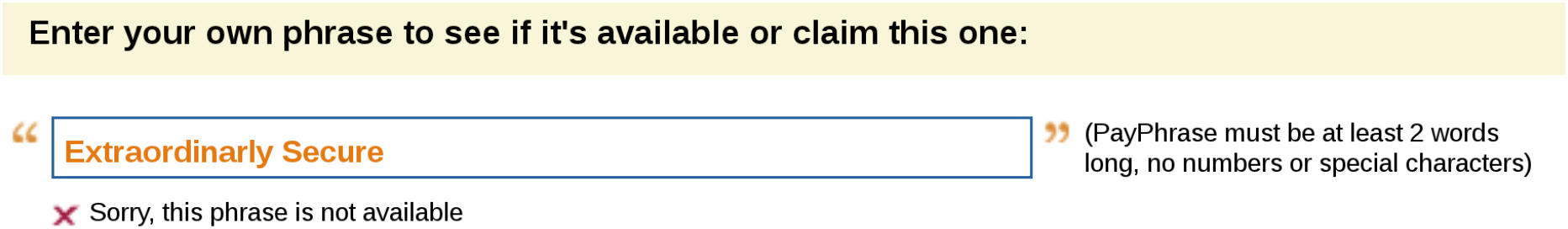
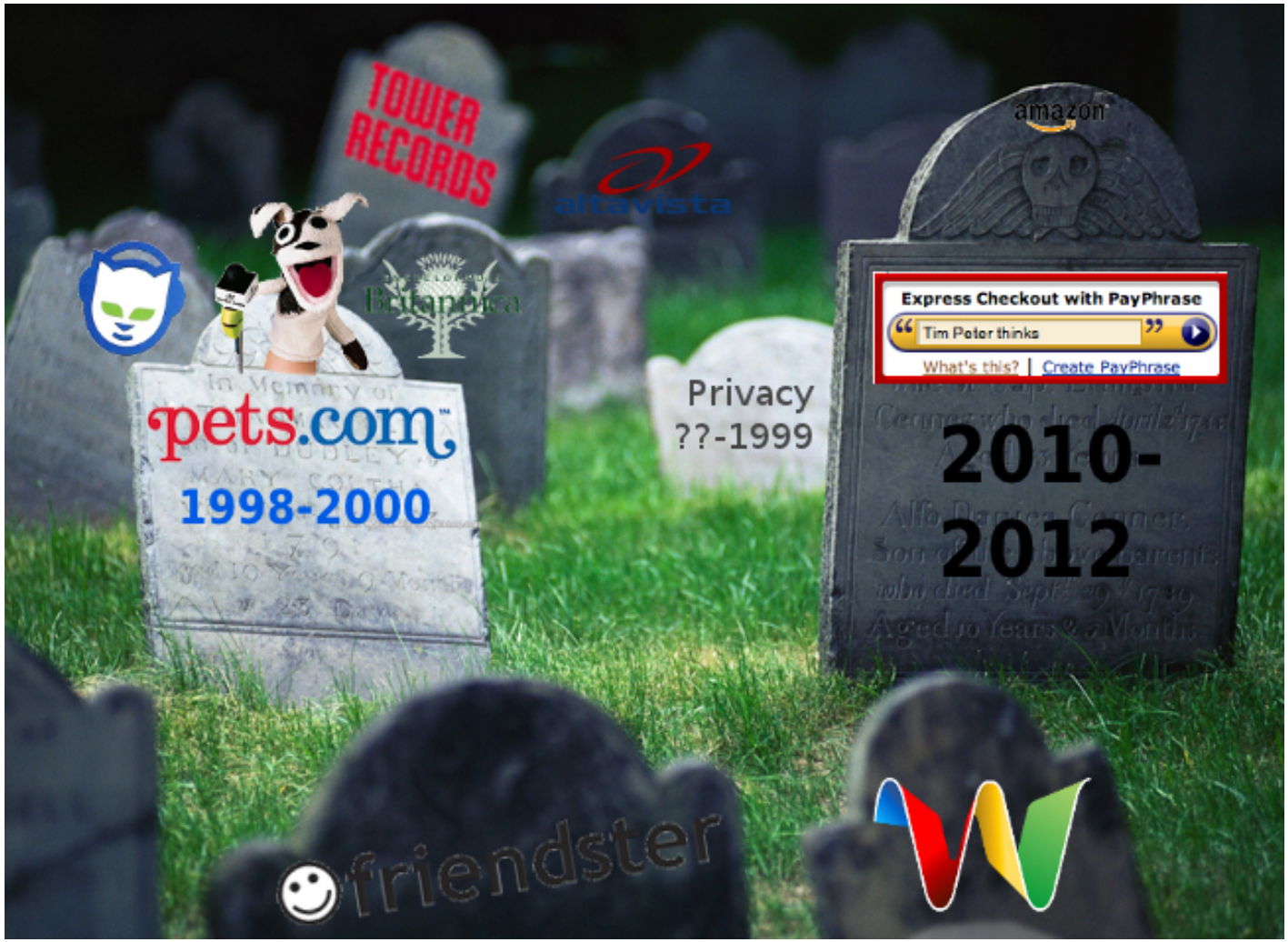
Data source: Amazon PayPhrases



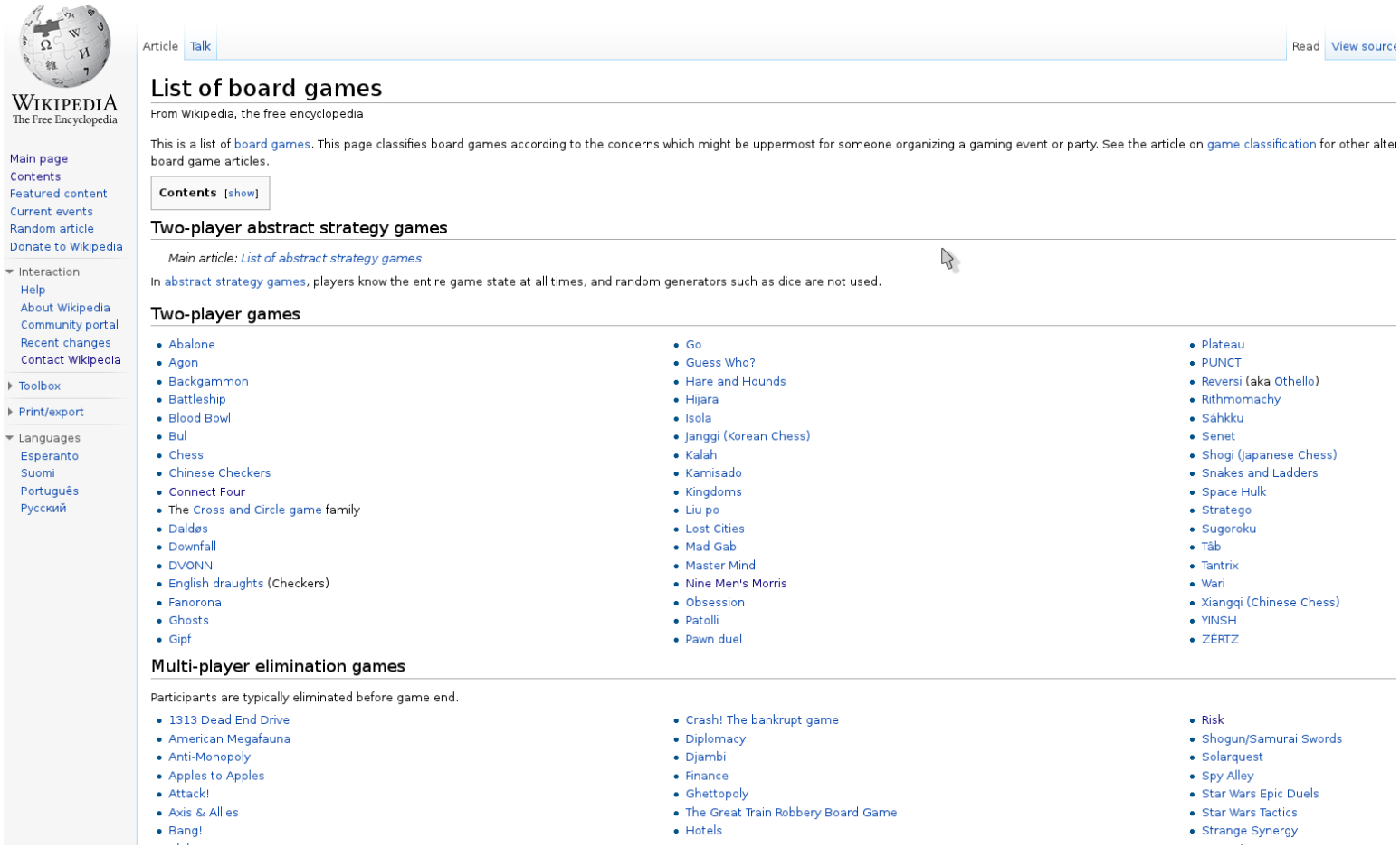
- must be at least two words
- must be globally unique
  - security $\leftarrow$ PIN + passphrase
- can only contain the letters a-z, A-Z, SPACE
  - capitalisation and spacing ignored

Data source: Amazon PayPhrases



PayPhrases killed 2012-02-20

A simple dictionary attack



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List of board games

From Wikipedia, the free encyclopedia

This is a list of board games. This page classifies board games according to the concerns which might be uppermost for someone organizing a gaming event or party. See the article on game classification for other alter board game articles.

Contents [show]

Two-player abstract strategy games

Main article: List of abstract strategy games

In abstract strategy games, players know the entire game state at all times, and random generators such as dice are not used.

Two-player games

- Abalone
- Agon
- Backgammon
- Battleship
- Blood Bowl
- Bul
- Chess
- Chinese Checkers
- Connect Four
- The Cross and Circle game family
- Dalđøs
- Downfall
- DVONN
- English draughts (Checkers)
- Fanorona
- Ghosts
- Gipf
- Go
- Guess Who?
- Hare and Hounds
- Hijara
- Isola
- Janggi (Korean Chess)
- Kalah
- Kamisado
- Kingdoms
- Liu po
- Lost Cities
- Mad Gab
- Master Mind
- Nine Men's Morris
- Obsession
- Patolli
- Pawn duel
- Plateau
- PÜNCT
- Reversi (aka Othello)
- Rithmomachy
- Sáhkku
- Senet
- Shogi (Japanese Chess)
- Snakes and Ladders
- Space Hulk
- Stratego
- Sugoroku
- Tâb
- Tantrix
- Wari
- Xiangqi (Chinese Chess)
- YINSH
- ZÈRTZ

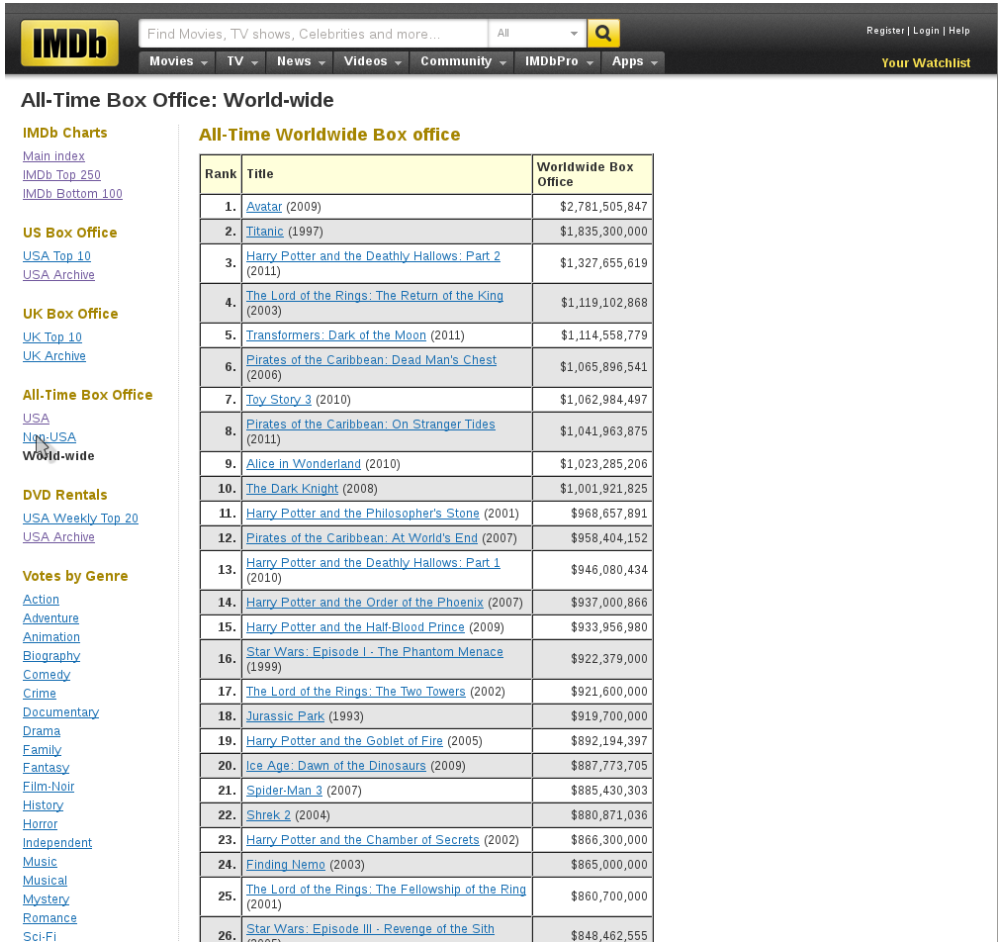
Multi-player elimination games

Participants are typically eliminated before game end.

- 1313 Dead End Drive
- American Megafauna
- Anti-Monopoly
- Apples to Apples
- Attack!
- Axis & Allies
- Bang!
- Crash! The bankrupt game
- Diplomacy
- Djambi
- Finance
- Ghettopoly
- The Great Train Robbery Board Game
- Hotels
- Risk
- Shogun/Samurai Swords
- Solarquest
- Spy Alley
- Star Wars Epic Duels
- Star Wars Tactics
- Strange Synergy

- proper nouns
- titles
- idiomatic phrases
- slang

A simple dictionary attack



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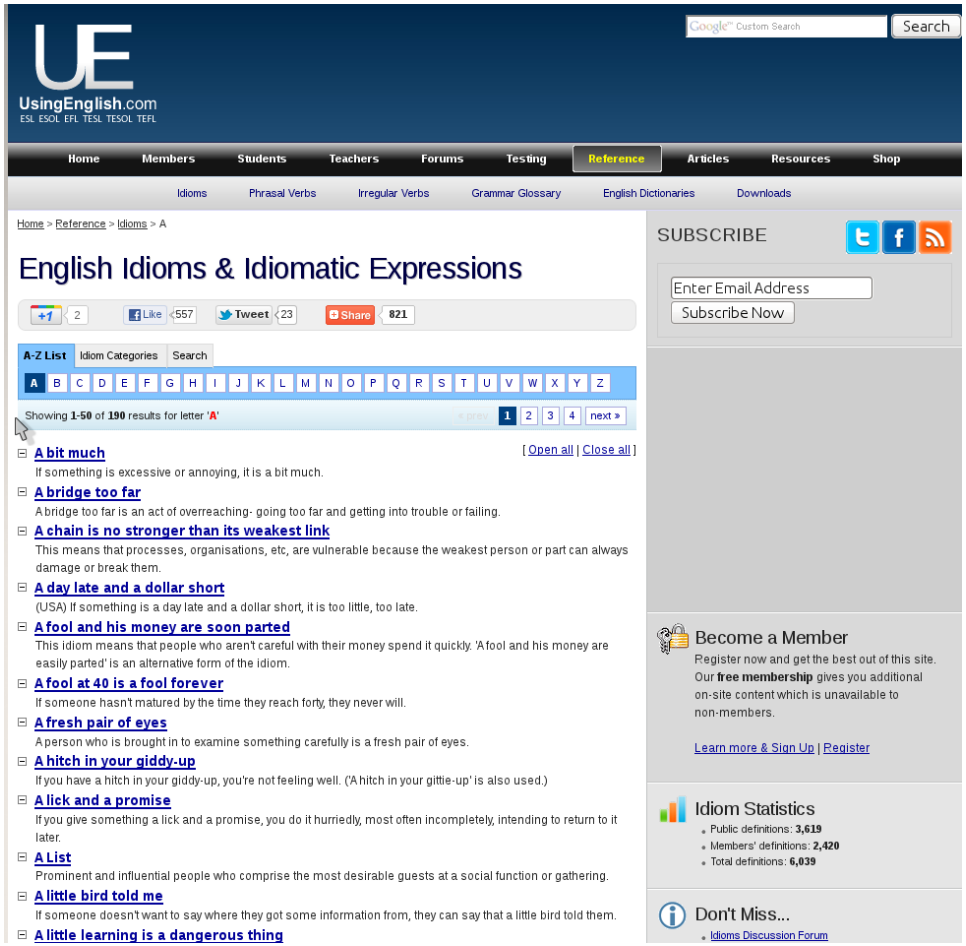

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A simple dictionary attack

- proper nouns
- titles
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Results

word list	example	list size	success rate	$\hat{p}$
	arts			
musicians	three dog night	679	49.5%	0.0464%
albums	all killer no filler	446	56.5%	0.0372%
songs	with or without you	476	72.9%	0.0623%
movies	dead poets society	493	69.6%	0.0588%
movie stars	patrick swayze	2012	28.1%	0.0663%
books	heart of darkness	871	47.0%	0.0553%
plays	guys and dolls	75	70.7%	0.0093%
operas	la gioconda	254	17.3%	0.0048%
TV shows	arrested development	836	46.3%	0.0520%
fairy tales	the ugly duckling	813	13.3%	0.0116%
paintings	birth of venus	268	11.2%	0.0032%
brand names	procter and gamble	456	17.3%	0.0087%
total		7679	38.5%	0.4159%
	sports teams			
NHL	new jersey devils	30	83.3%	0.0056%
NFL	arizona cardinals	32	87.5%	0.0070%
NBA	sacramento kings	29	93.1%	0.0085%
MLB	boston red sox	30	90.0%	0.0074%
NCAA	arizona wildcats	126	56.3%	0.0105%
fantasy sports	legion of doom	121	71.1%	0.0151%
total		368	71.7%	0.0542%
	sports venues			
professional stadiums	soldier field	467	14.1%	0.0071%
collegiate stadiums	beaver stadium	123	12.2%	0.0016%
golf courses	shadow creek	97	6.2%	0.0006%
total		687	12.7%	0.0094%

Results

word list	example	list size	success rate	$\hat{p}$
	games			
board games	luck of the draw	219	28.8%	0.0074%
card games	pegs and jokers	322	27.6%	0.0104%
video games	counter strike	380	28.4%	0.0127%
total		921	28.2%	0.0306%
	comics			
print comics	kevin the bold	1029	29.5%	0.0361%
web comics	something positive	250	16.8%	0.0046%
superheros	ghost rider	488	45.3%	0.0295%
total		1767	32.1%	0.0701%
	place names			
city, state (USA)	plano texas	2705	33.8%	0.1117%
multi-word city (USA)	maple grove	820	79.0%	0.1283%
city, country	lisbon portugal	479	35.7%	0.0212%
multi-word city	ciudad juarez	55	69.1%	0.0066%
total		4059	43.7%	0.2677%
	phrases			
sports phrases	man of the match	778	26.1%	0.0235%
slang	sausage fest	1270	45.0%	0.0761%
idioms	up the creek	3127	43.6%	0.1789%
total		5175	41.3%	0.2785%

Results

- Estimating $N = 10^6$, our 20k dictionary covers 1.1% of users
  - Equivalent to 20.8 bits
- Password comparison #1: 2 passwords cover 1.1% of users
  - Equivalent to 7.5 bits
- Password comparison #2: 20k dictionary covers 26.3% of users
  - Equivalent to 16.3 bits

Similar to mnemonic-phrase passwords

Which syntactic construction do users prefer?

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bigram type	example	list size	success rate
adverb-verb	probably keep	4999	5.0%
verb-adverb	send immediately	4999	1.9%
direct object-verb	name change	5000	1.2%
verb-direct object	spend money	5000	2.4%
verb-indirect object	go on holiday	4999	0.7%
nominal modifier-noun	operation room	4999	9.8%
subject-verb	nature explore	4999	1.3%

Phrases generated from British National Corpus/Robust Accurate Statistical Parser

Single objects or actions strongly preferred

Which factors predict a phrase's popularity?

Which factors predict a phrase's popularity?

bigram type	example	list size	success rate
adjective-noun	powerful form	10000	13.3%
noun-noun	island runner	10000	4.4%

Phrases generated from Google n-gram corpus

Which factors predict a phrase's popularity?

Possible selection models:

baseline	random
natural-language production	$p(w_1 \mid\mid w_2)$
independent word selection	$p(w_1) \cdot p(w_2)$
mutual information	$pmi(w_1, w_2) = \lg \frac{p(w_1 \mid\mid w_2)}{p(w_1) \cdot p(w_2)}$
blended model	$p(w_1 \mid\mid w_2) \cdot pmi(w_1, w_2)$

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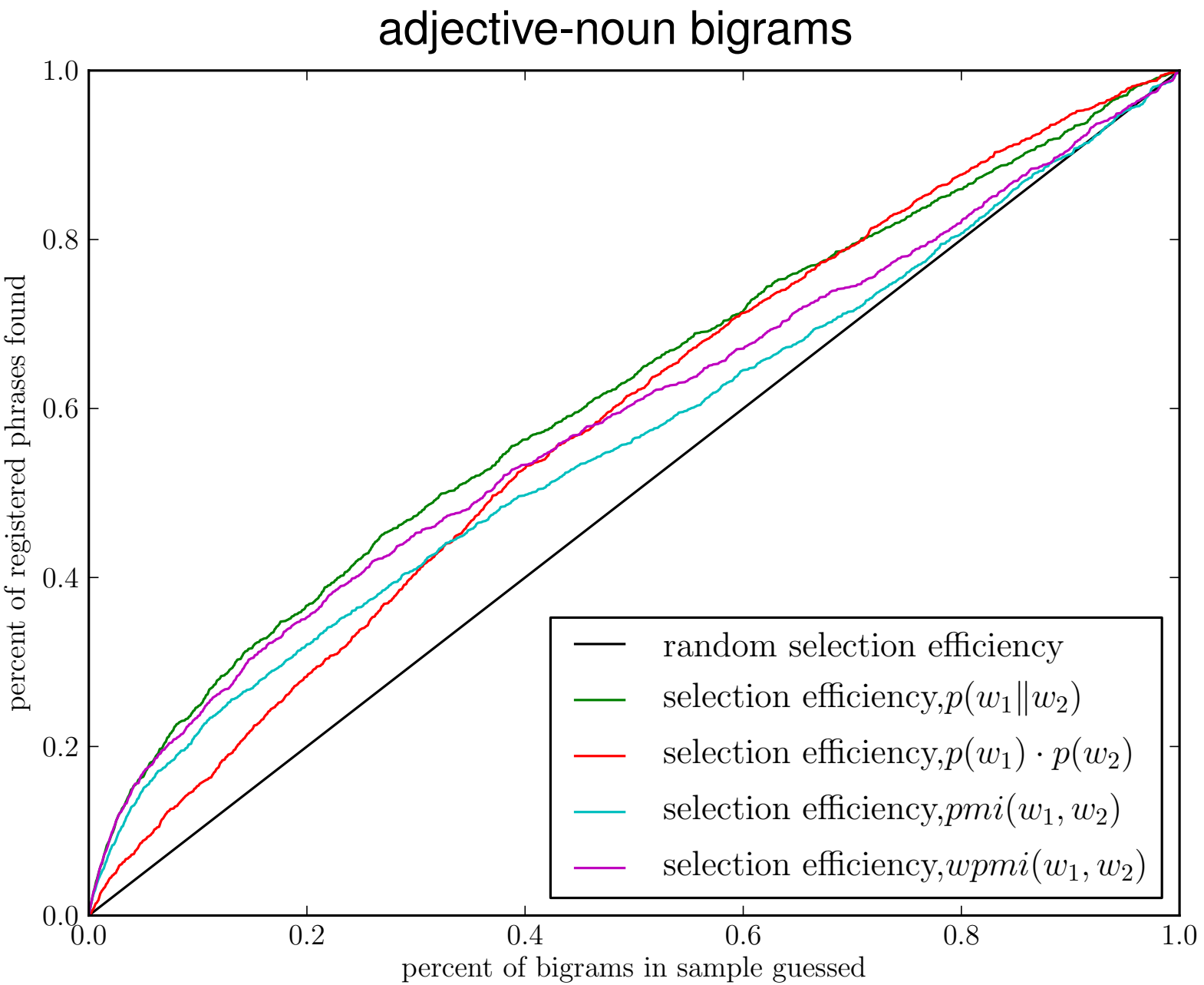

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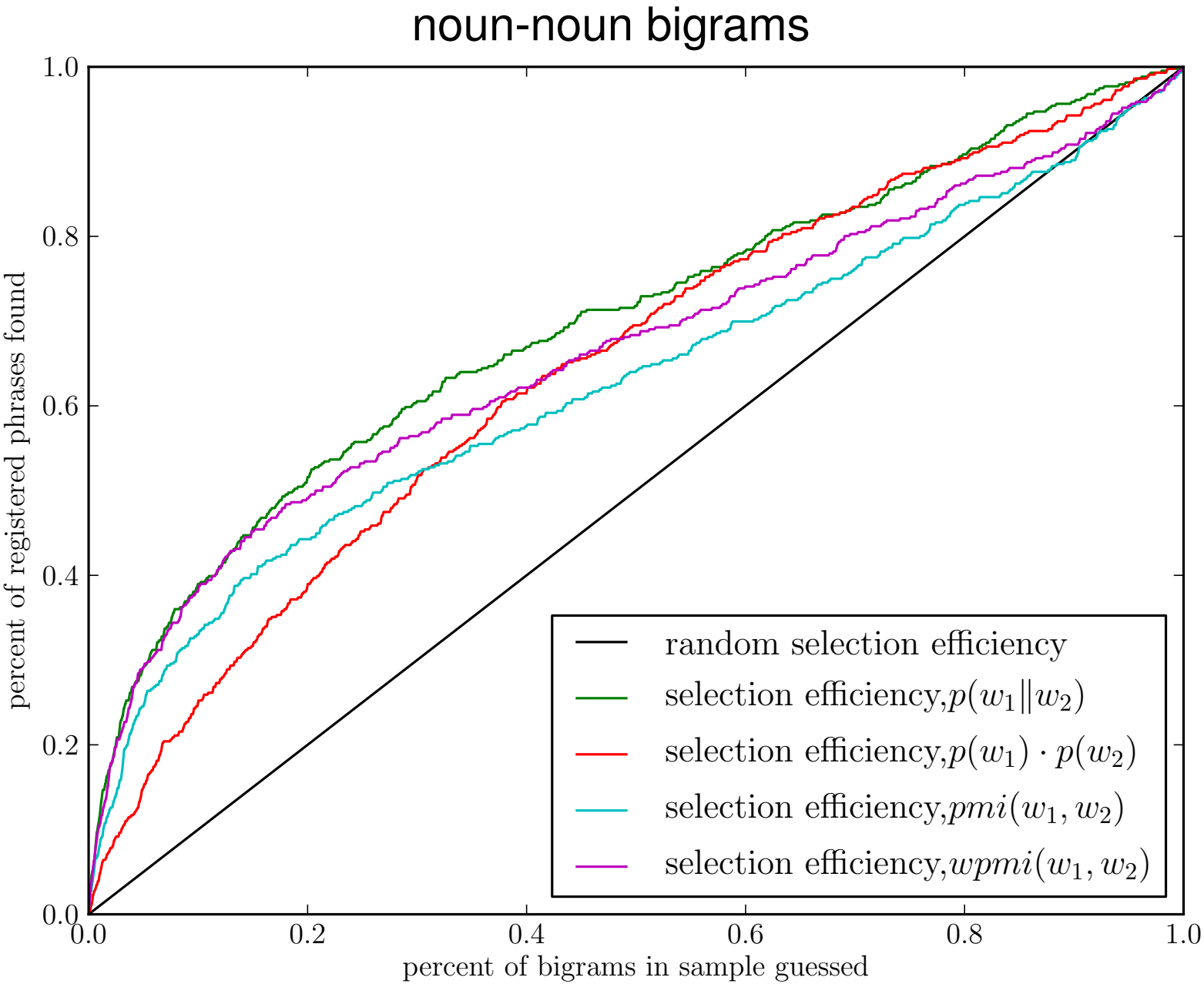

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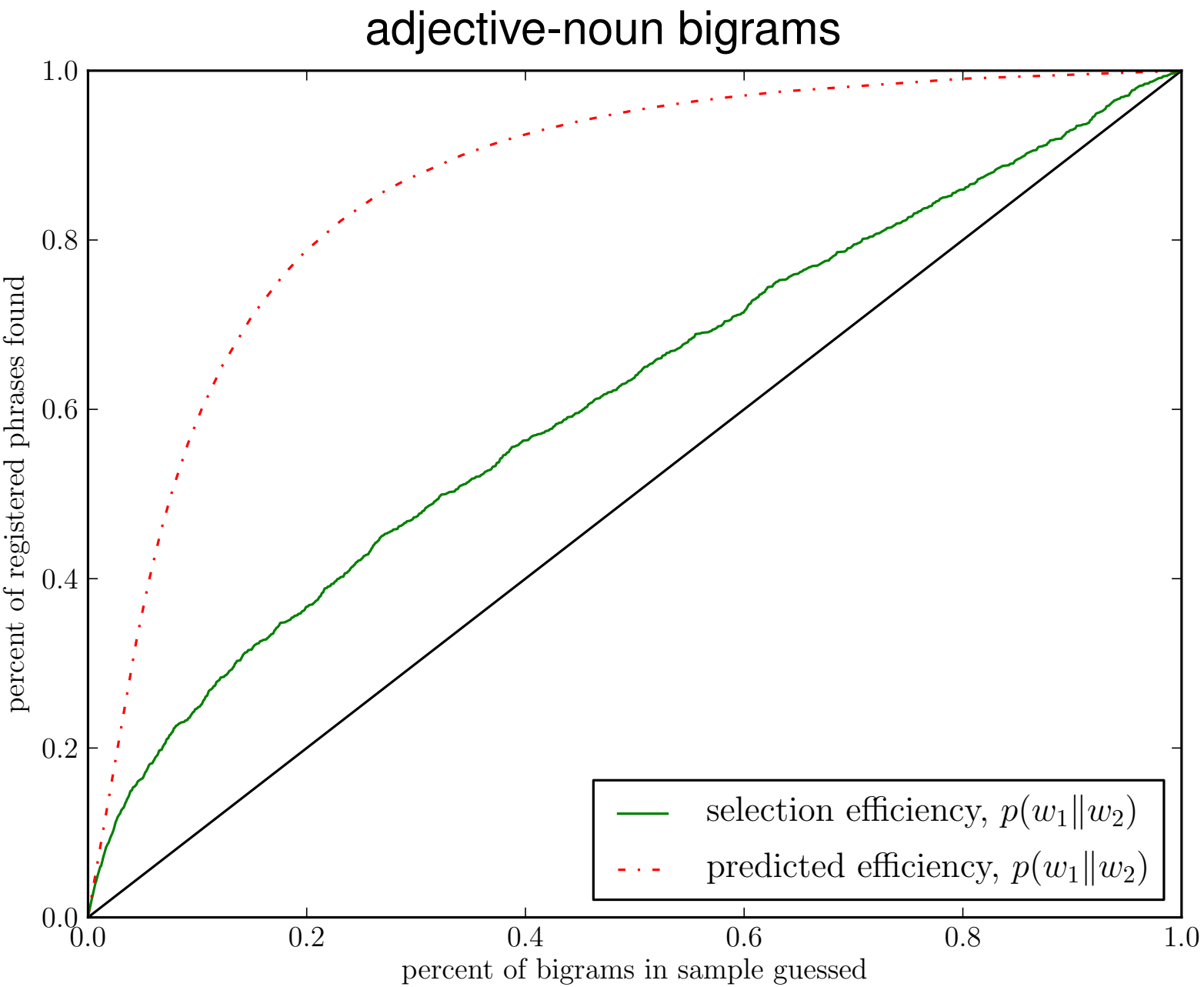

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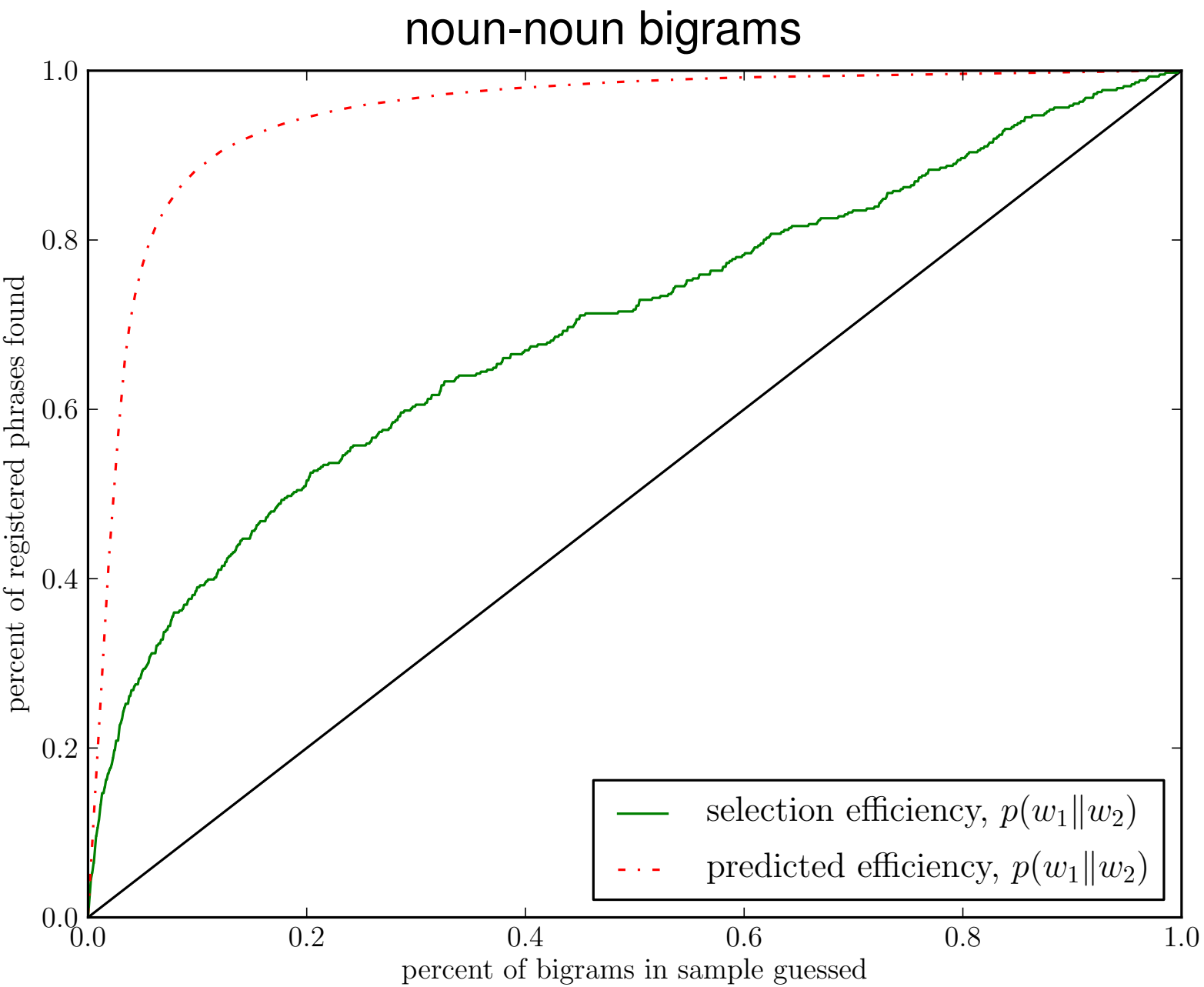

Are natural language phrases difficult to guess?

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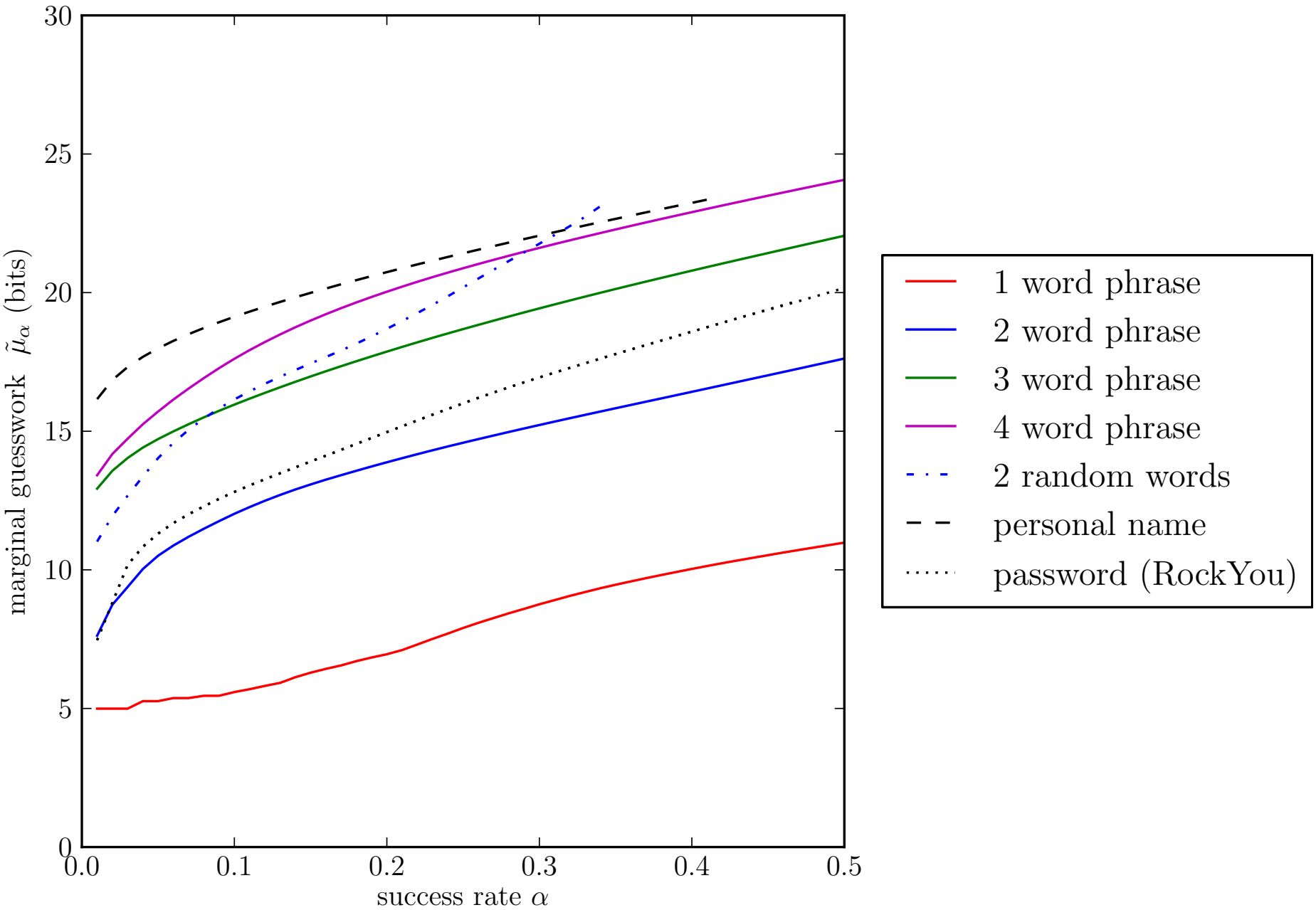

Thank you

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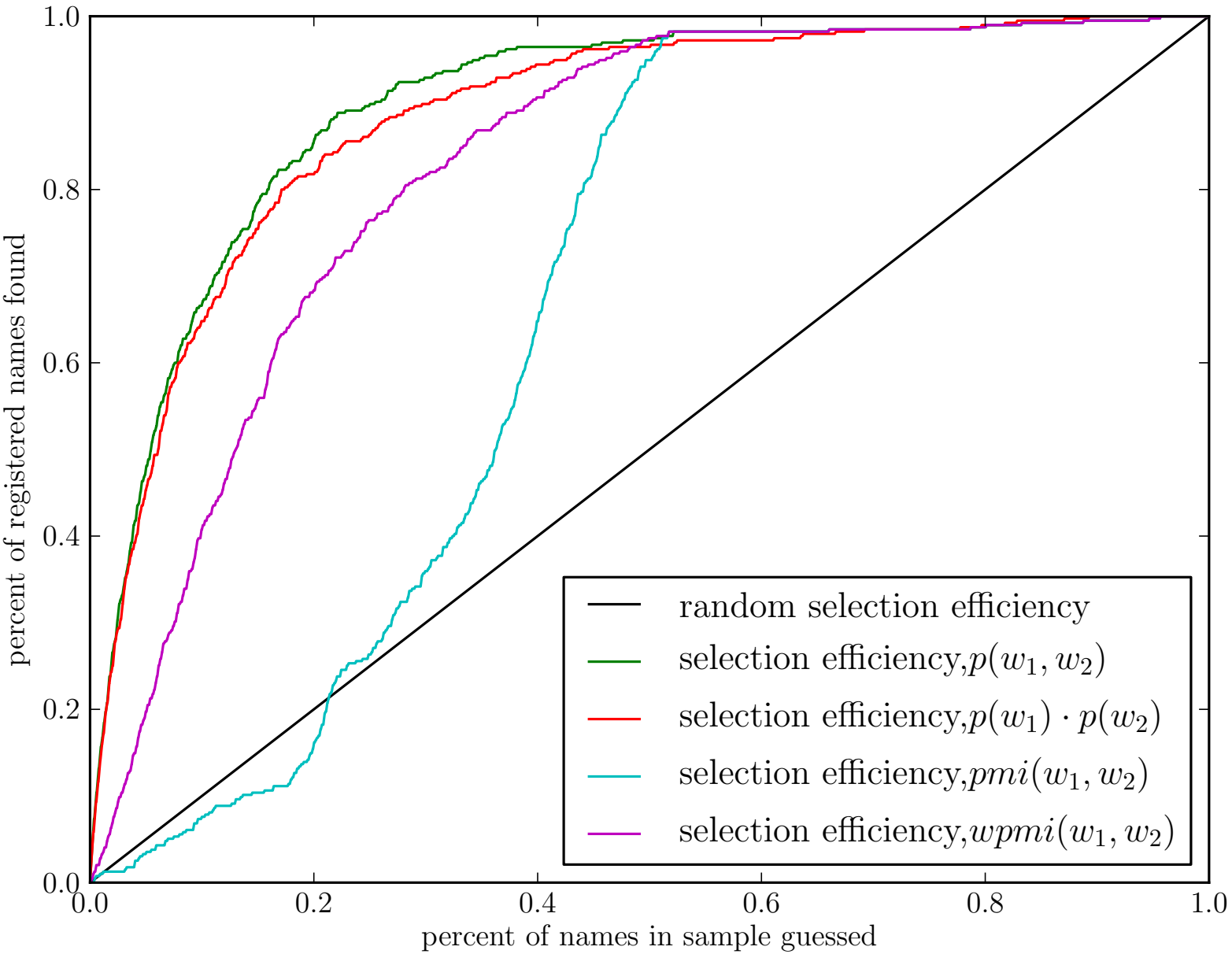
Similar results for names



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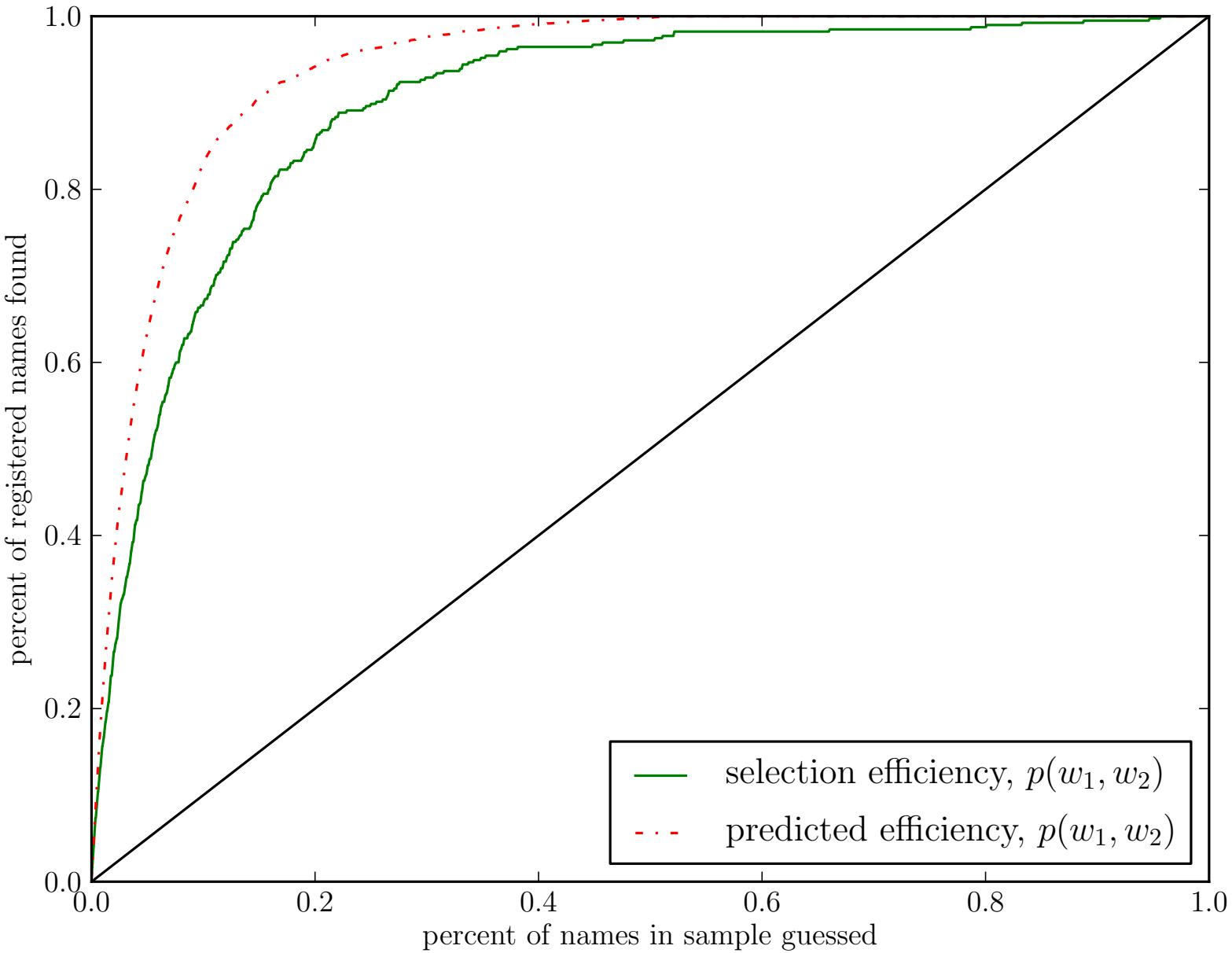

Estimating the probability of each class of phrase

Assumptions:

- N total phrases
- n phrases in this class of equal probability
- k were selected

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solve as a weighted coupon collector's problem:

$$\hat{p} = \frac{\prod_{j=1}^{k} \frac{n}{n-j}}{N \cdot n}$$