
# Robust Entity Clustering via Phylogenetic Inference

Nicholas Andrews
with Jason Eisner and Mark Dredze

human language technology
center of excellence

# Some data

Did **Taylor swift** just dis harry sytles on the #grammys ? Lmao

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# Entity clustering

(1)

Did **Taylor swift(1)** just dis harry sytles on the #grammys ? Lmao

Lets see how bad **T Swift(1)** will be. #grammys

Watching the Grammy's - it's clear that **T-Swizzle (1)** is on drugs. Lots of drugs.

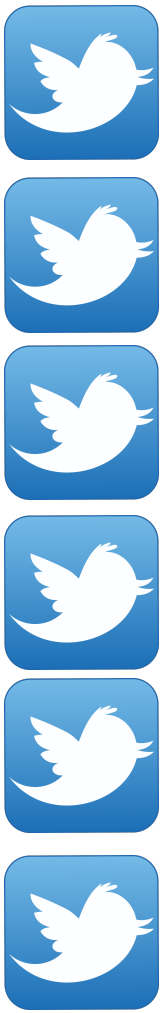
**Taylor swift(1)** is apart of the Illuminati #grammys

Ladies STILL love **LL Cool James(2)**.

**LL Cool J(2)** is looking reallllll chizzled!

(2)

# Key idea: “Directed” name variation



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Abbreviation

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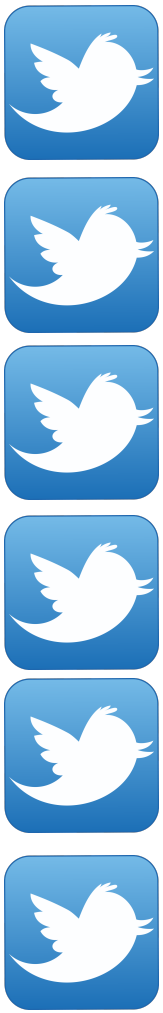

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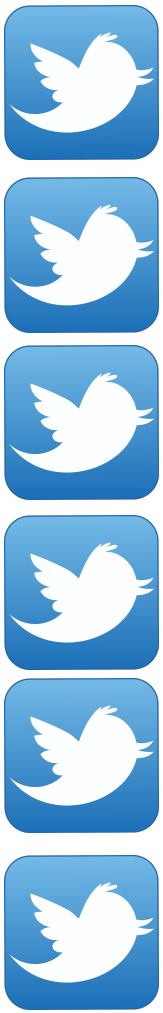

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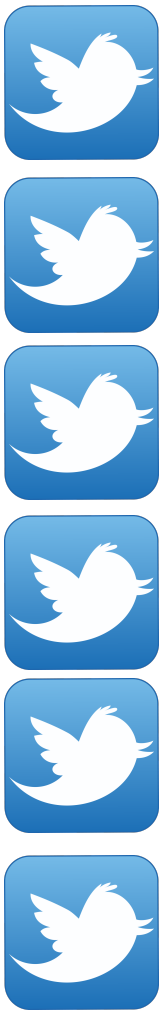

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**Abbreviation**

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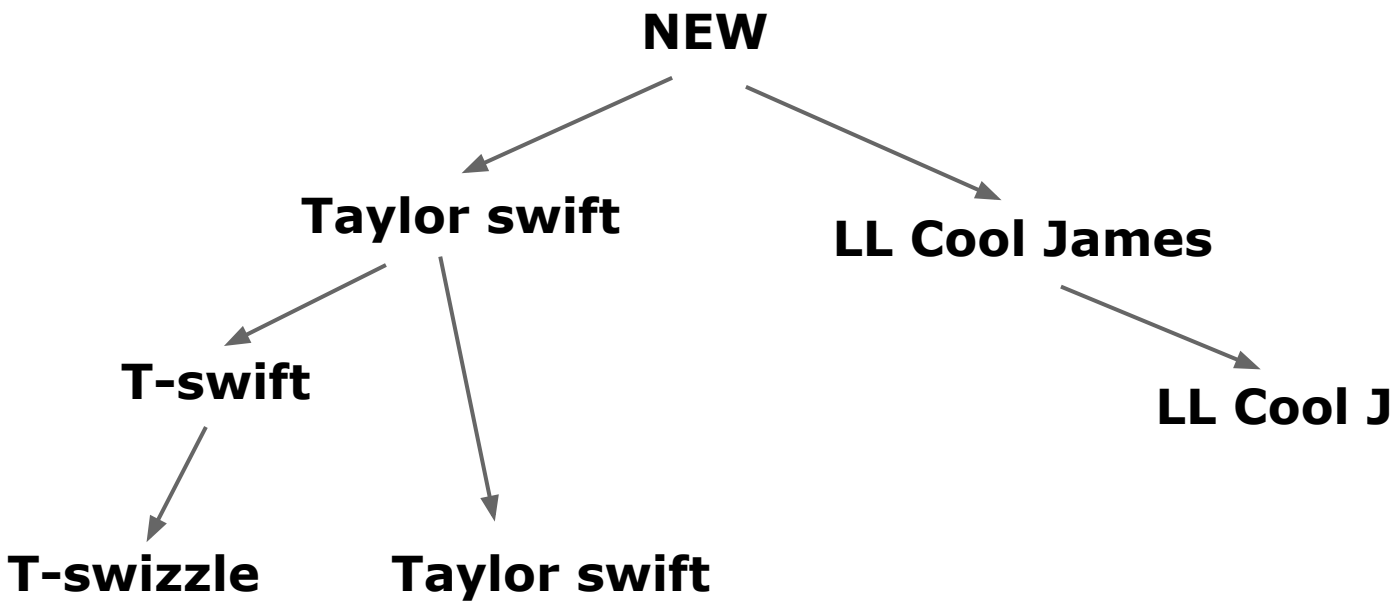
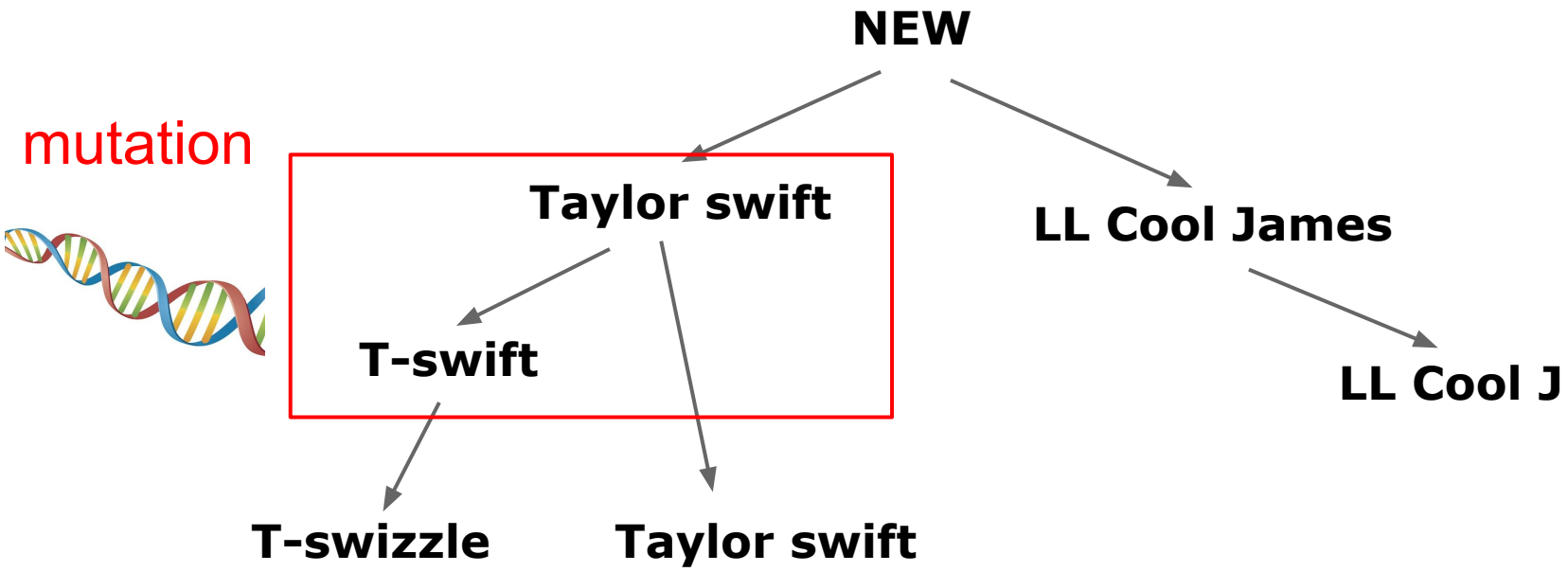
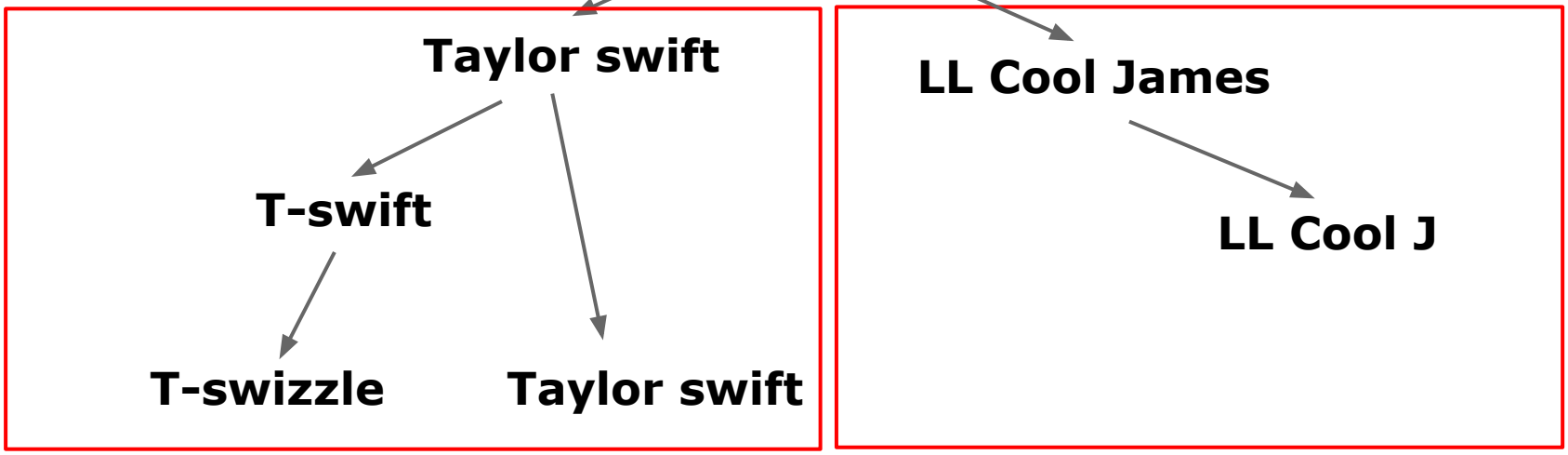

NEW
Taylor swift
LL Cool James
T-swift
LL Cool J
T-swizzle
Taylor swift

# “phylogeny”?

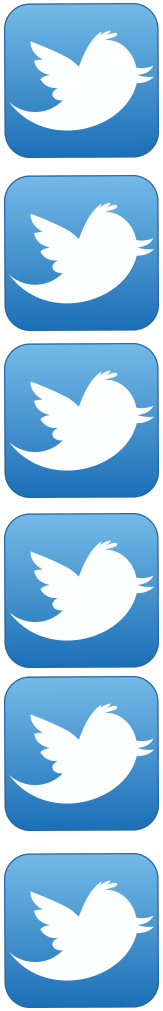

NEW
mutation
Taylor swift
LL Cool James
T-swift
LL Cool J
T-swizzle
Taylor swift

# “phylogeny”?

species



# A Generative Story



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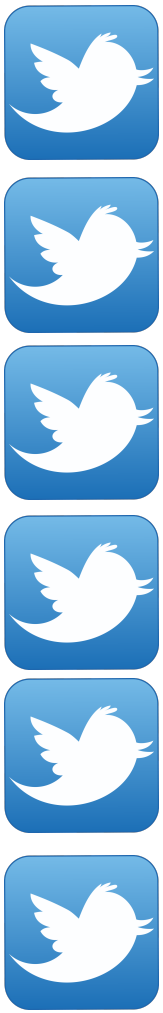

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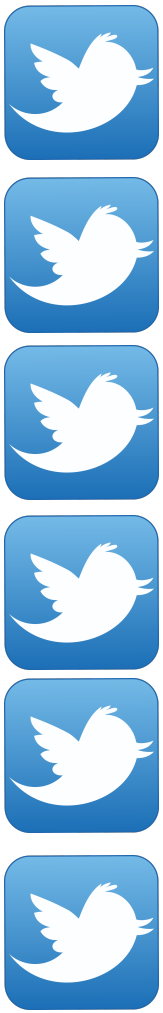
# Pick topics



1 **5** 2 1 2 3

Did **Taylor swift** just dis harry sytles

3 4 1 2 **5** 1 2 7

Lets see how bad **T Swift** will be. #grammys

3 1 2 **5** 1 2 4

it's clear that **T-Swizzle** is on drugs

**5** 1 3 2 3 8

**Taylor swift** is apart of the Illuminati

1 2 3 **10**

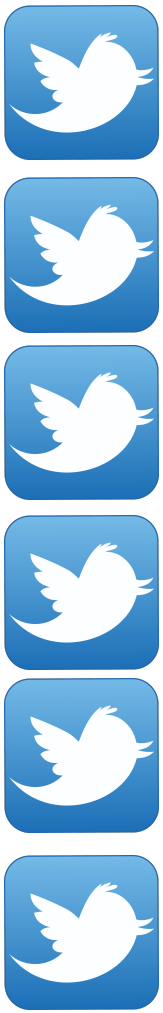
Ladies STILL love **LL Cool James** .

**10** 2 5 1 7

**LL Cool J** is looking reallllll chizzled!

[ ] is a placeholder for an entity mention

# Pick words | topics



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# Talk about NEW entity or an old one?

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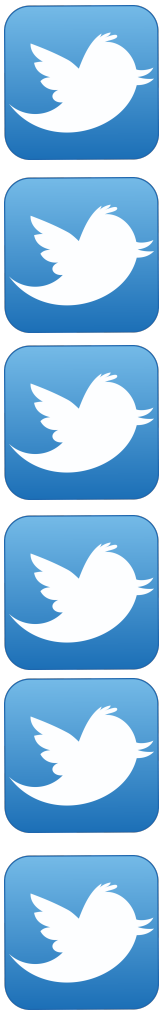

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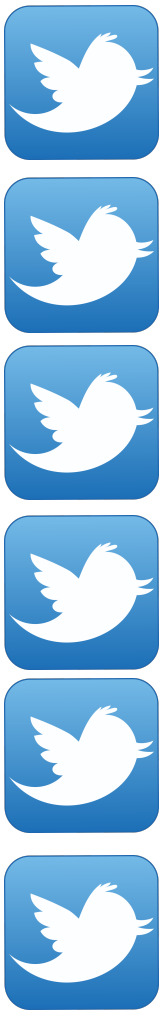

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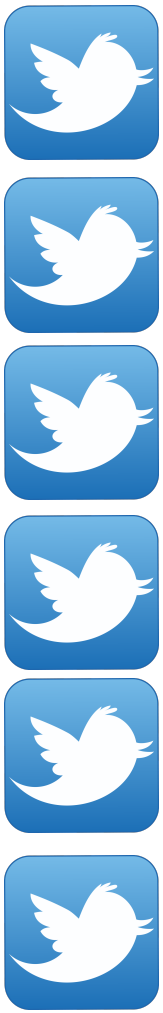

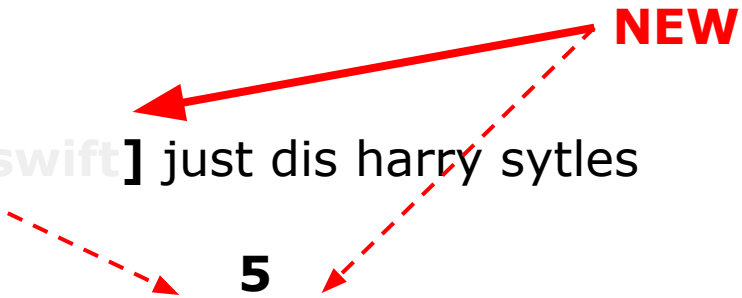


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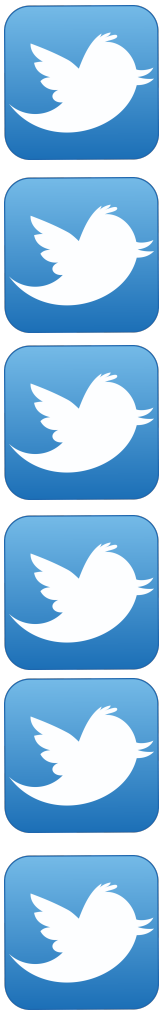

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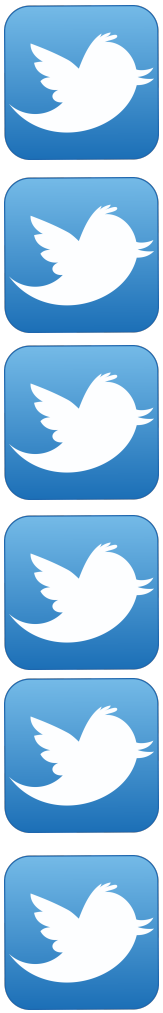

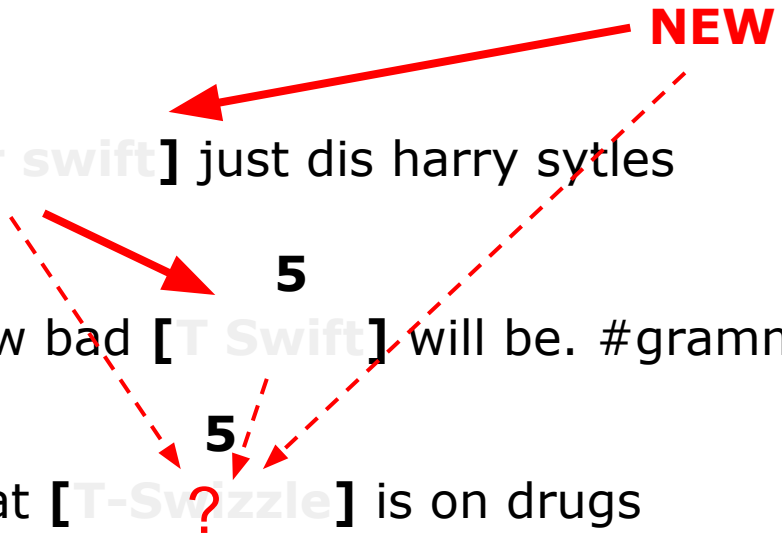


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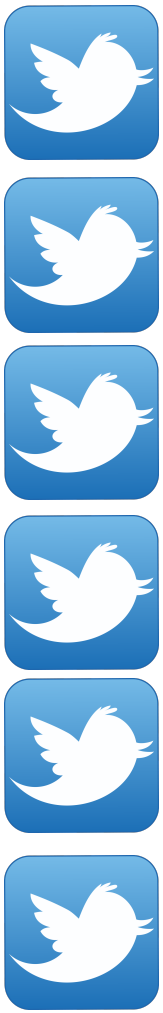

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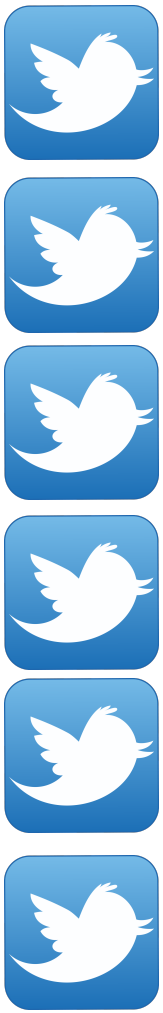

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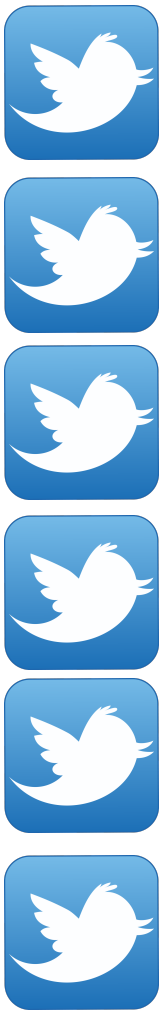

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# Selecting a parent

$$p(\text{parent}) = \frac{\exp\left(\mathbf{f}(\text{parent}, \text{child}) \cdot \phi\right)}{Z}$$

NEW

5

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# Selecting a parent

Unknown parameters

$$p(\text{parent}) = \frac{\exp\left(\phi_{10,10} + \phi_{\text{equal}}\right)}{Z}$$

NEW

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# Selecting a parent

$$p(\text{parent}) = \frac{\exp\left(\phi_{5,10} + \phi_{\text{diff}}\right)}{Z}$$

5

NEW

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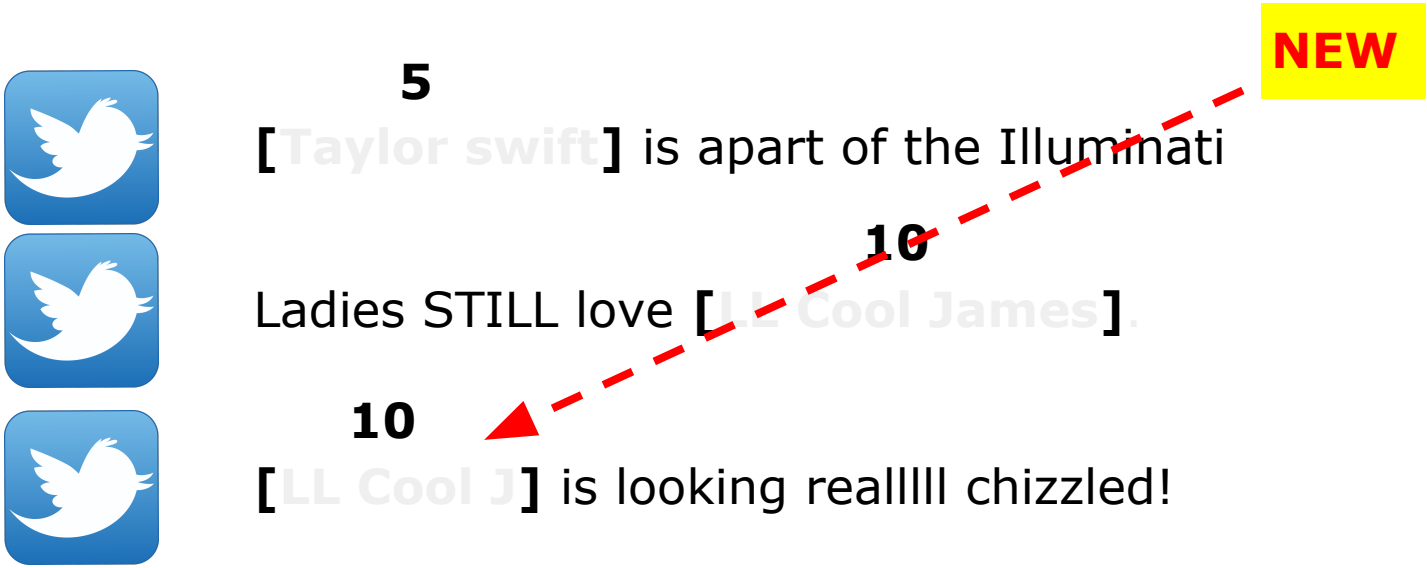
# Selecting a parent

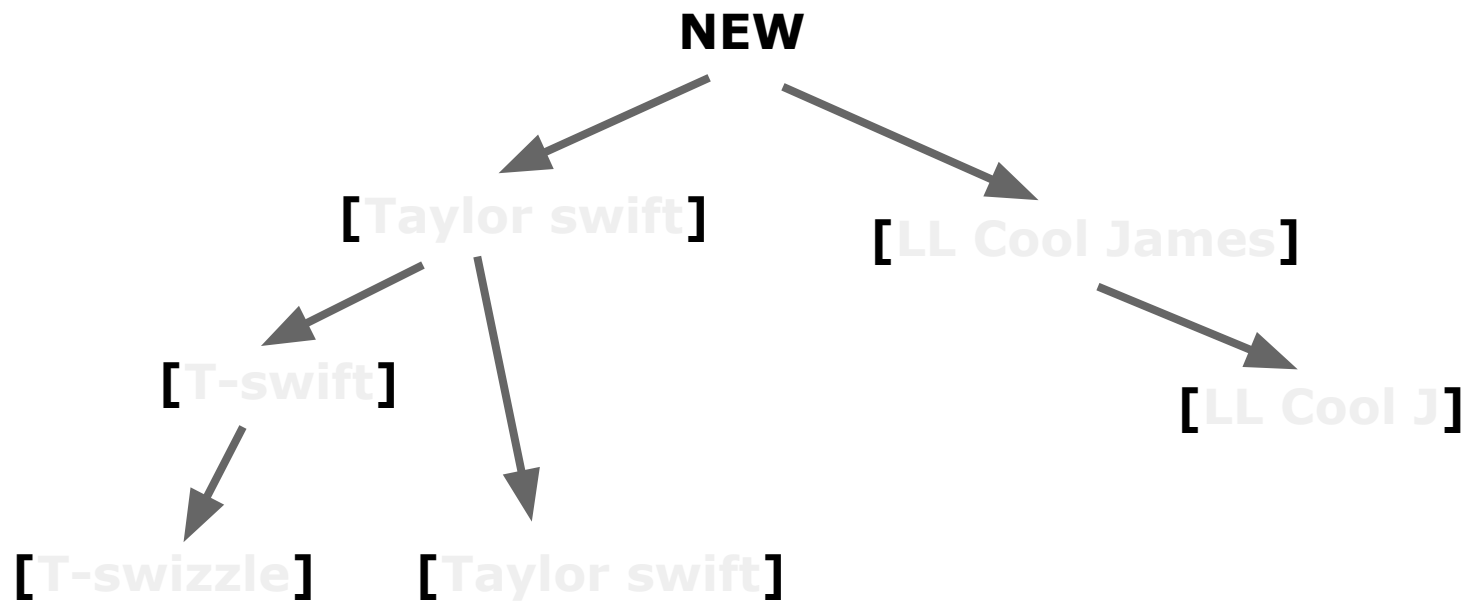
Hyperparameter:
controls # of entities

$$p(\text{parent}) = \frac{\exp(\phi_{\text{new}})}{Z}$$



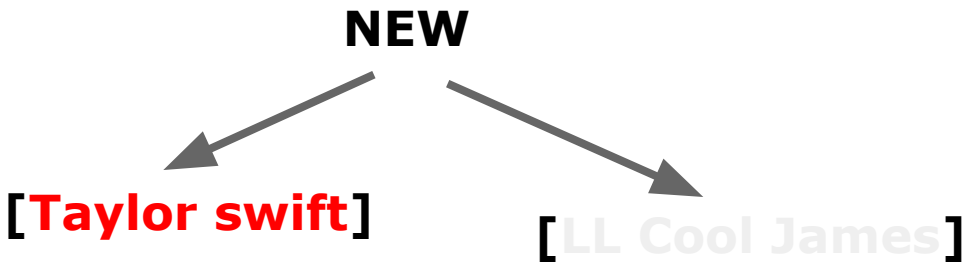
# Another view

**Note: No names yet, that's next…**



# Generating a name

If parent = NEW: name new entity



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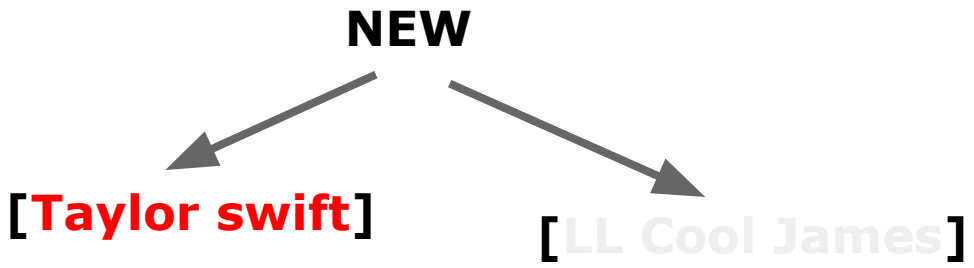
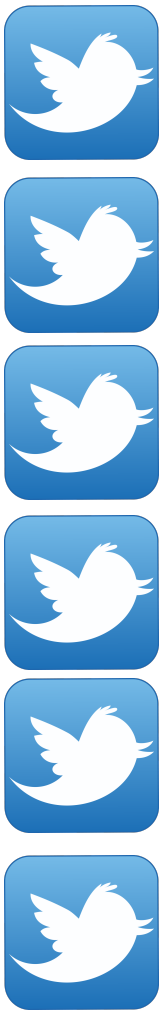



We draw a name from a simple character LM with trainable parameters θ

(... room for fancier distributions over $\sum^*$ …)

# Pick mention name | parent



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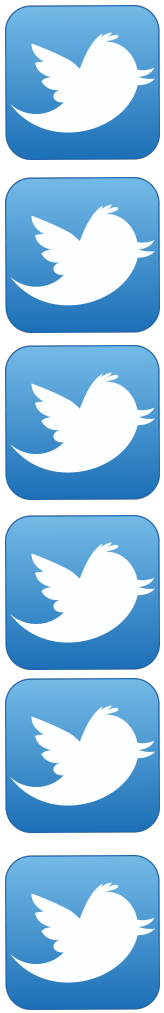

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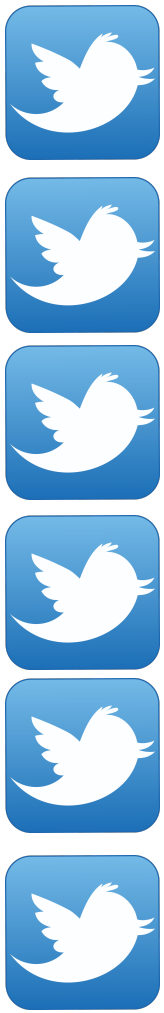

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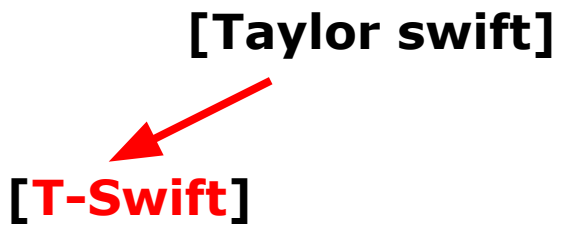
# Generating a name

If parent != NEW: copy (maybe mutate) the parent's name

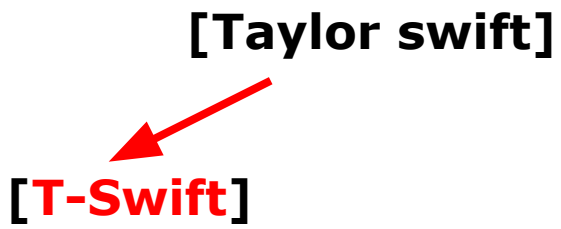



We draw the name from a stochastic contextual edit model (see Cotterell et al., 2014) with trainable parameters θ

```
Taylor swift
Tεεεεε-Swift
Copy  Del      Subst  Copy    Stop
```

# Generating a name

If parent != NEW: copy (maybe mutate) the parent's name

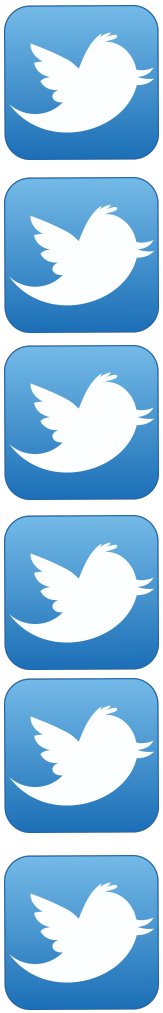



We draw the name from a stochastic contextual edit model (see Cotterell et al., 2014) with trainable parameters θ

θ gives the contextual probability of different character edits

- copy, delete, substitute *c*, insert *c*

# Pick mention name | parent



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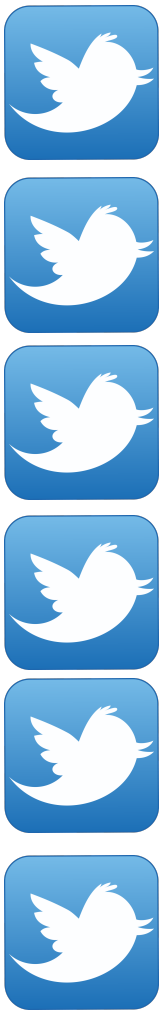
**NEW**

# Pick mention name | parent



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Lets see how bad **[T Swift]** will be. #grammys

it's clear that **[T-Swizzle]** is on drugs

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Ladies STILL love **[LL Cool James]**

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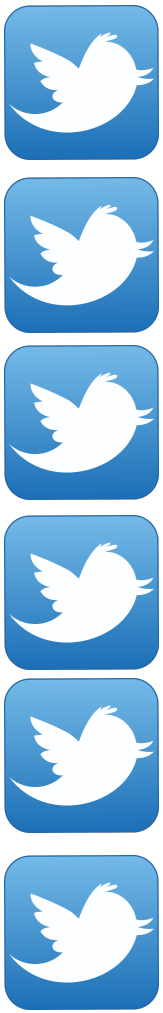

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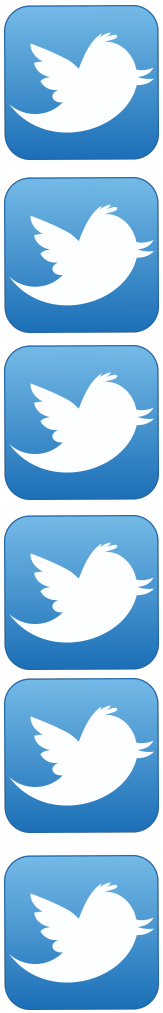

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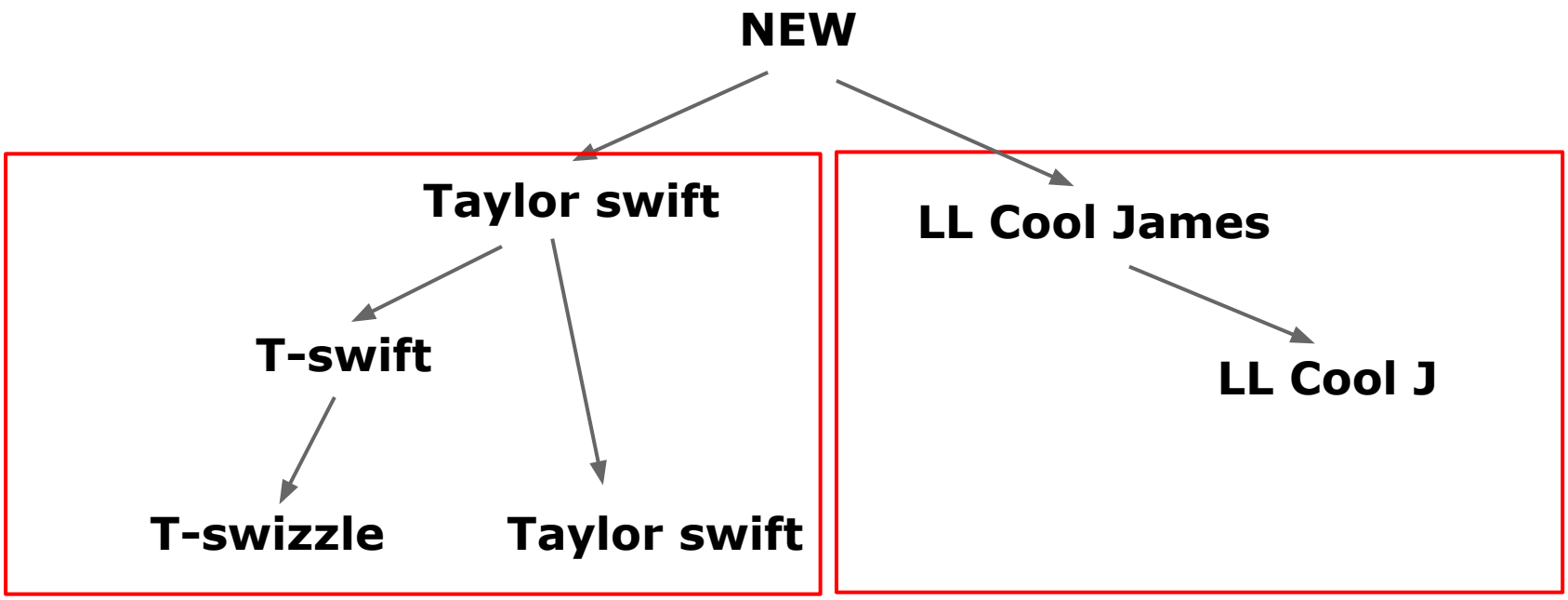
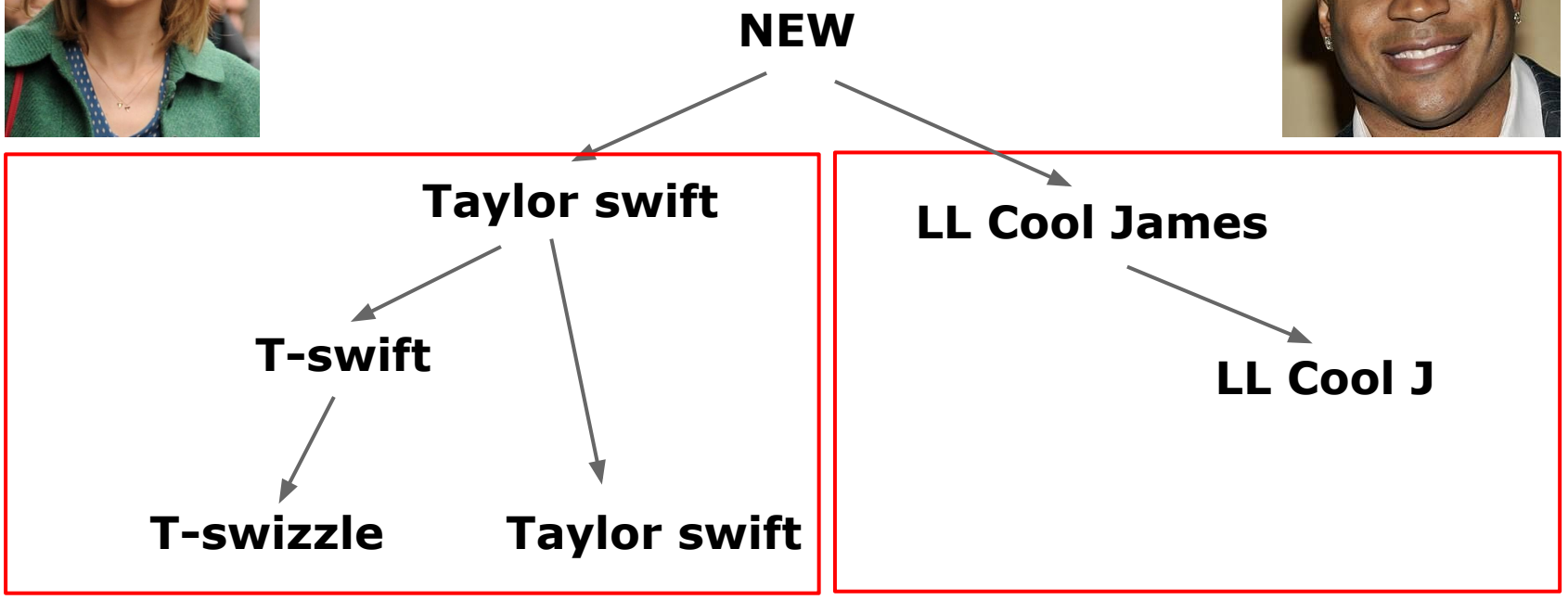
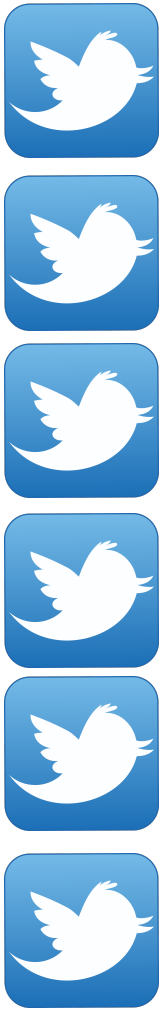
# End result


NEW
Taylor swift
T-swift
T-swizzle
Taylor swift
LL Cool James
LL Cool J

# End result


NEW
Taylor swift
T-swift
T-swizzle
Taylor swift
LL Cool James
LL Cool J

# Inference (fixed parameters)



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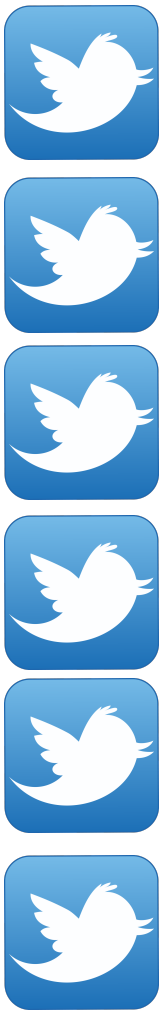

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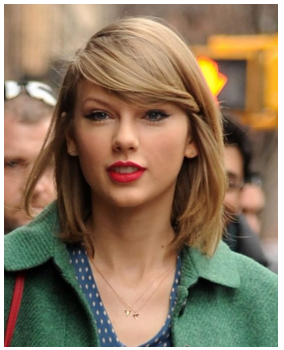

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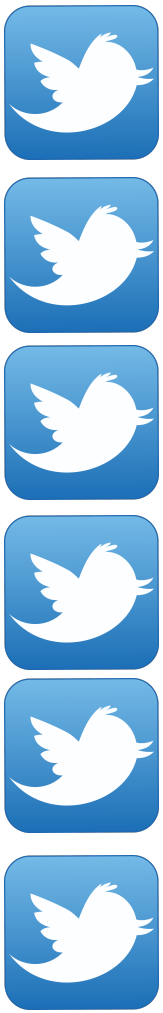

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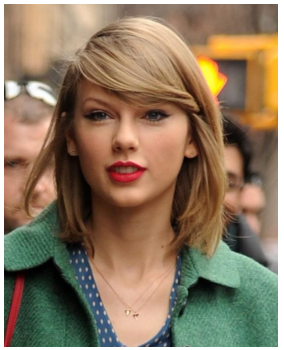

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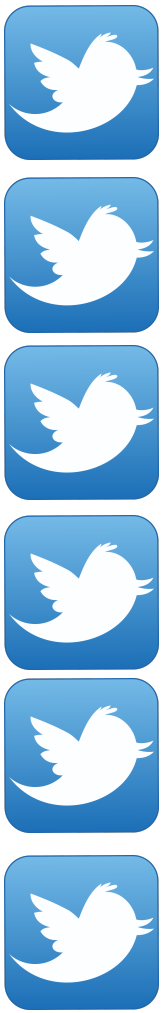

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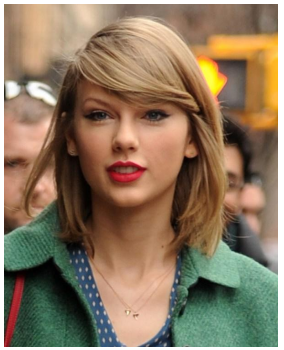

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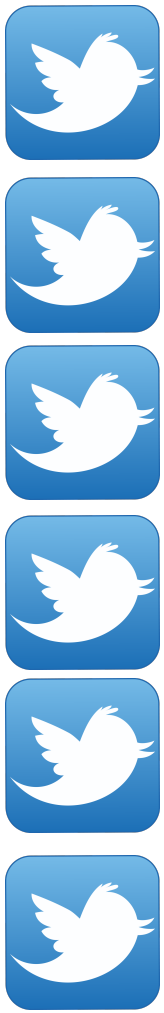

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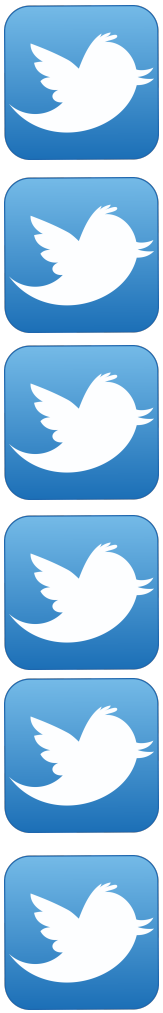

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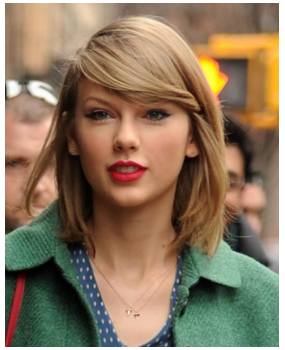
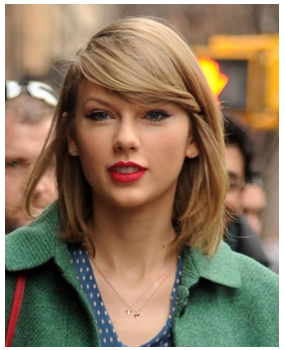
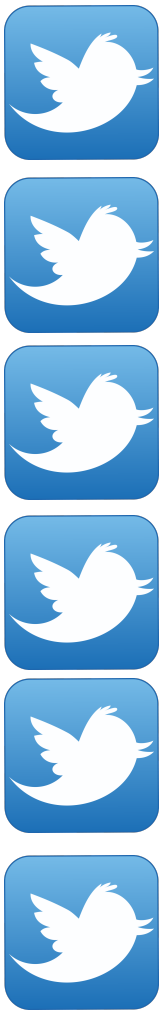




# Many possible topic assignments



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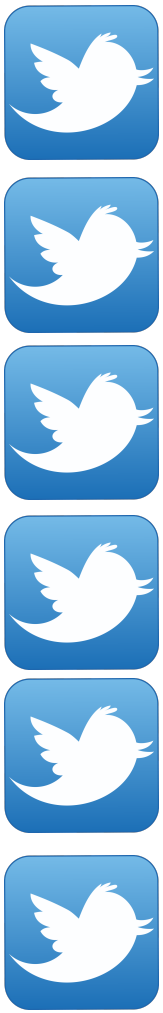

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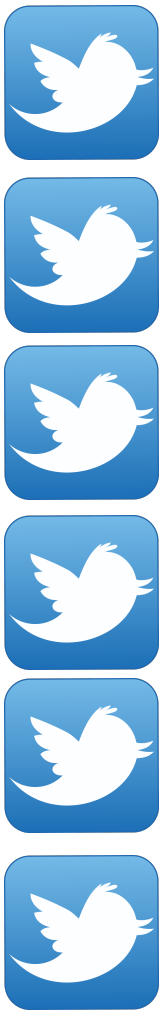

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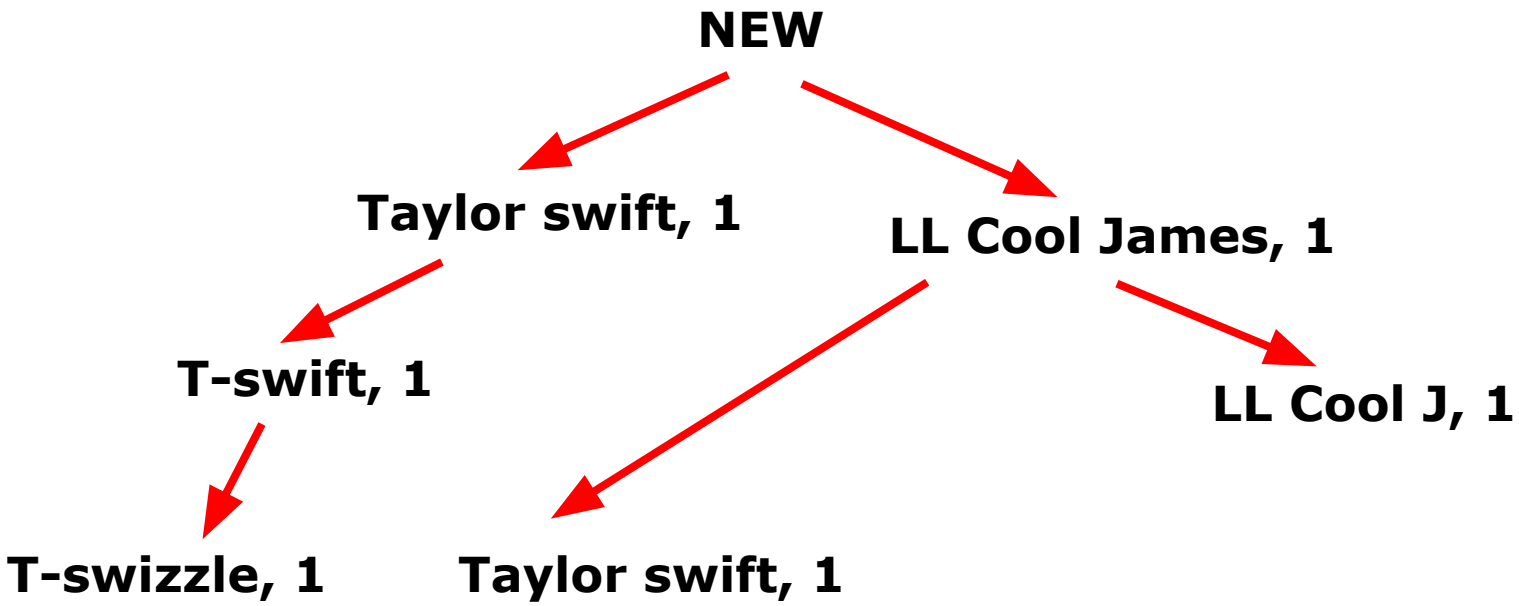
# Block Gibbs (fixed parameters)

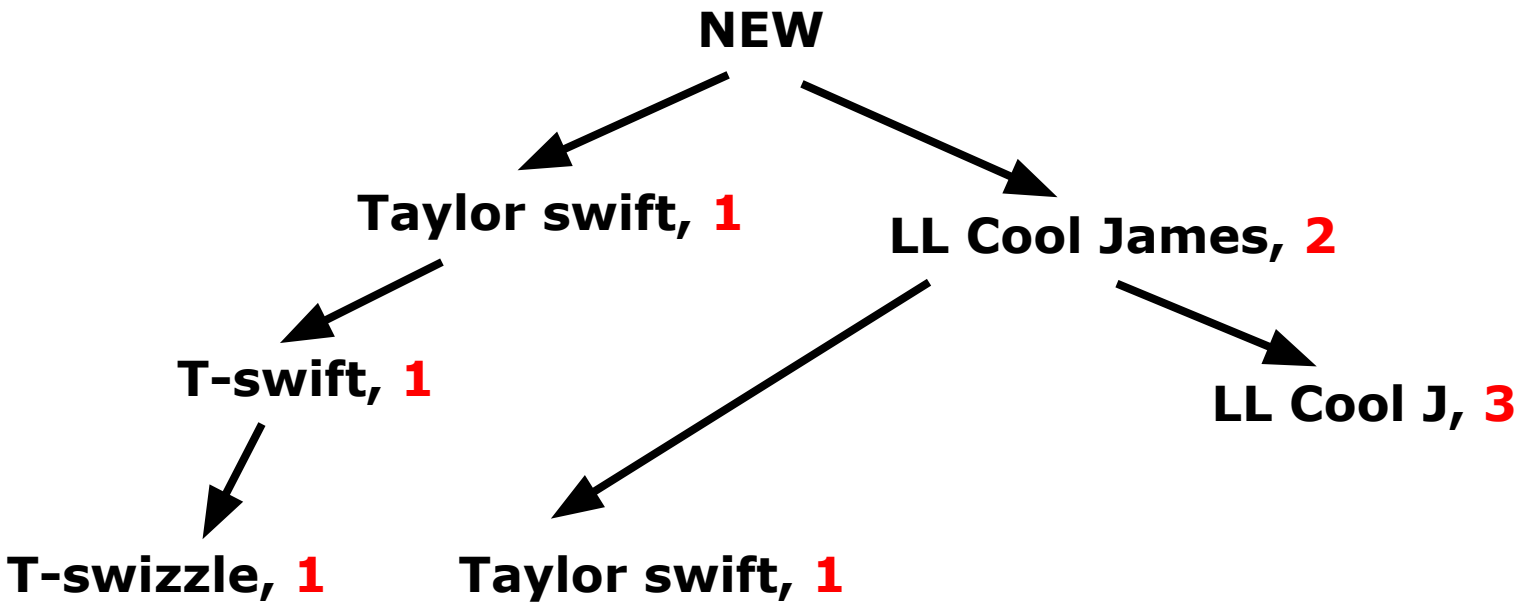
Sample phylogeny | topics




$$p(x \to y) \propto p_\phi(x \mid y) p_\theta(y.\text{name} \mid x.\text{name})$$

# Block Gibbs (fixed parameters)

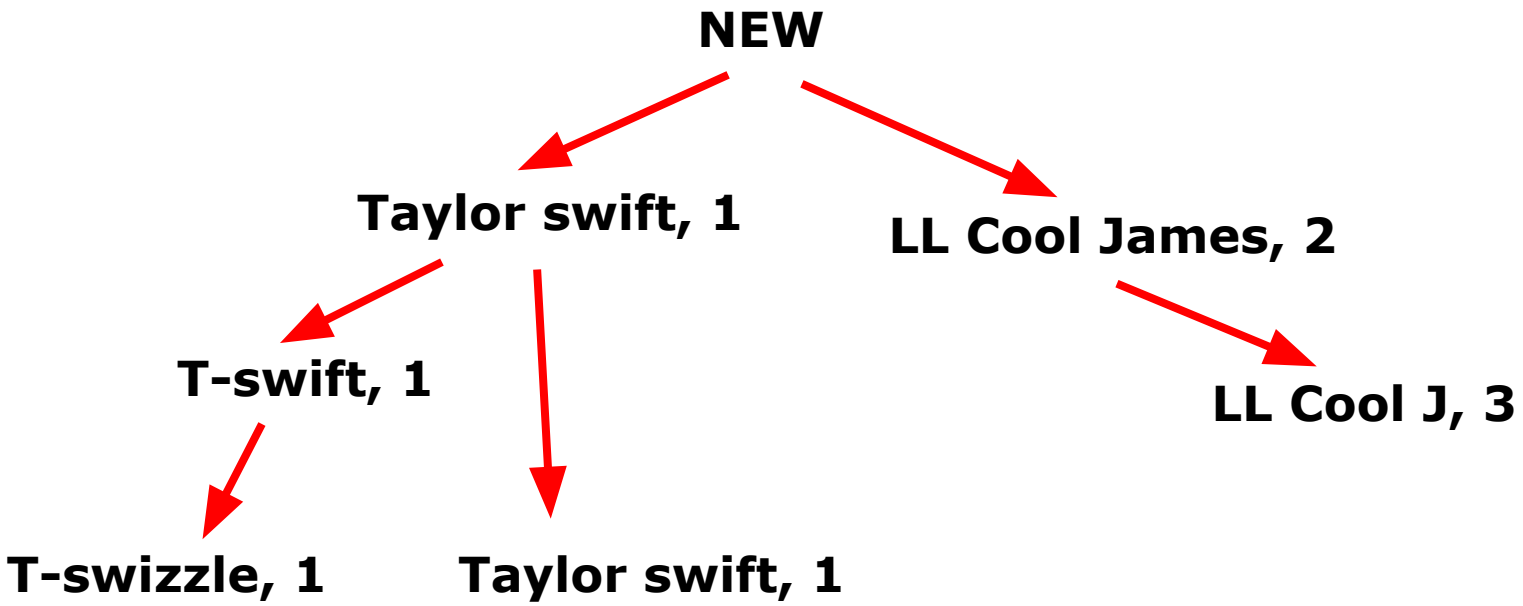
Sample topics | phylogeny




(We use tree-structured BP to construct proposals; see paper for details.)

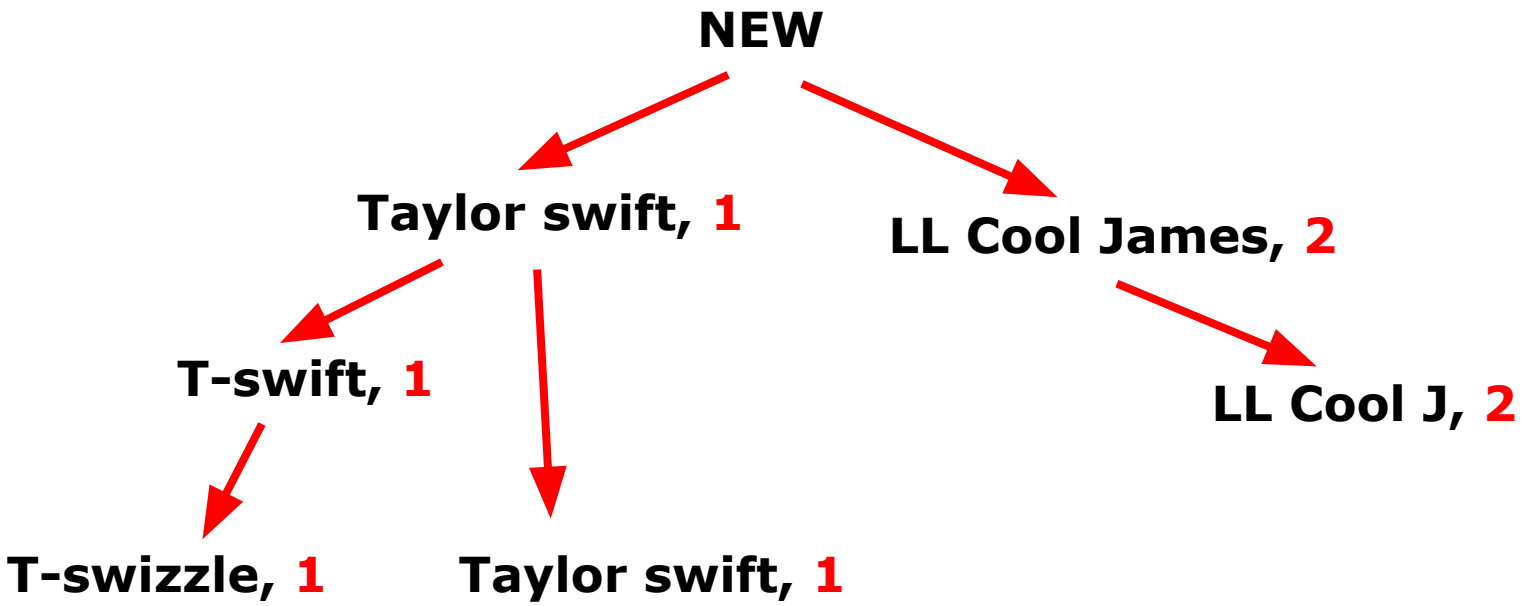
# Block Gibbs (fixed parameters)

Sample phylogeny | topics

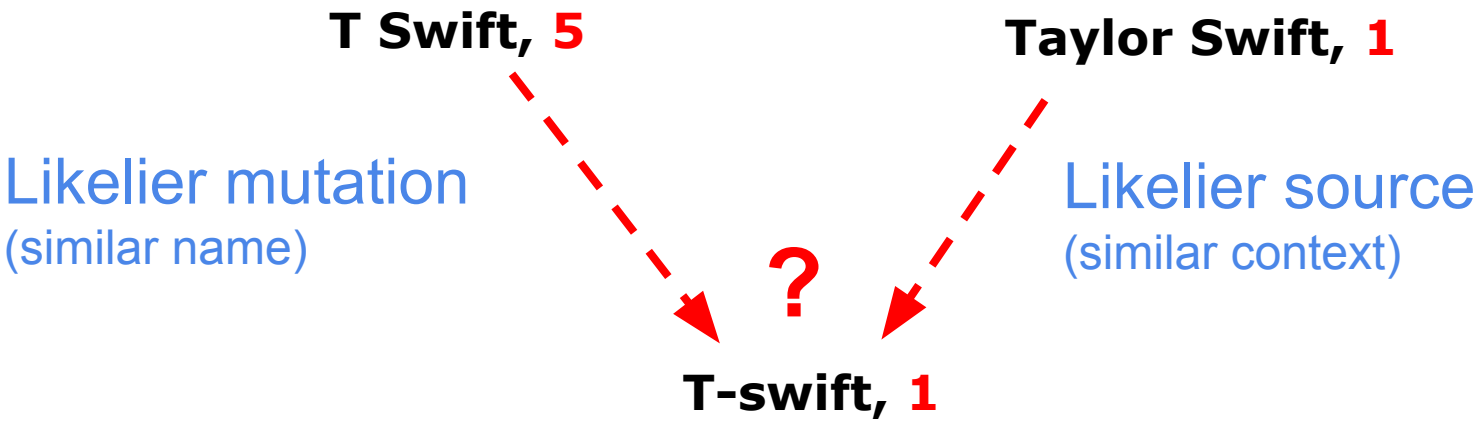


# Block Gibbs (fixed parameters)

Sample topics | phylogeny



# What is the sampler thinking about?



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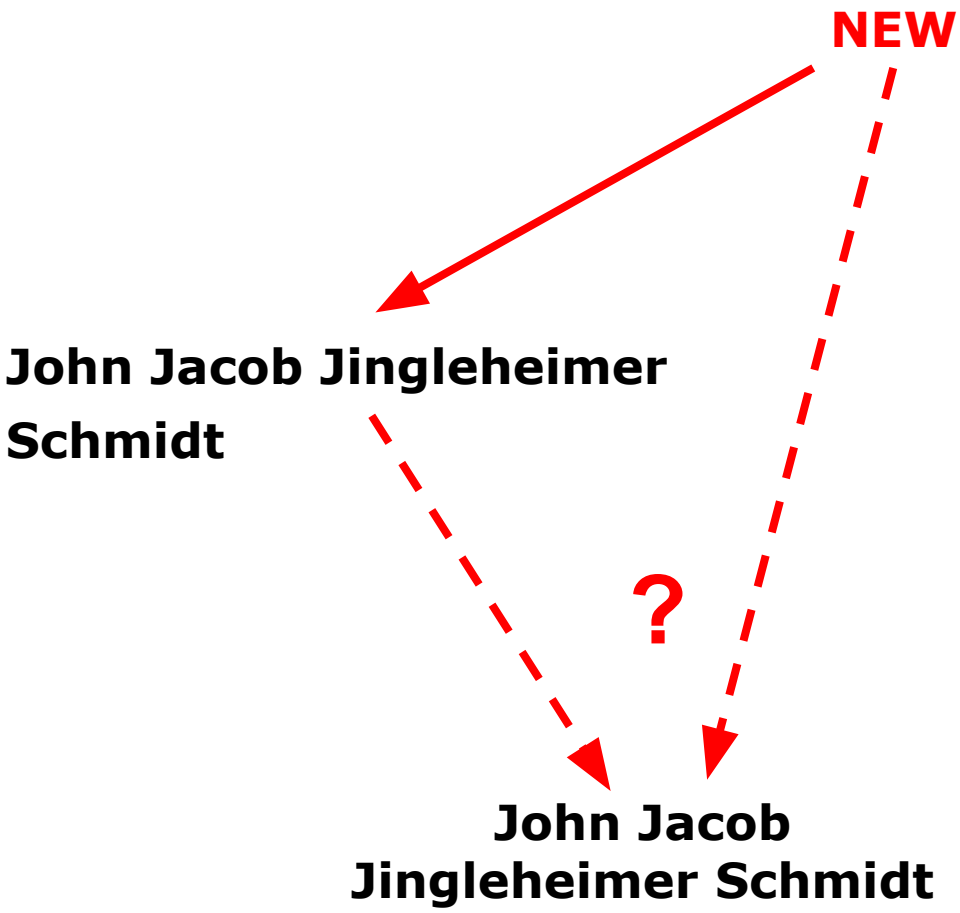


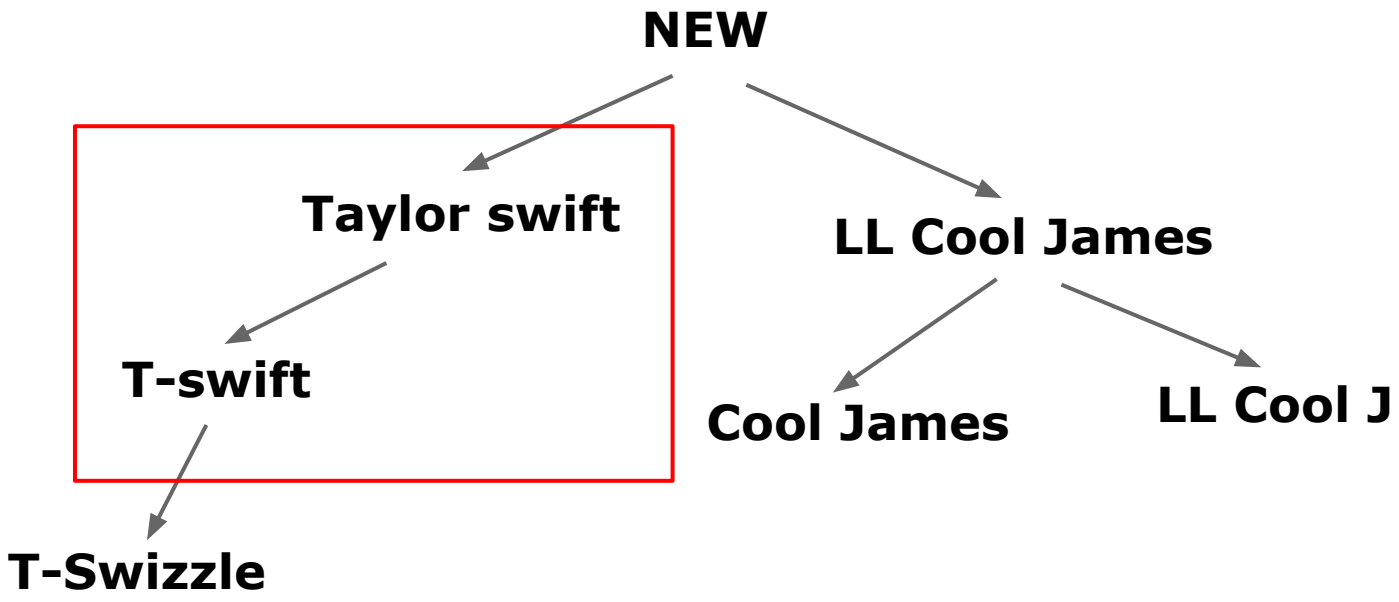

Prefer to **copy** rather than generate from scratch

(short or common names *would* be plausible to generate twice)

(see paper for an improved mutation model that considers pragmatics)

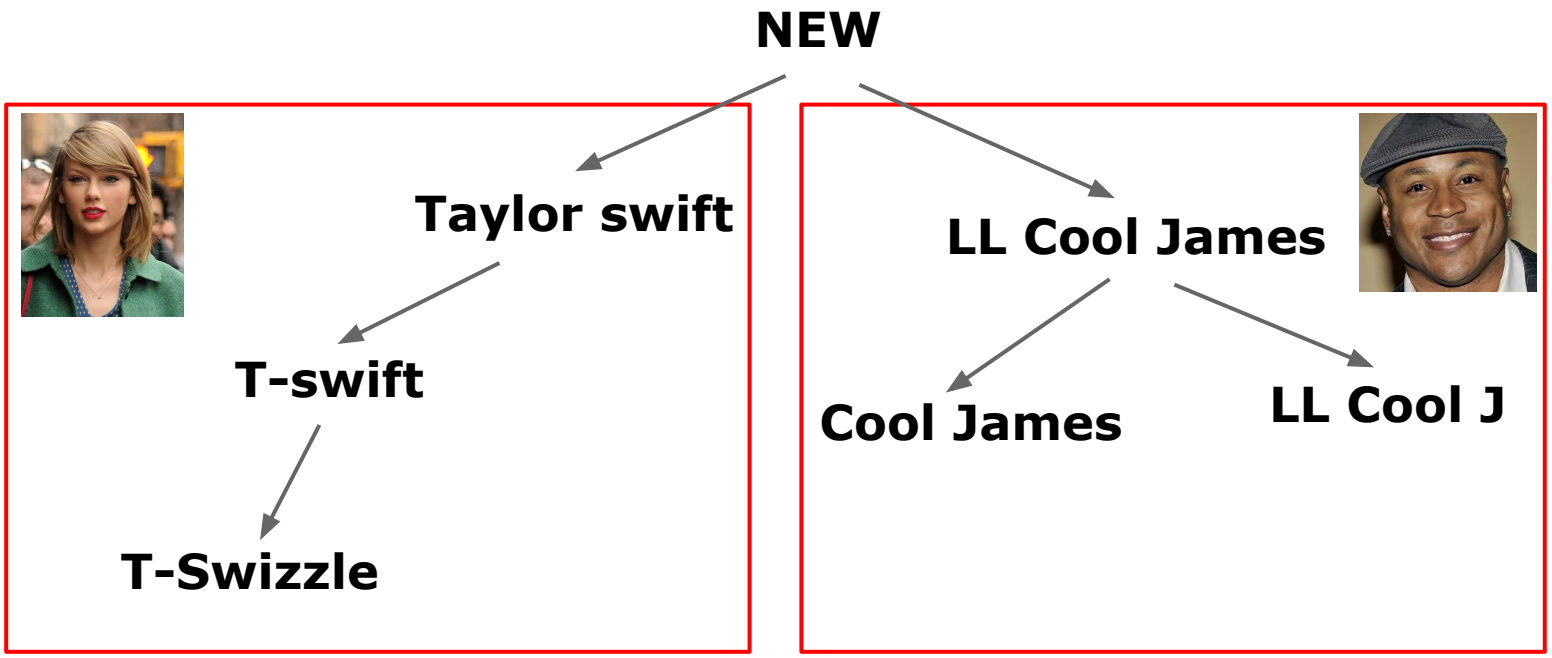
# What do samples tell us?

1. Which names are copies of other names
   *(used for EM training of all parameters)*

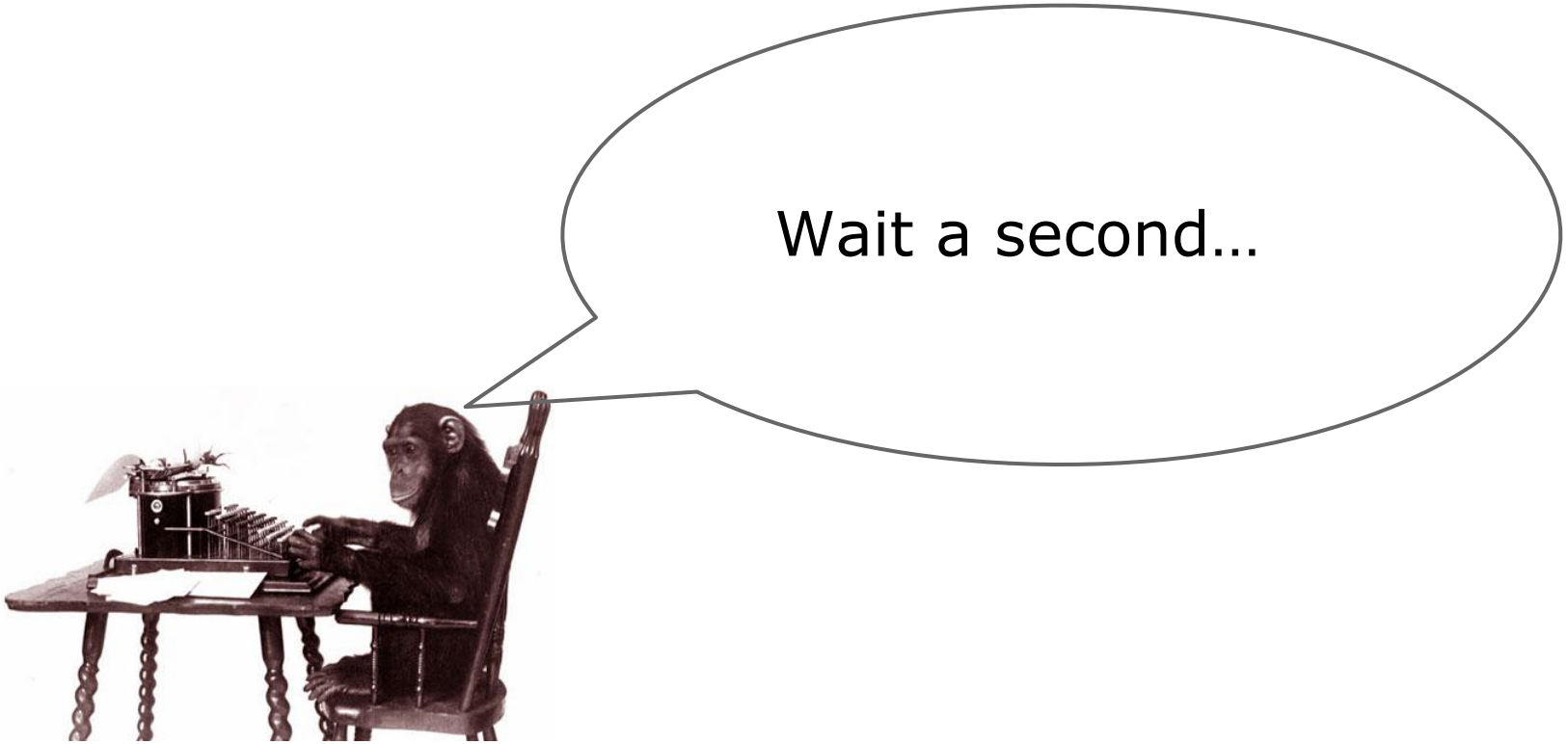


# What do samples tell us?

2. Which names corefer
   *(used for your IE task)*

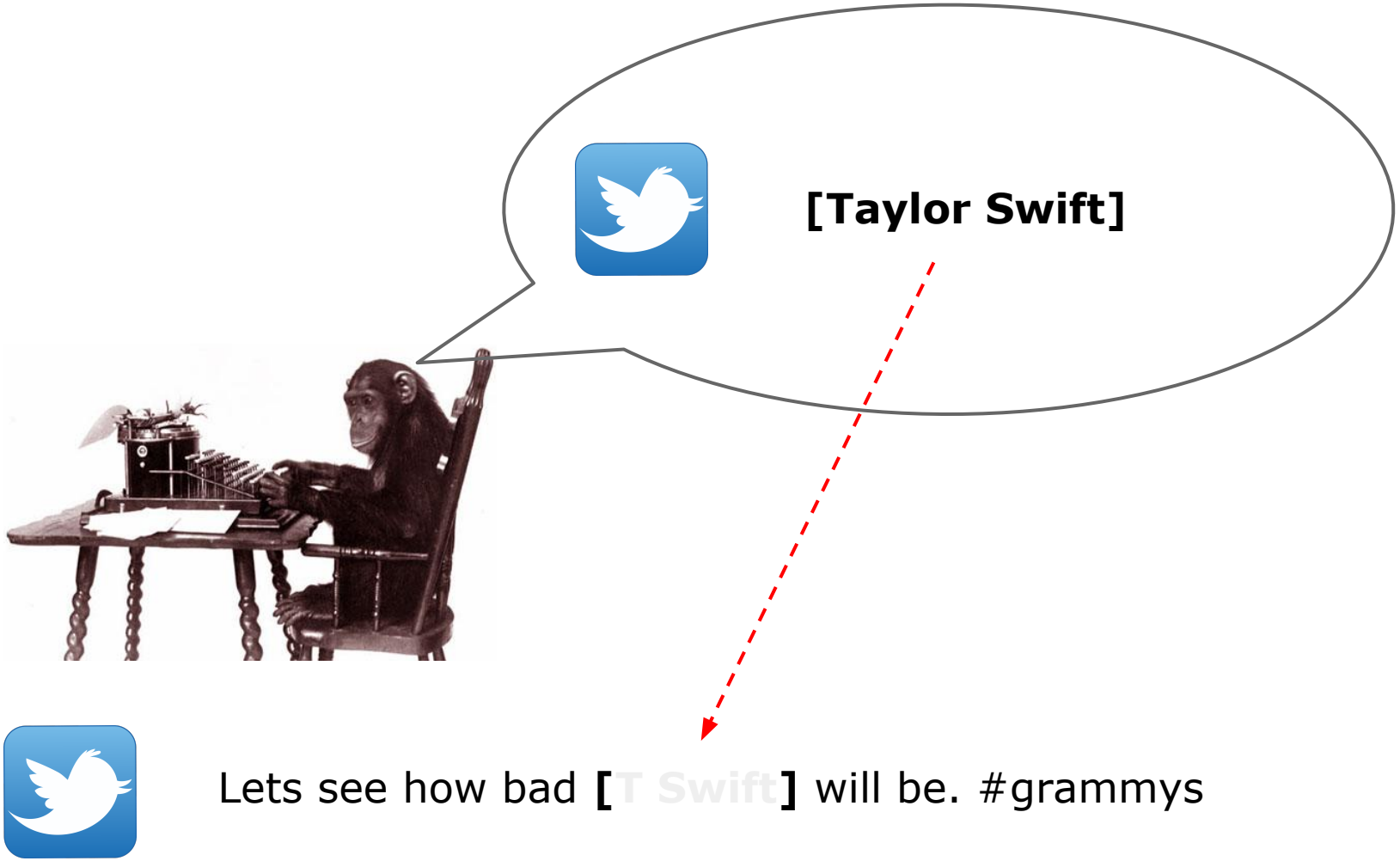


# A complication




Lets see how bad **[**T Swift**]** will be. #grammys

# Authors copy from multiple sources



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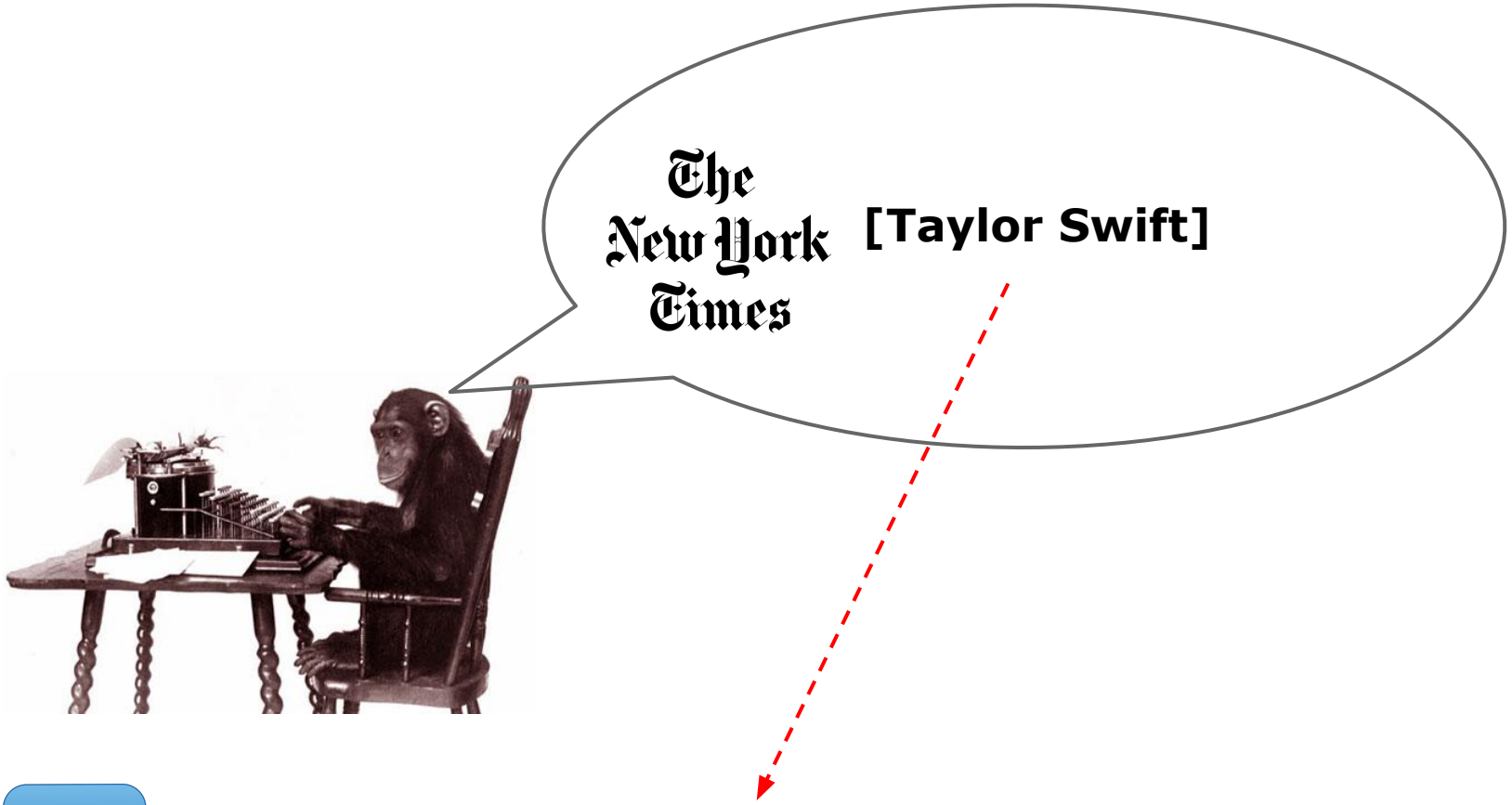

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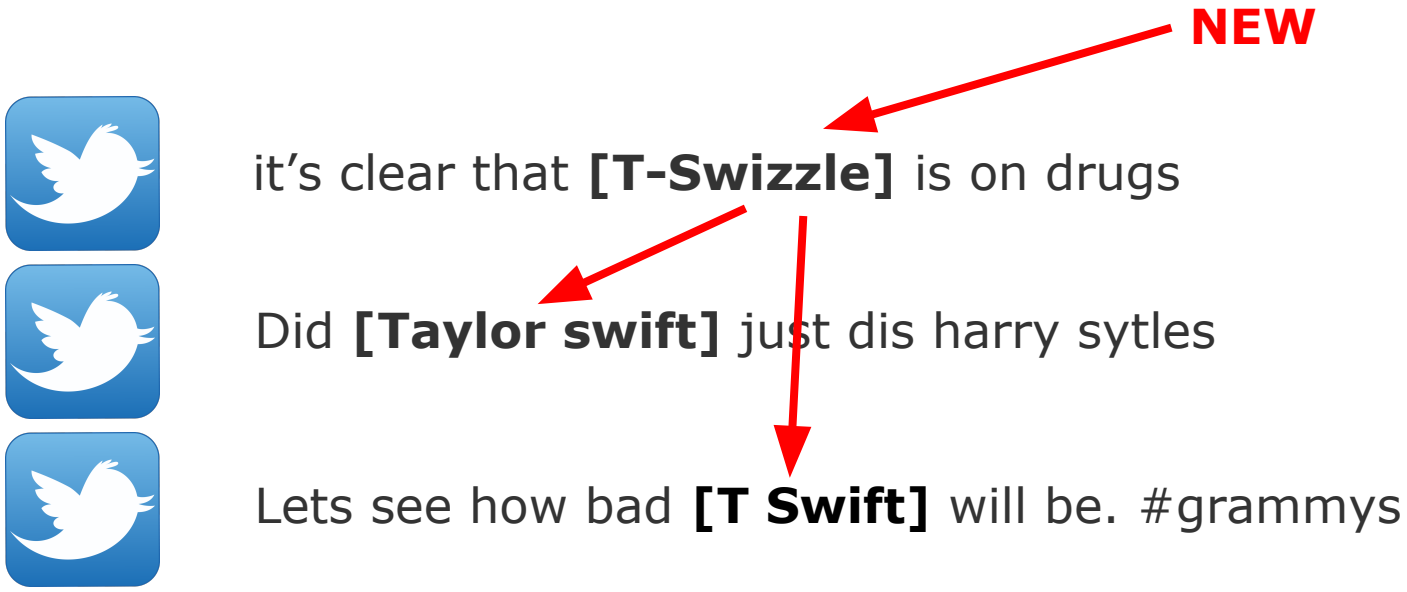
CNN [Taylor Swift]

Lets see how bad [T Swift] will be. #grammys

# Bad ordering



# Bad ordering

**[Taylor Swift]**

**[T Swift]**

it’s clear that **[T-Swizzle]** is on drugs

Did **[Taylor swift]** just dis harry sytles

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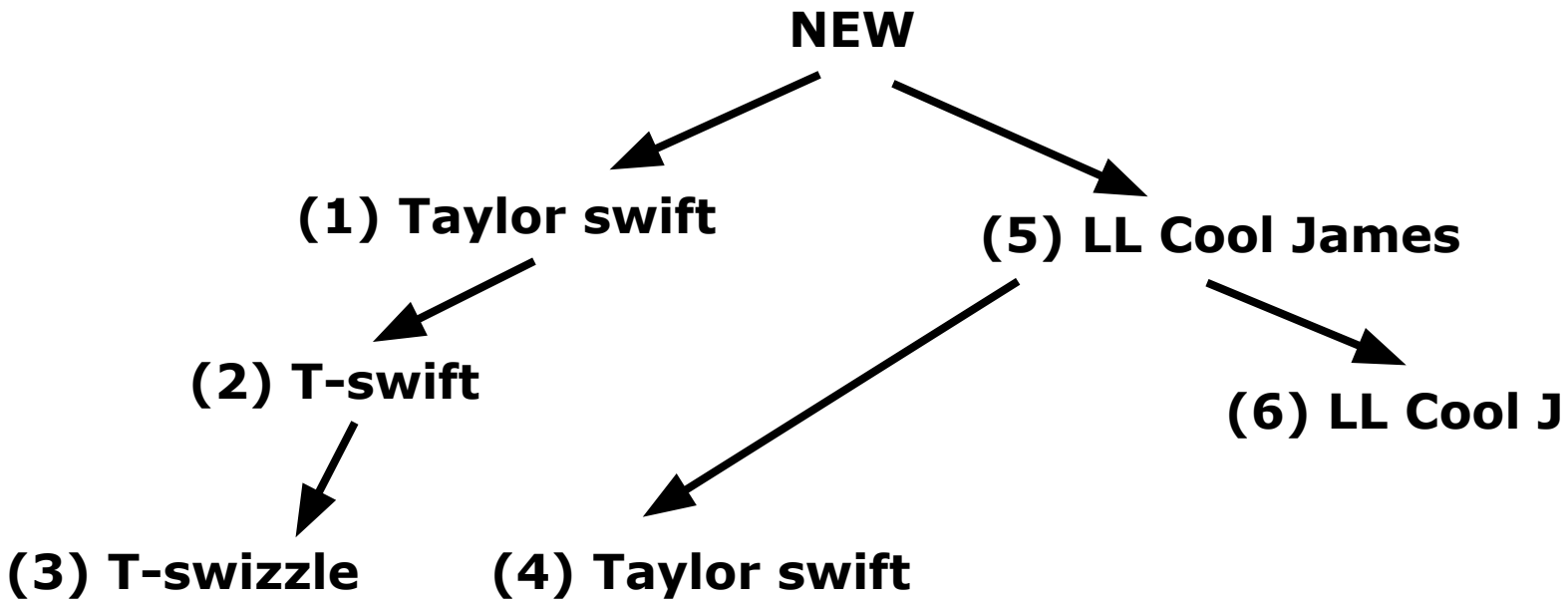
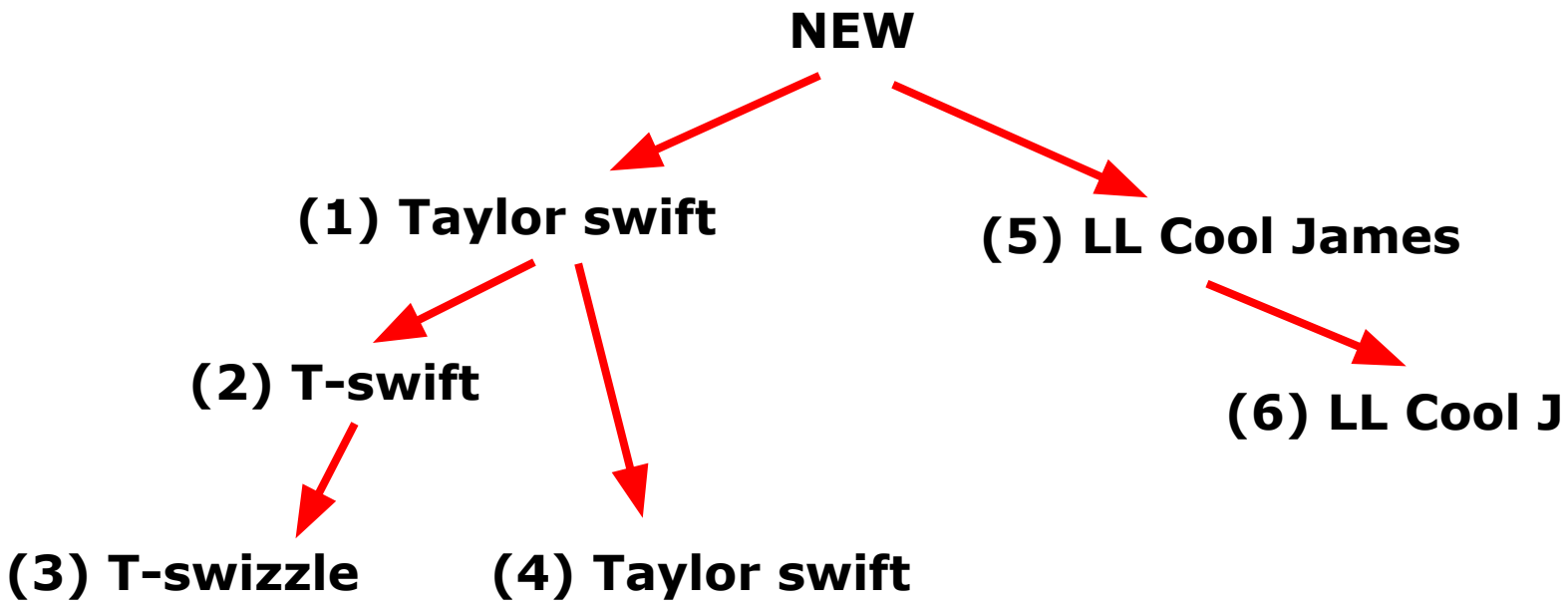
# Solution: Treat order as unknown



# Updated Block Gibbs (fixed params)

Sample phylogeny | **ordering**, topics



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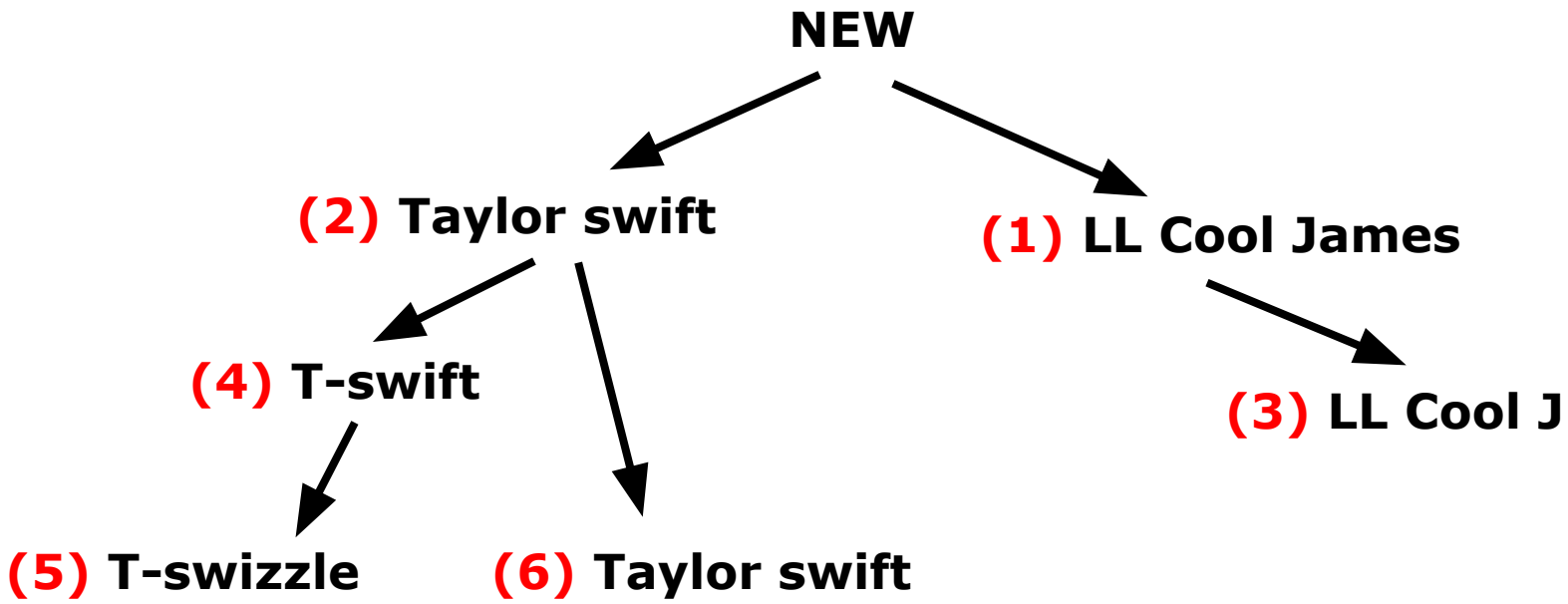


(we use a proposal distribution and correct with MH; see paper for details)

# Summary

So far we've seen:

- The generative story
- A sampler for posterior inference

Wrap up with:

- Parameter estimation
- MBR decoding
- Experiments

# Parameter Estimation

## Monte Carlo EM

Repeat:

- **E-Step:** Count edges in sample
- **M-Step:** Take stochastic gradient step
  - Update* parent model parameters
  - Update* mutation model parameters

* We use AdaGrad which has an adaptive learning rate

# Consensus Clustering

To get a single “hard” clustering C for evaluation, we use minimum Bayes risk:

$$\text{argmin}_C \, \mathbf{E}_{C'}[\, \text{loss}(C, C') \,]$$

- Minimize expected loss of C
  - With respect to C’ drawn from the model posterior
  - Estimate this using our samples of C’

(we approximate argmin using spectral clustering; see paper for details)

# Summary

## Unsupervised clustering procedure:

1. Train model using Monte Carlo EM
2. Sample from the posterior
3. Pick the MBR clustering given posterior

# Evaluation: Twitter

Corpus of Twitter messages discussing the 2013 Grammy award ceremony (~5000 posts total, ~300 entities).

- Procedure: 4-fold cross validation
  - **Train:** Tune weight of picking NEW as the parent to control precision / recall trade-off
  - **Test:** Run clustering procedure with this weight fixed

# Results: Twitter

| System | **$B^3$ F1** |
| --- | --- |
| Exact-Match | 69.8 |

(averages over 4 folds)

# Results: Twitter

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| Phylo + Topic + MBR | 91.9 |

(averages over 4 folds)

# Results: ACE 2008


Corpus of news articles, mostly politics

~4000 mentions, ~2000 entities

- Procedure

  **Train:** Tune weight of picking NEW as the parent to control precision / recall trade-off

  **Test:** Run clustering procedure with this weight fixed

# Evaluation: ACE 2008

| System | PER B3 F1 | ORG B3 F1 |
|---|---|---|
| Exact-Match | 88.8 | 87.1 |

# Evaluation: ACE 2008

| System | PER B3 F1 | ORG B3 F1 |
|---|---|---|
| Exact-Match | 88.8 | 87.1 |
| Green et al. (2012) | 91.9 | 90.3 |

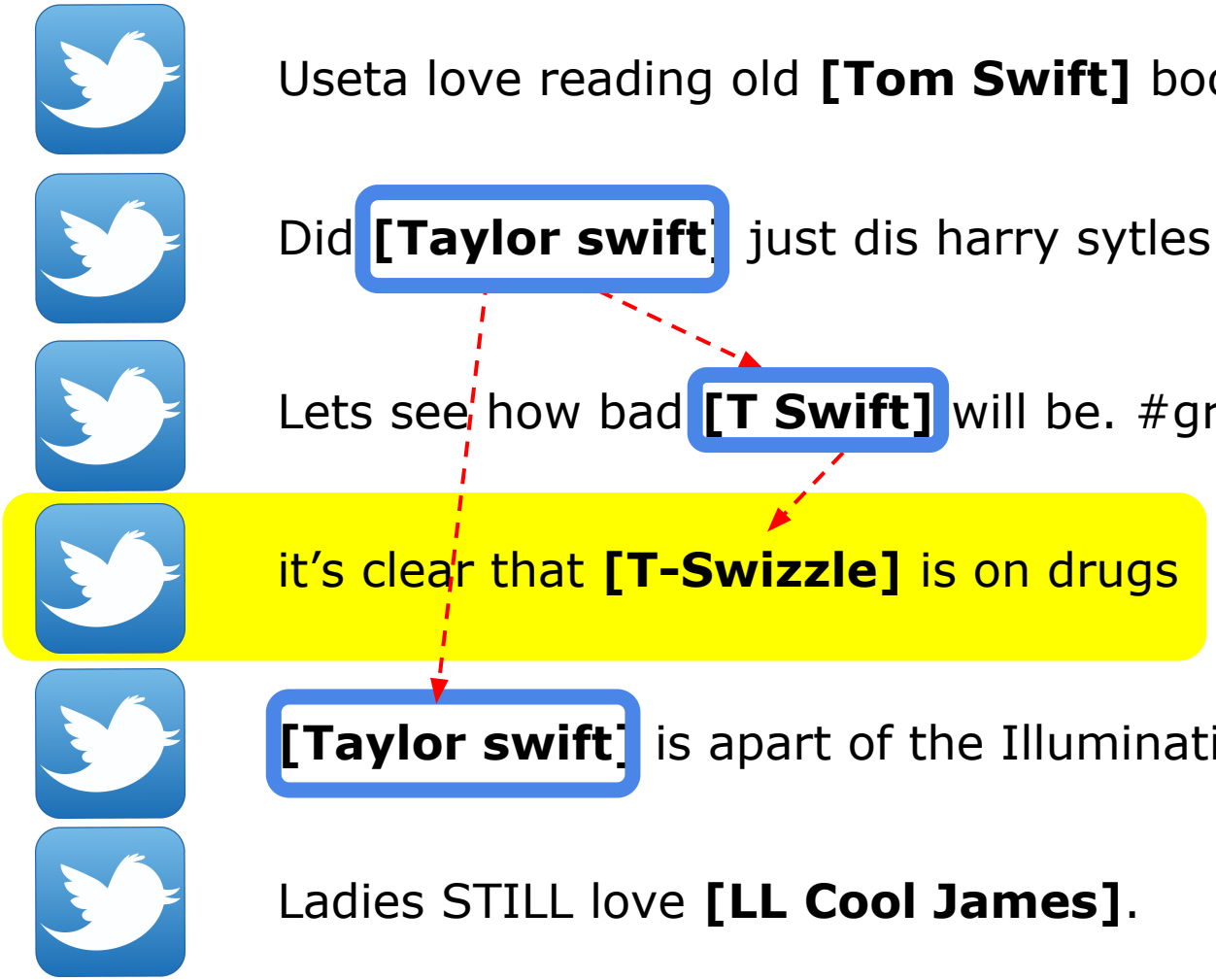
# Evaluation: ACE 2008

| System | PER B3 F1 | ORG B3 F1 |
|---|---|---|
| Exact-Match | 88.8 | 87.1 |
| Green et al. (2012) | 91.9 | 90.3 |
| Phylo+Topic+MBR | 92.7 | 87.6 |

# Thanks!

- More experiments in the paper
  - Name canonicalization
- Code will be released soon
  - https://bitbucket.org/noandrews/phyloinf
- Future uses of model and code?
  - Track diffusion of memes through social media
  - Derivational morphology

# Samples tell us which entities corefer



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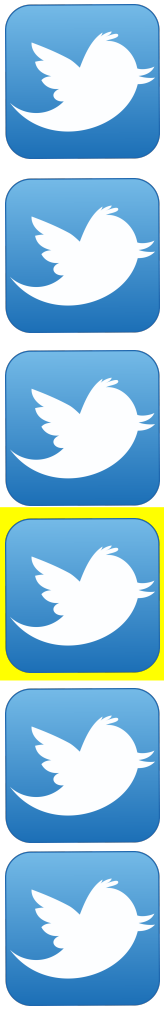

Useta love reading old **[Tom Swift]** books

Did **[Taylor swift]** just dis harry sytles

Lets see how bad **[T Swift]** will be. #grammys

it's clear that **[T-Swizzle]** is on drugs

**[Taylor swift]** is apart of the Illuminati

Ladies STILL love **[LL Cool James]**.

More about this person?

# Coref probabilities from many samples

.1  Useta love reading old **[Tom Swift]** books

.8  Did **[Taylor swift]** just dis harry sytles

.9  Lets see how bad **[T Swift]** will be. #grammys

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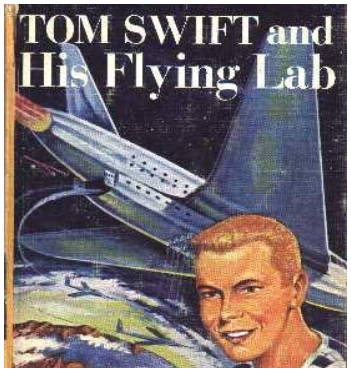
.8


.1

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|---|---|---|
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