Generative Models of Monolingual and Bilingual Gappy Patterns

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Overview

- We present models that generate text using patterns with gaps
- Posterior inference allows us to discover the most salient gappy patterns in a corpus

  e.g., *not only __ but* *either __ or*
- We validate the models by including patterns as features in a phrase-based MT system
- Code is available: `www.ark.cs.cmu.edu/MT`

Motivation

- Gappy translation units have received a lot of attention recently
  - Mostly bilingual: Simard et al. (2005), Chiang (2005), Galley and Manning (2010), *inter alia*
  - But also monolingual: Xiong et al (2011)
- All rely on heuristics or mutual information
- Can we discover gappy patterns using generative models?

Monolingual Pattern Models

- “Unigram” model: patterns generated independently
- Main intuition: words in a pattern are generated all at once
- Bayesian nonparametric priors and posterior inference favor the use of a small set of patterns to explain the data

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  - □ Generate number of word positions
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  - □ Assign word positions to colors
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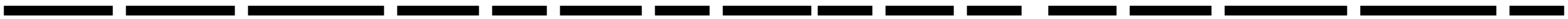

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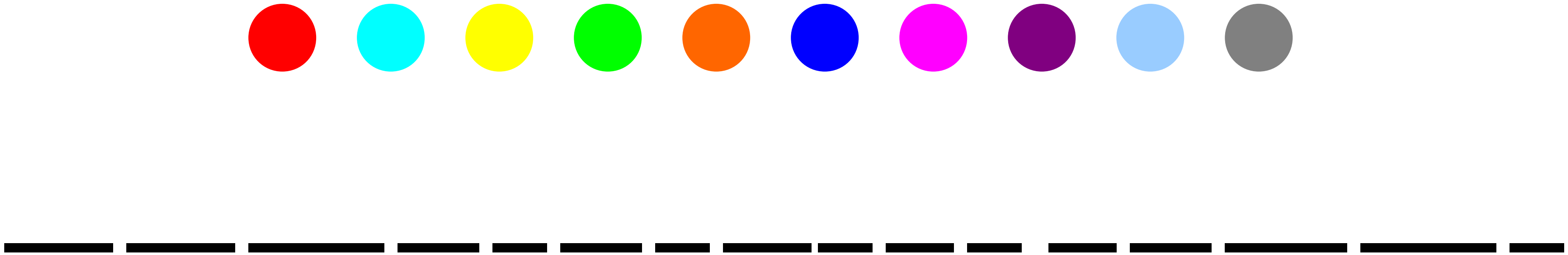

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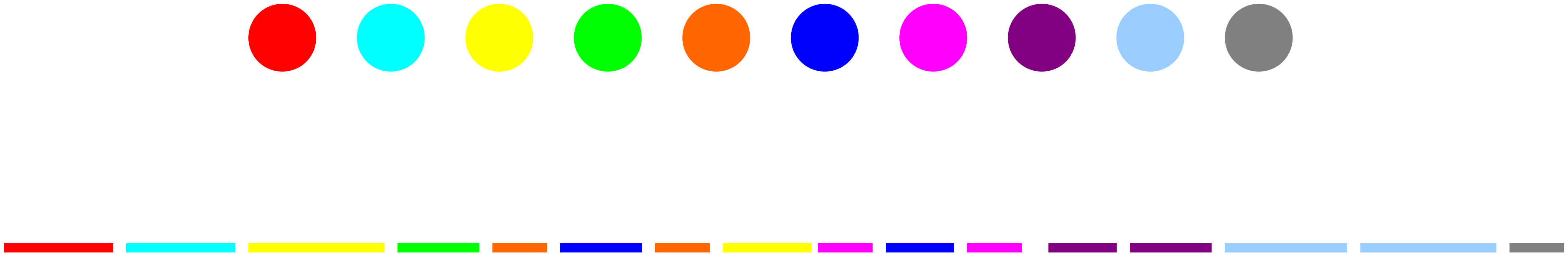

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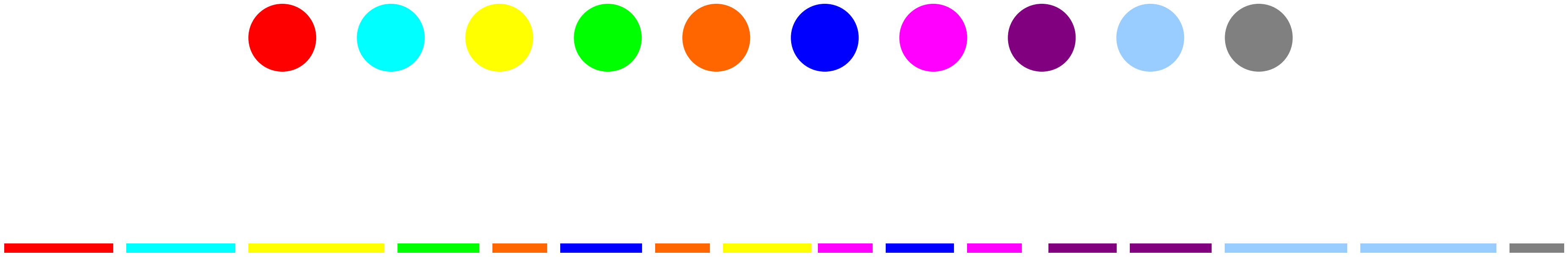

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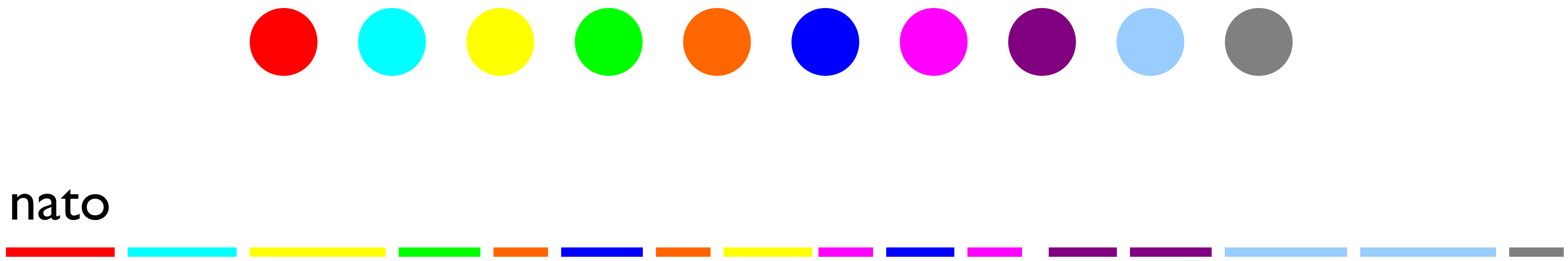

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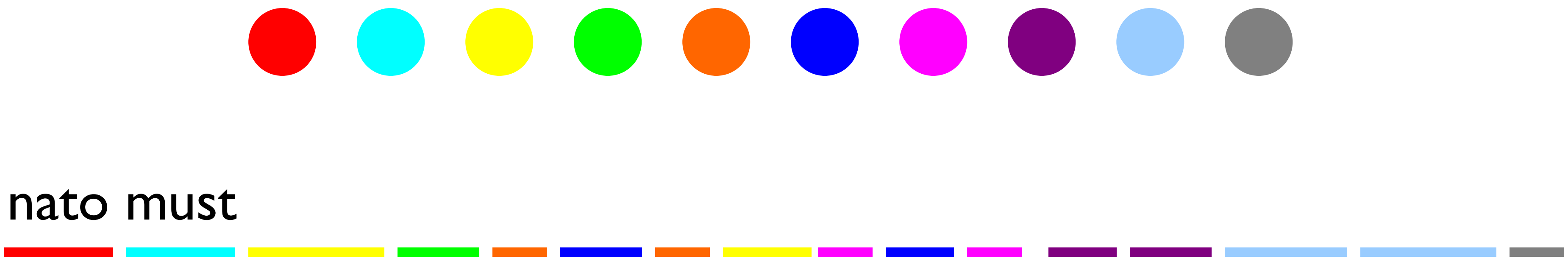
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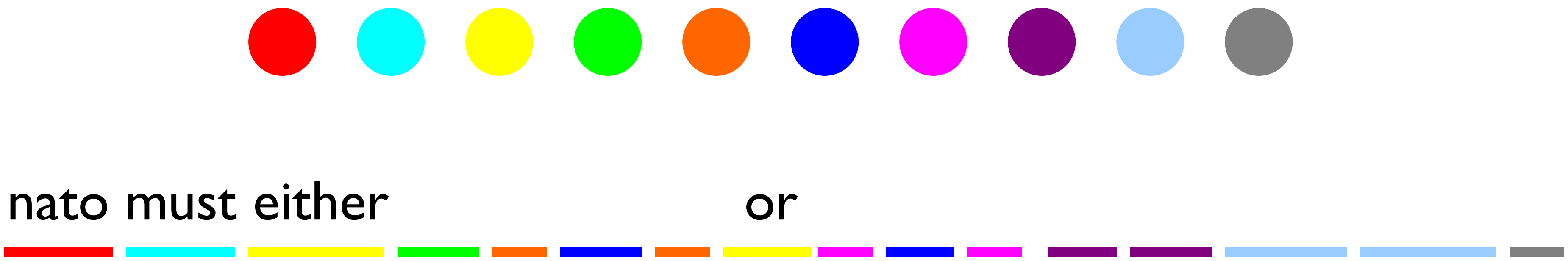

nato must either

or

What is a **pattern**?

A sequence of symbols, possibly including the special symbol "___" which is used to indicate a gap of nonzero length

Examples:

nato

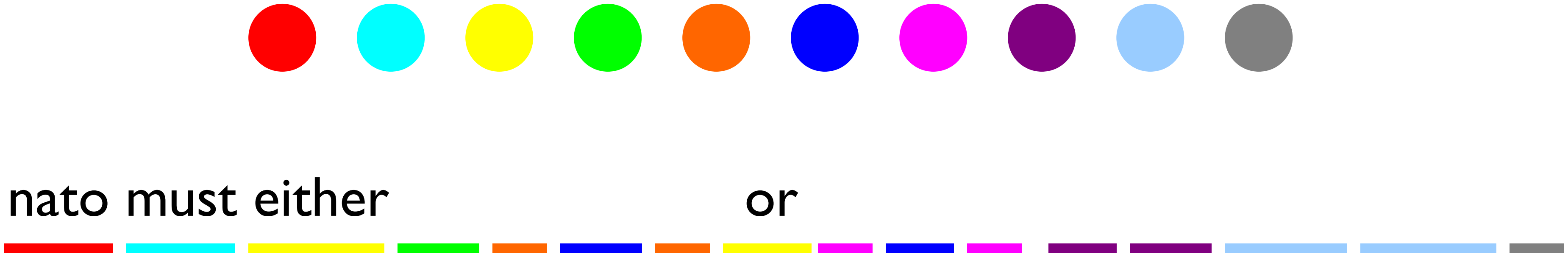
must

either ___ or

the united states

according to the ___ ,

countries ___ their ___ the united states



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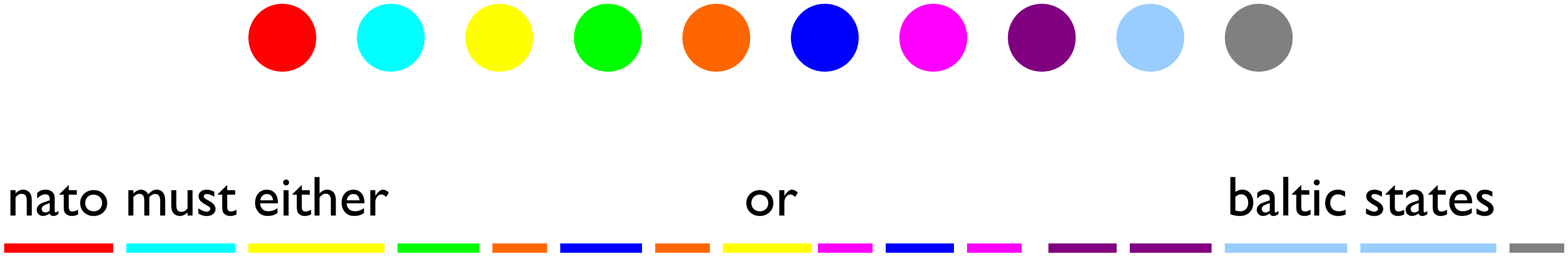

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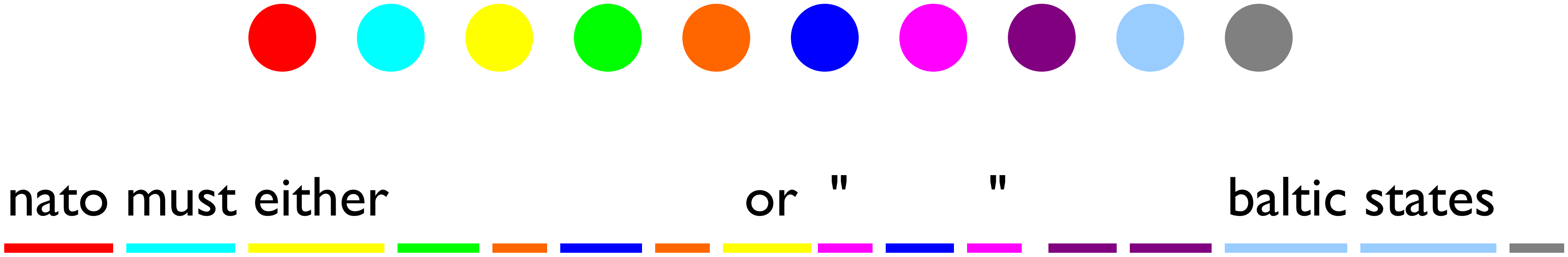

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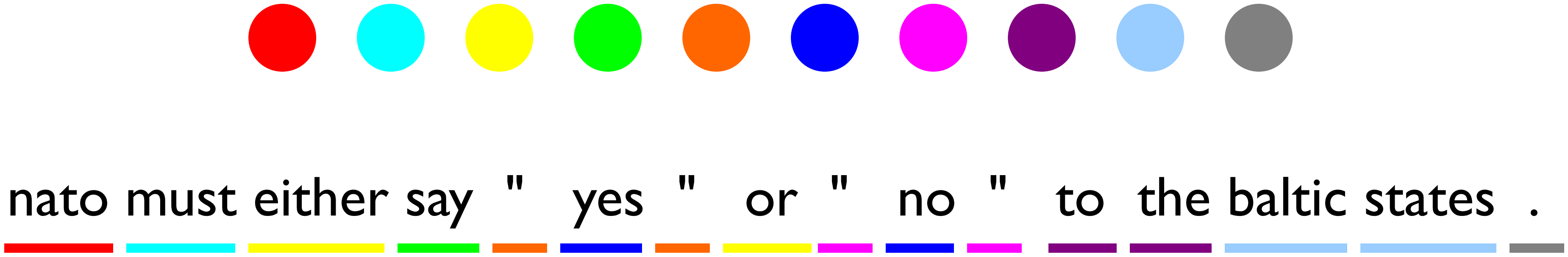

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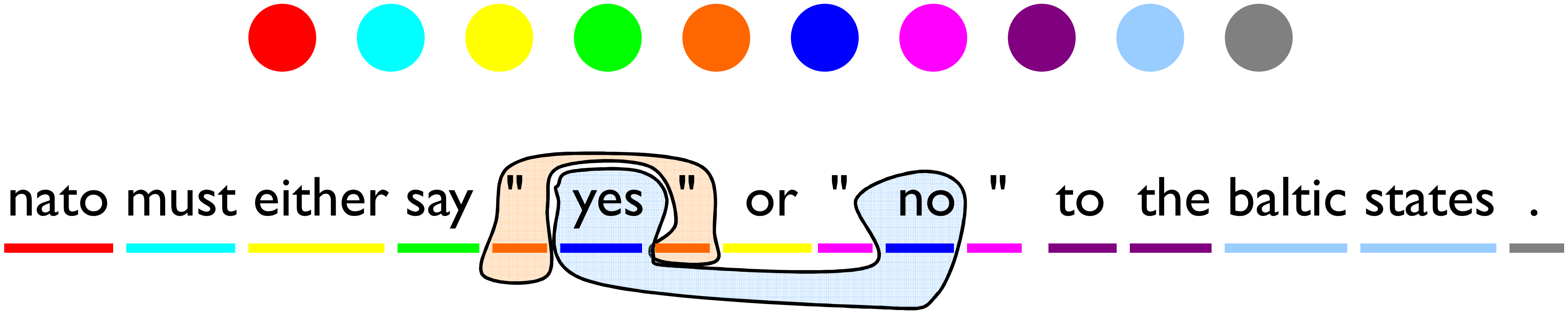

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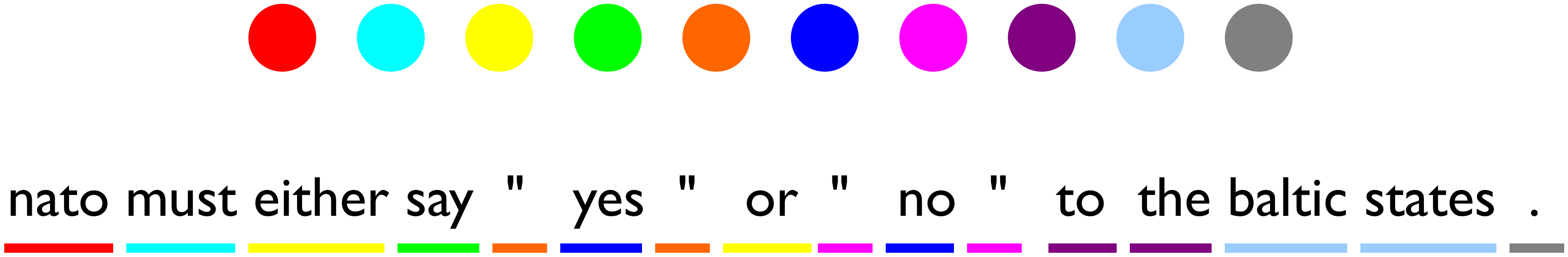

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Nonparametric Priors

- We use a single multinomial distribution over patterns ("unigram pattern model")
- Dirichlet process prior for this multinomial

Inference

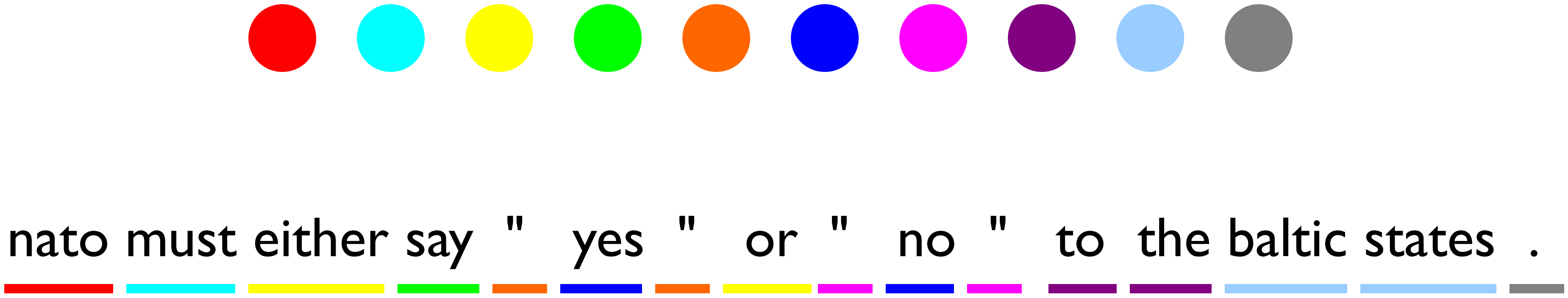
- Goal:
  - □ Given a corpus, obtain an estimate for how probable each pattern is
- To do this:
  - □ Obtain samples from posterior distribution over color assignments
  - □ Compute pattern counts from samples

Inference

- Goal:
  - Given a corpus, obtain an estimate for how probable each pattern is
- To do this:
  - Obtain samples from posterior distribution over color assignments
  - Compute pattern counts from samples
  - We use collapsed Gibbs sampling to marginalize out the multinomial distribution over patterns

Gibbs Sampling

- Go through each word and sample a new color



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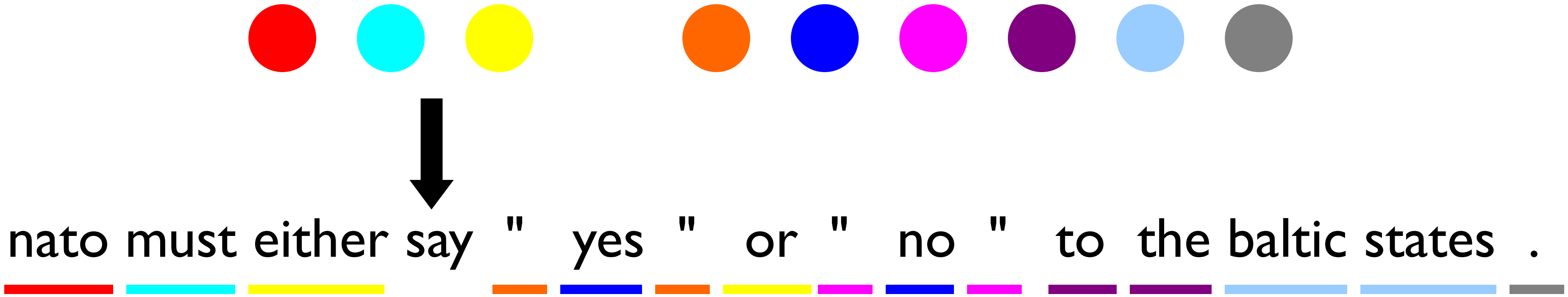

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- Go through each word and sample a new color
  - □ Choose any of the existing colors in the sentence, or
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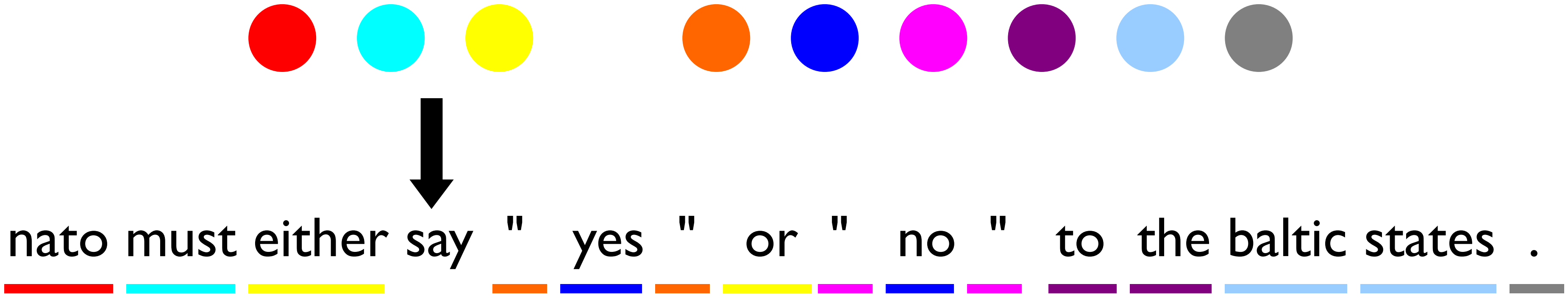

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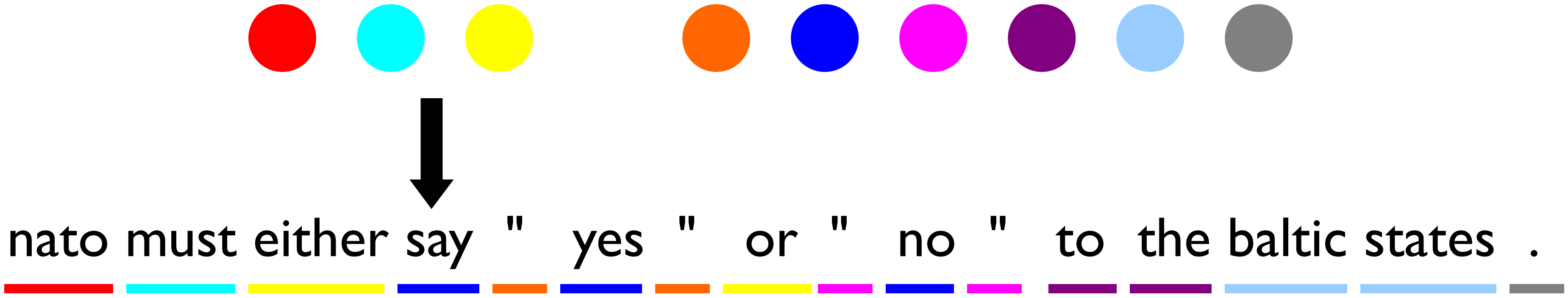

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Gibbs Sampling

- We run sampling for 600 iterations on 125,000 sentences of English news commentary text
- After burn-in, we average pattern counts across all samples

Most Probable Patterns

.	the ___ " ___ "	in ___ , ___ in	, however ,
" ___ "	the united states	america 's	" ___ " ___ " ___ "
-- ___ --	rather than	more than	does not
(___)	as ___ as	china 's	why ___ ?
the ___ of	the ___ of ___ in	the ___ of ___ ,	country 's
, ___ , ___ ,	the ___ is	prime minister	, ___ the ___ of
the ___ (___)	not only ___ but	russia 's	its own
both ___ and	the	europe 's	from ___ to
have been	it is ___ that	is	part of
the ___ of ___ and	should be	what ___ ?	the ___ between ___ and
more ___ than	their own	the world 's	such as ___ ,
- ___ -	based on	between ___ and	these
as well	of ___ " ___ "	developing countries	either ___ or
this	not ___ , but	climate change	economic growth
, ___ " ___ "	has been	the ___ of ___ 's	european union

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Sorting by Conditional Probability

academy __ sciences	treasury secretary __ geithner	at __ ghraib
beijing __ shanghai	sooner __ later	rule __ law
booms __ busts	first __ foremost	free __ fair
council __ advisers	played __ role	neither __ nor
dominicans __ haitian	down __ road	across __ border
flemish __ walloons	freedom __ expression	clash __ civilizations
gref __ program	at __ disposal	estonia __ lithuania
heat __ droughts	take __ granted	within __ framework
humanitarian __ displaced	- __ -	window __ opportunity
karnofsky __ hassenfeld	at __ expense	solve __ problem
kazakhstan __ kyrgyzstan	taken __ granted	paid __ price
portugal __ greece	billions __ dollars	taking __ account
regulators __ supervisors	answer __ yes	during __ period
sine __ non	poland __ slovakia	lender __ last
stalin __ mao	ukraine __ orange	positive __ negative

Using a Product of Experts

-- __ --	how __ ?	we __ our	his __ his
(__)	the __ (__)	over __ past	some __ others
- __ -	on __ basis	prevent __ from	may __ be
both __ and	less __ than	in __ way	as __ as
not only __ but	on __ other hand	one __ another	oil __ gas
" __ "	at __ level	political __ economic	at __ moment
more __ than	it is __ that	for __ reasons	such as __ and
either __ or	not __ , but	at __ time	question __ whether
why __ ?	play __ role	more __ more	if __ then
neither __ nor	france __ germany	the rest __ world	war __ iraq
what __ ?	he __ his	more __ less	; __ ;
rule __ law	allow __ to	in __ region	have __ been
whether __ or	for __ first time	rich __ poor	in __ cases
around __ world	china __ india	as __ whole	war __ terror
has __ been	what __ do	on __ scale	at __ cost

Punctuation

-- ___ --
(___)
- ___ -
both ___ and
not only ___ but
" ___ "
more ___ than
either ___ or
why ___ ?
neither ___ nor
what ___ ?
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how ___ ?
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over ___ past
prevent ___ from
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as ___ as
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if ___ then
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; ___ ;
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Connectives and Constructions

-- ___ --
(___)
- ___ -
both ___ and
not only ___ but
" ___ "
more ___ than
either ___ or
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Agreement

-- __ --
(__)
- __ -
both __ and
not only __ but
" __ "
more __ than
either __ or
why __ ?
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Topicality

-- __ --
(__)
- __ -
both __ and
not only __ but
" __ "
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Prepositional Phrases

-- __ --
(__)
- __ -
both __ and
not only __ but
" __ "
more __ than
either __ or
why __ ?
neither __ nor
what __ ?
rule __ law
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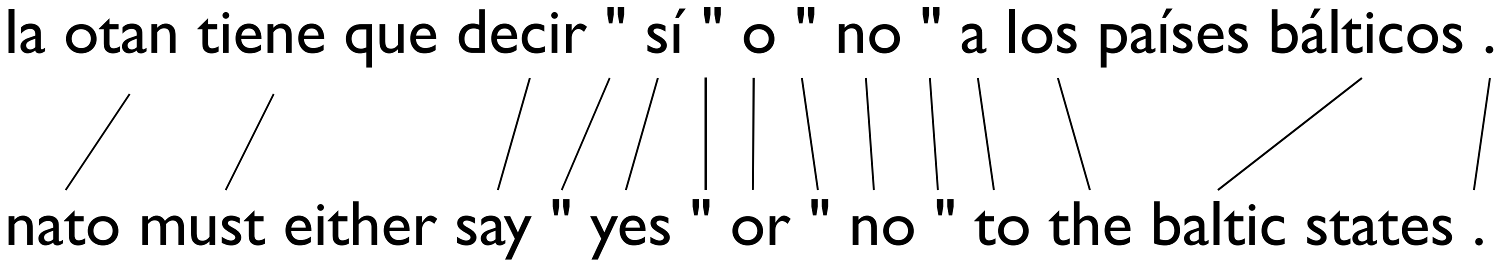
- How does this differ from word trigger pairs derived from mutual information (Rosenfeld, 1994)?
- The X __ Y pairs we extract are similar to his pairs
- We also model collocations and larger patterns:
  - X Y Z
  - X Y __ Z
  - X __ Y __ Z
  - X Y __ Z __ W __ V
  - etc.
- Generative models are also amenable to extensions…

Modeling Bilingual Patterns



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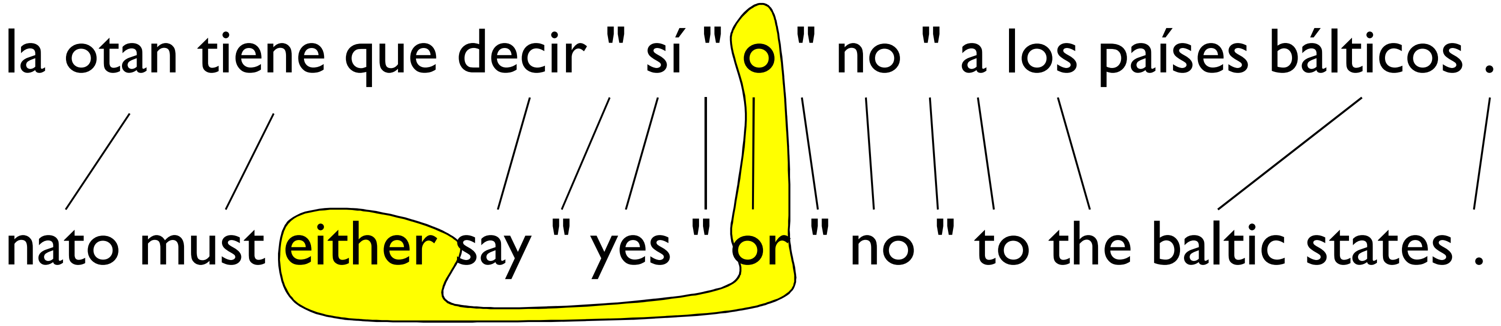

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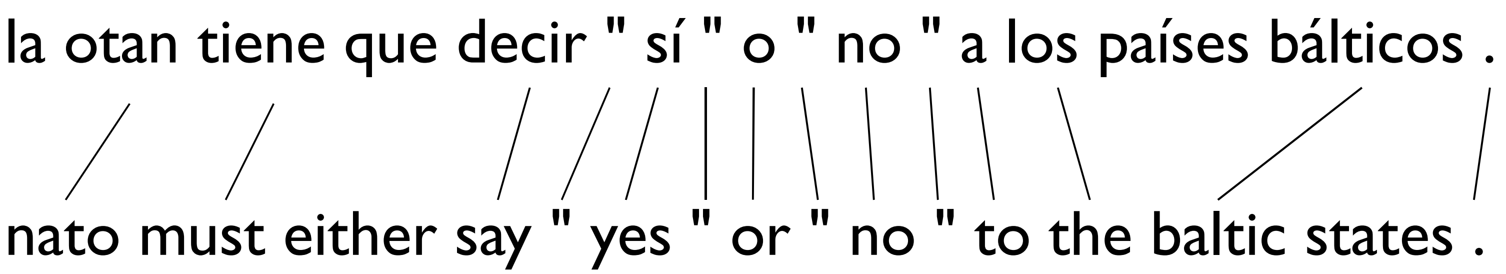

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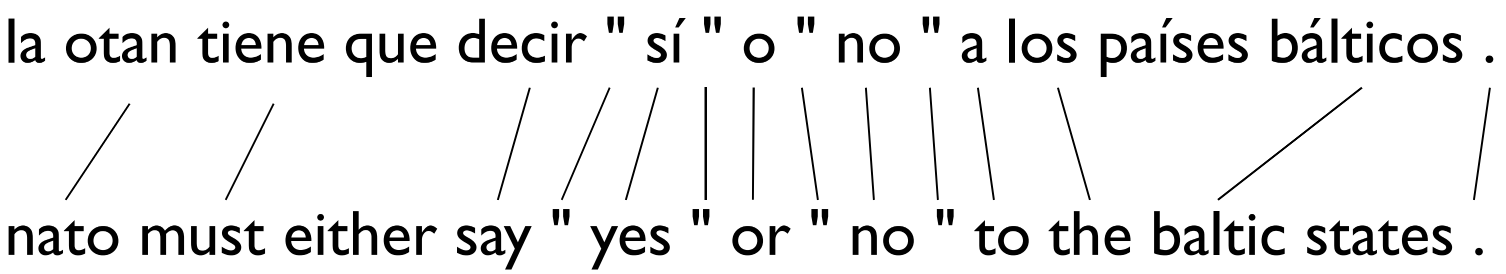

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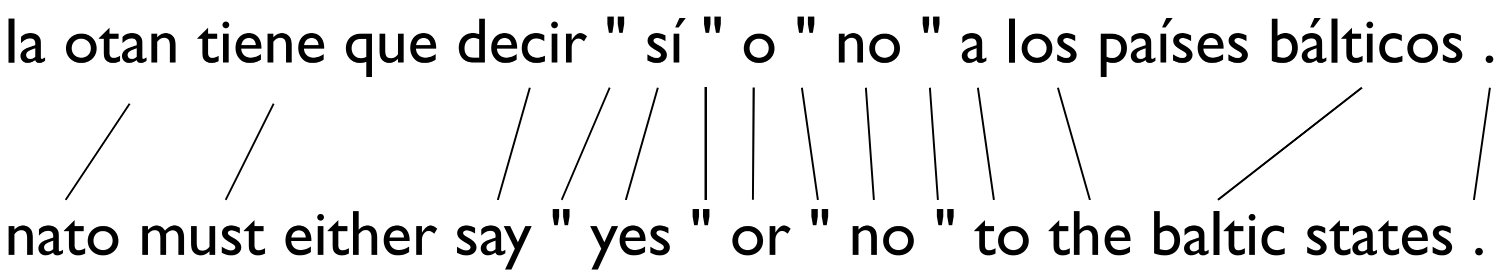
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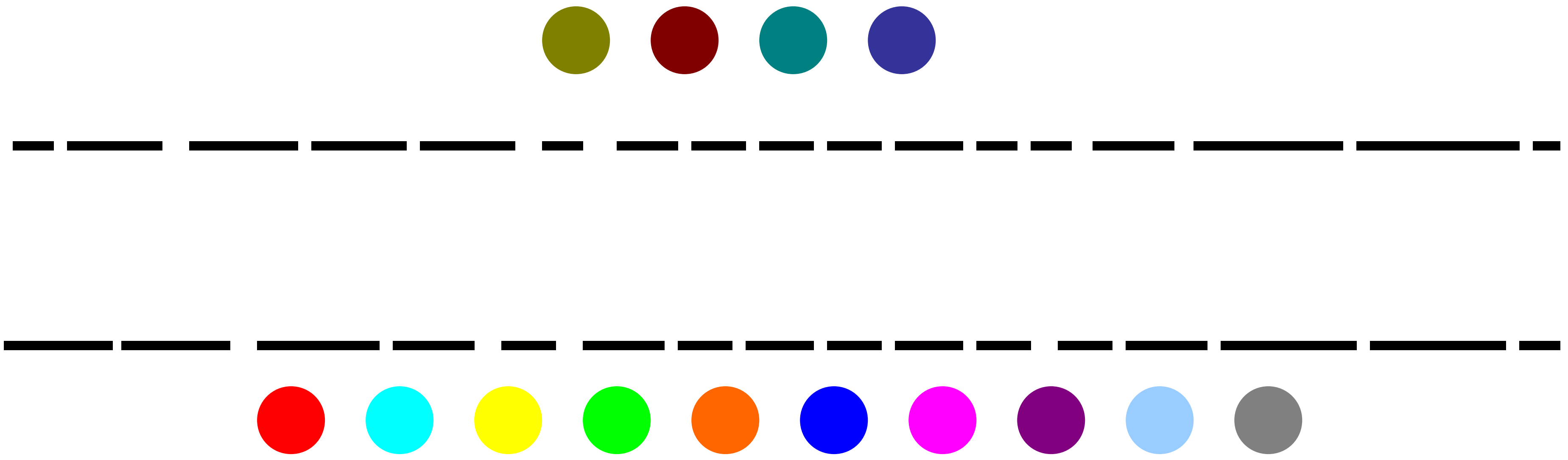

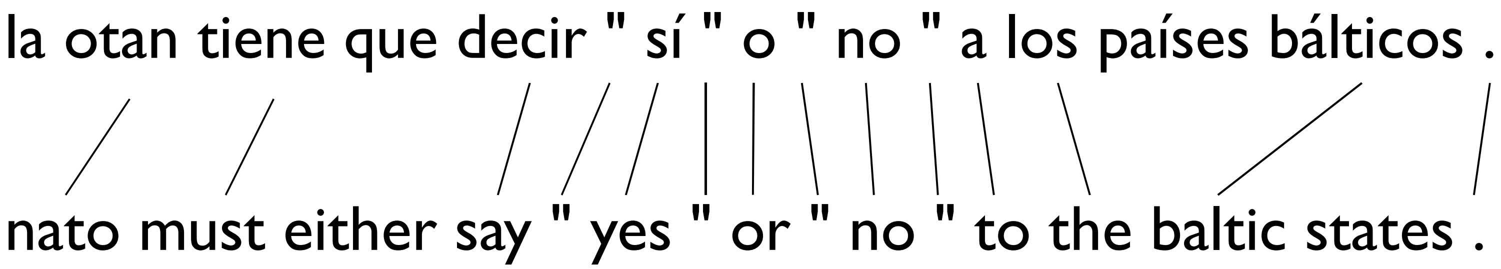

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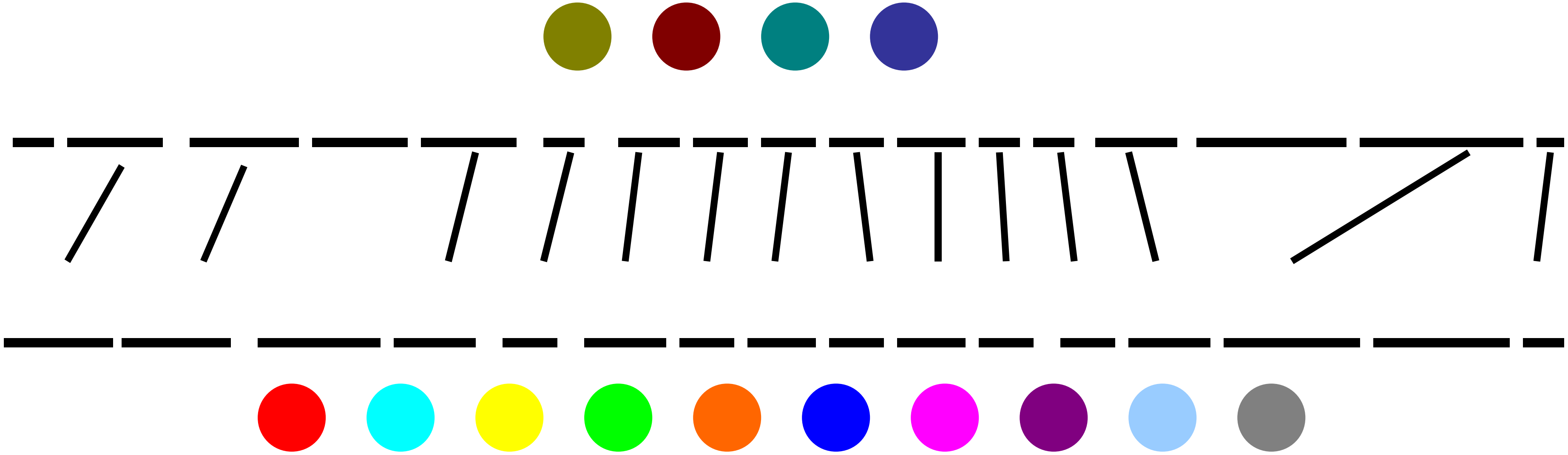

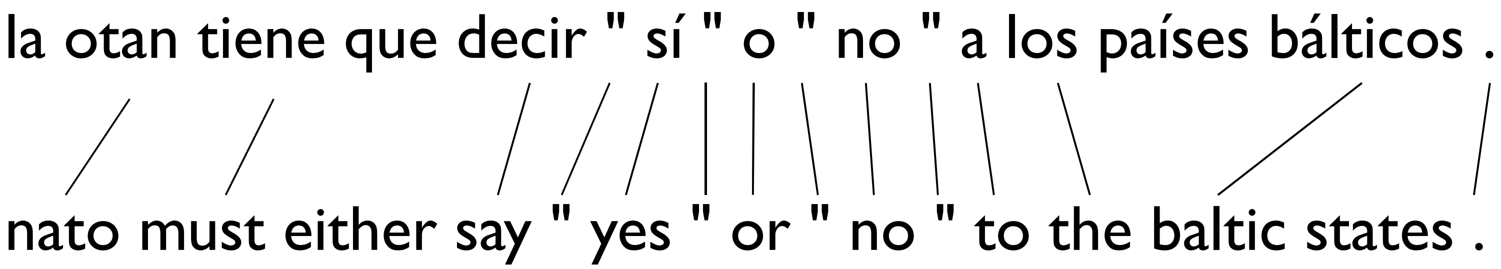

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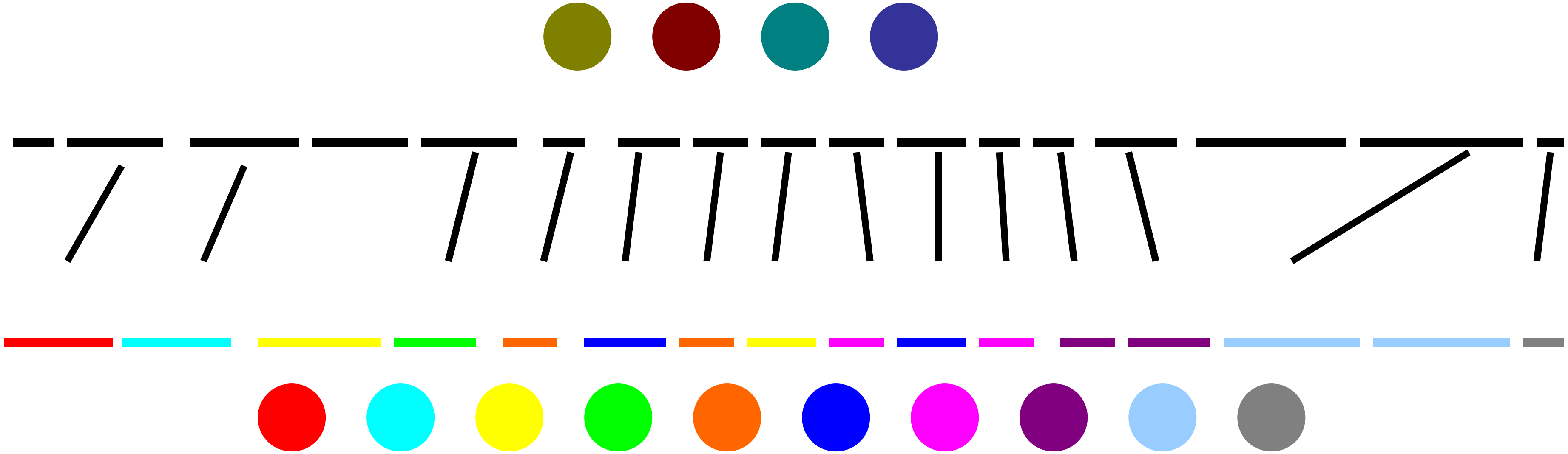

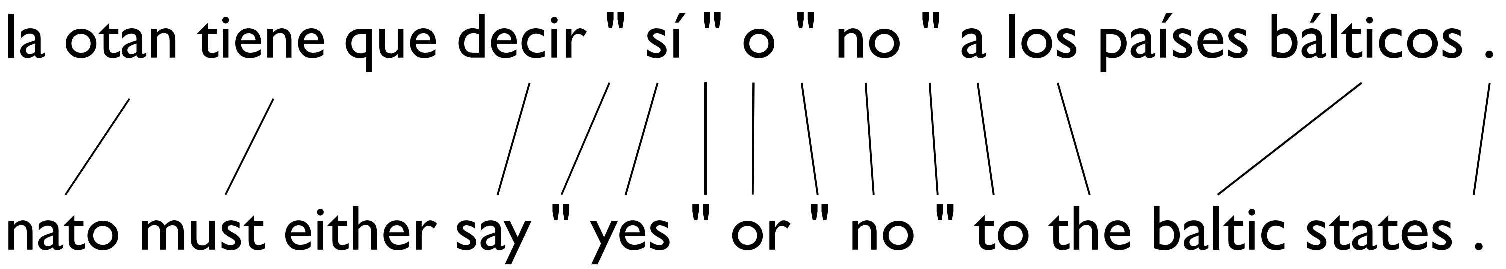

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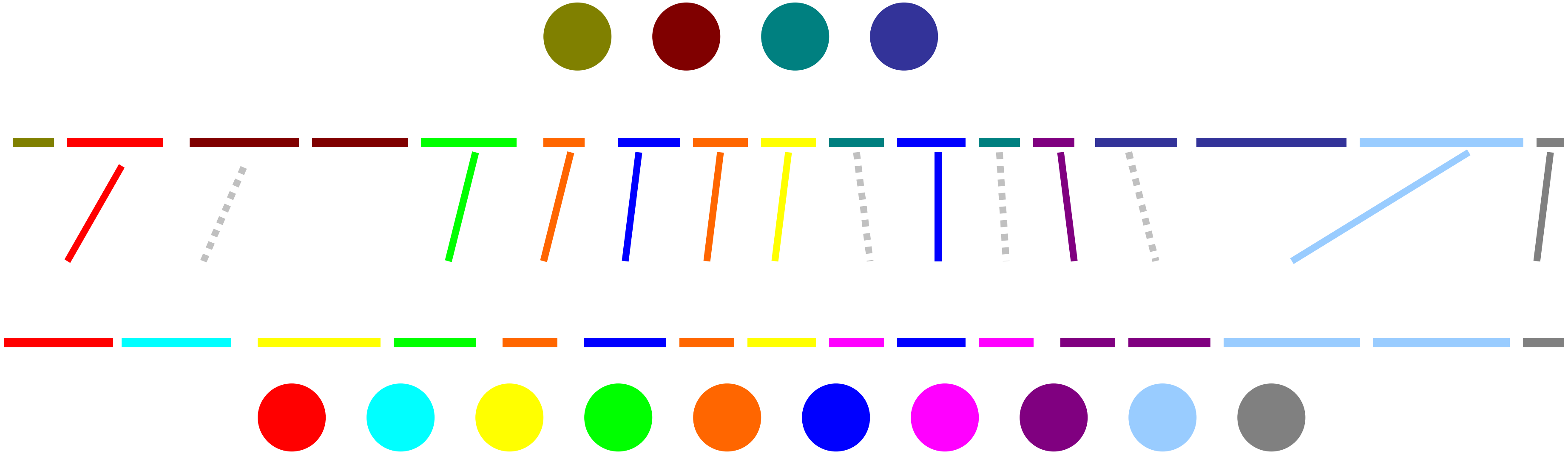

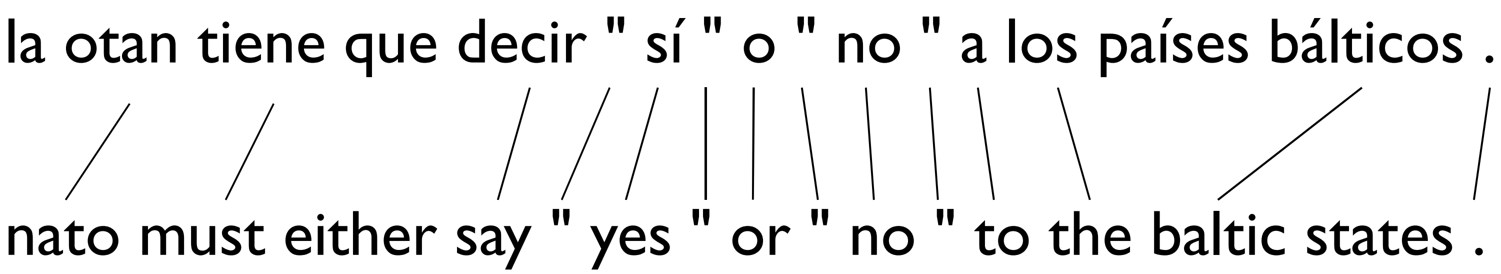
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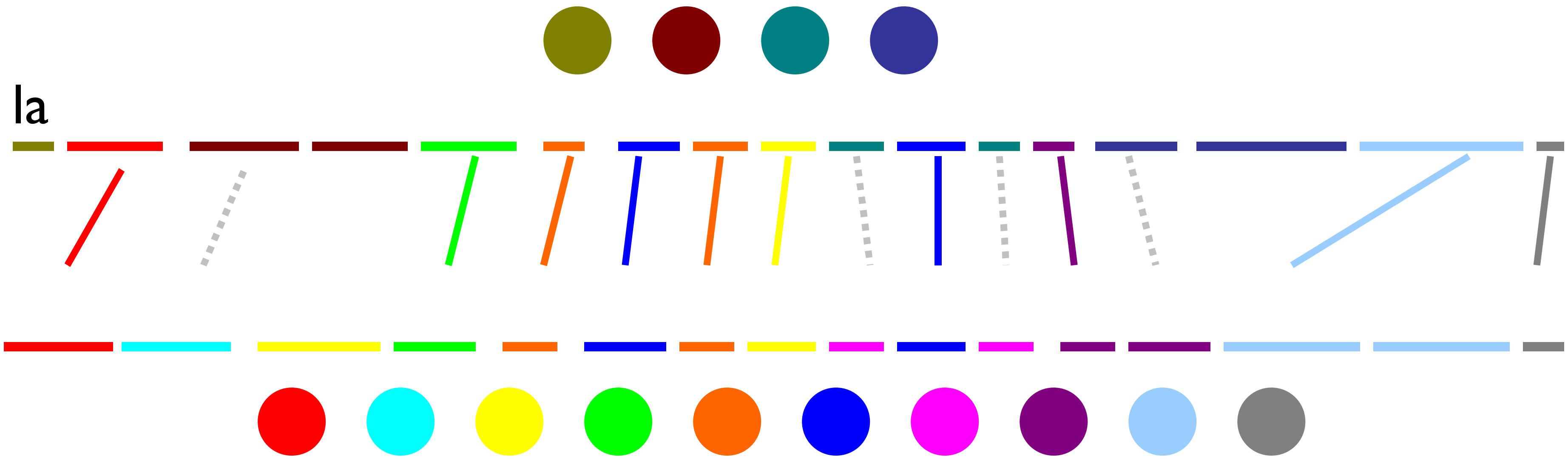

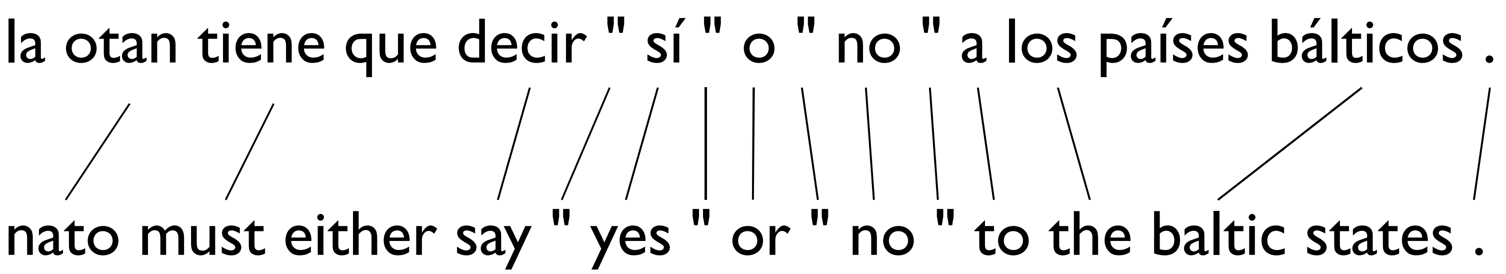

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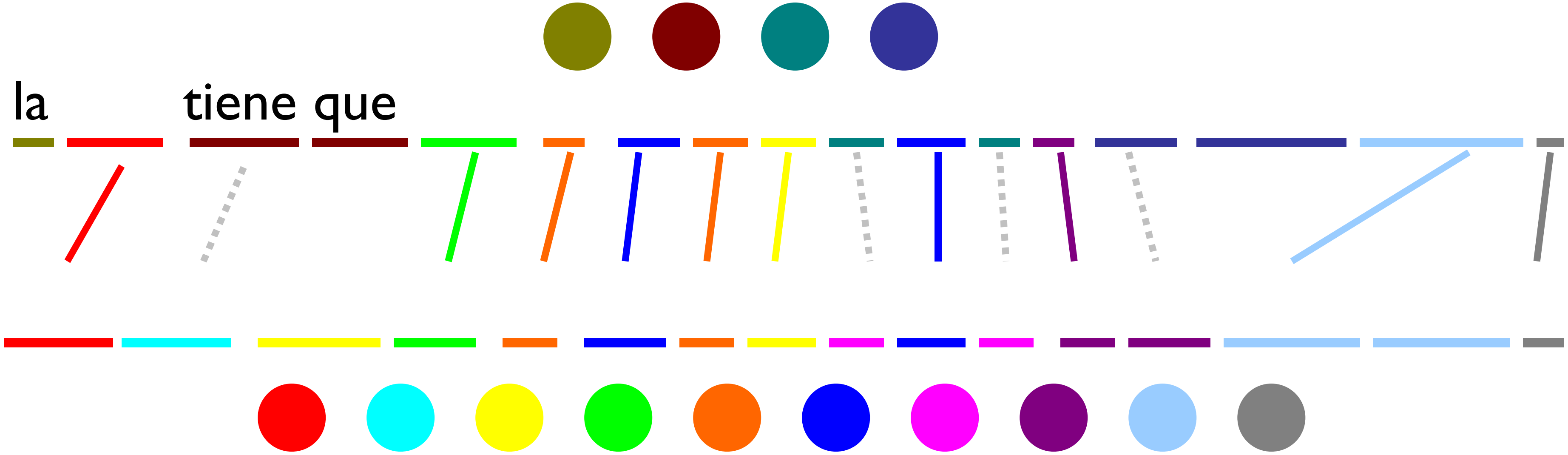

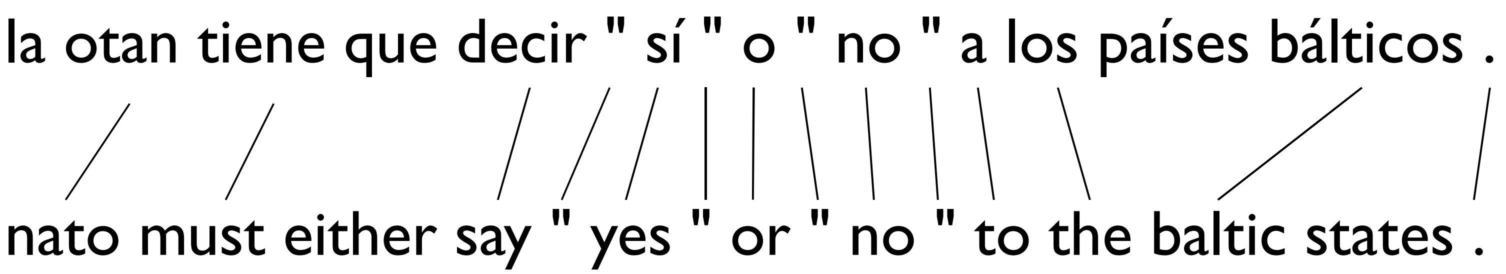
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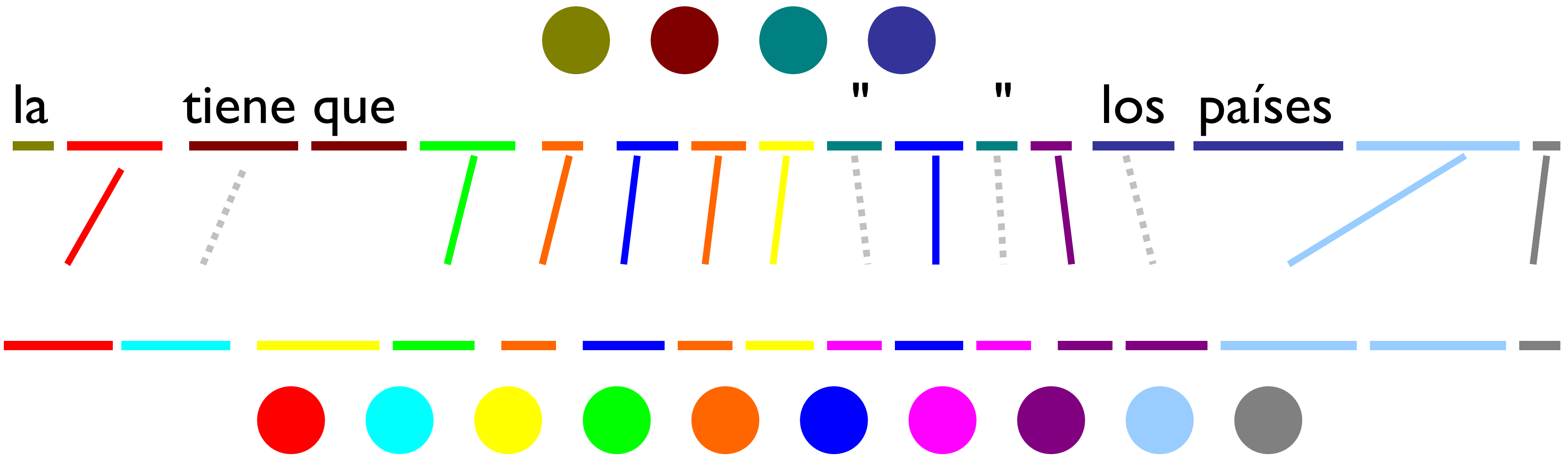

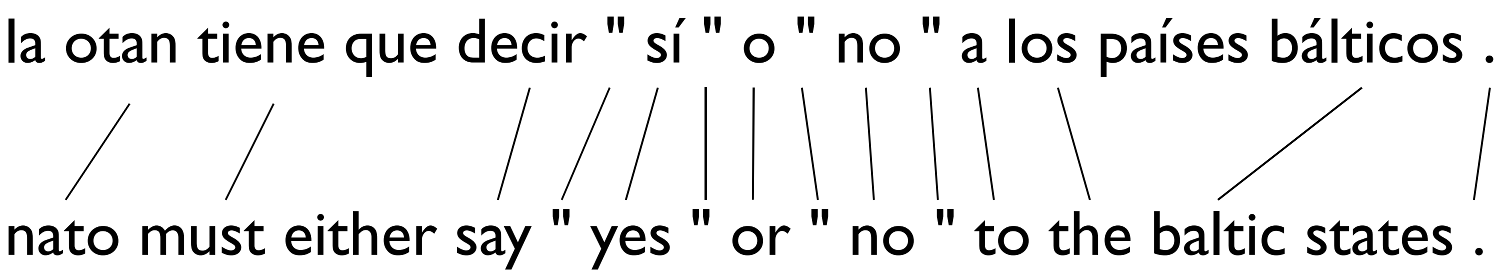

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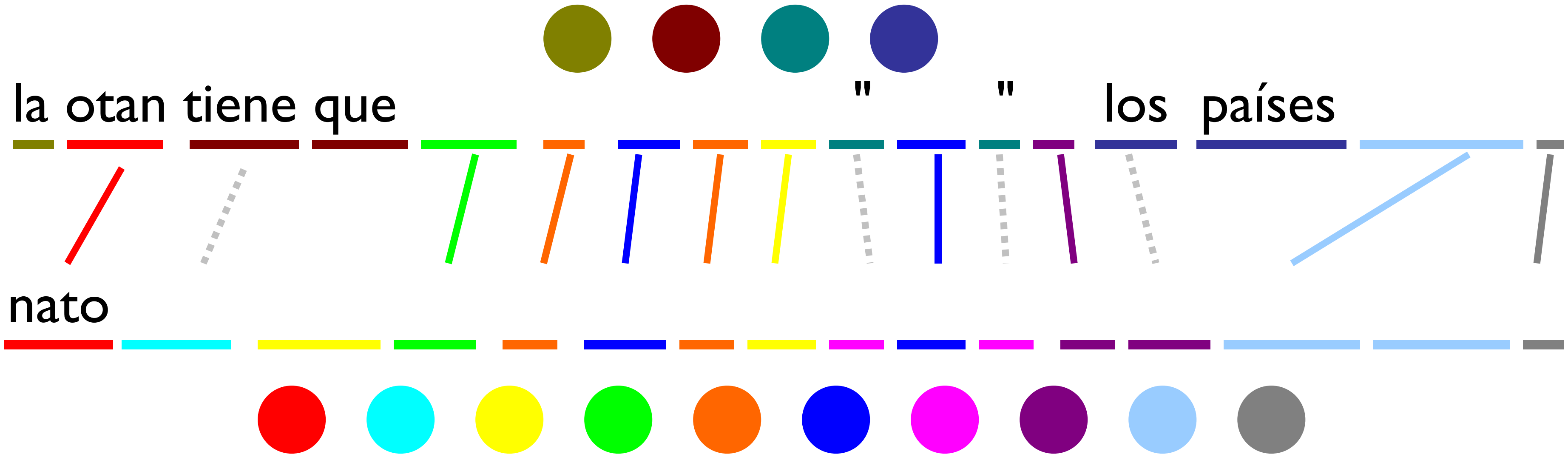

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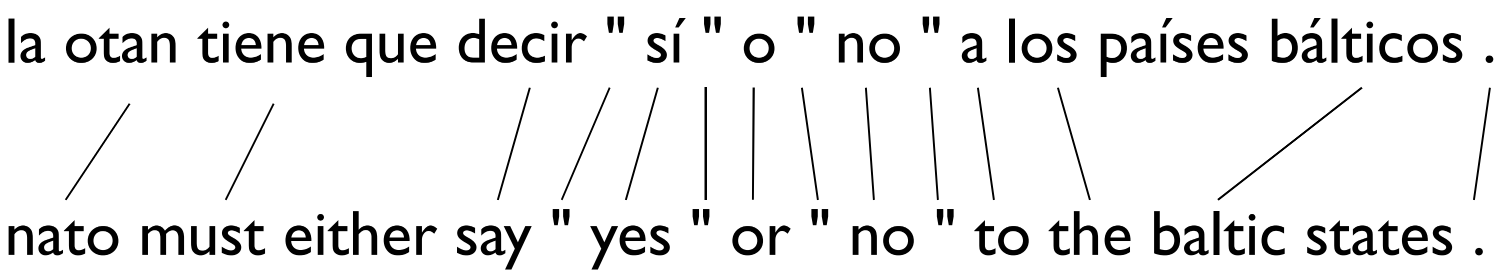
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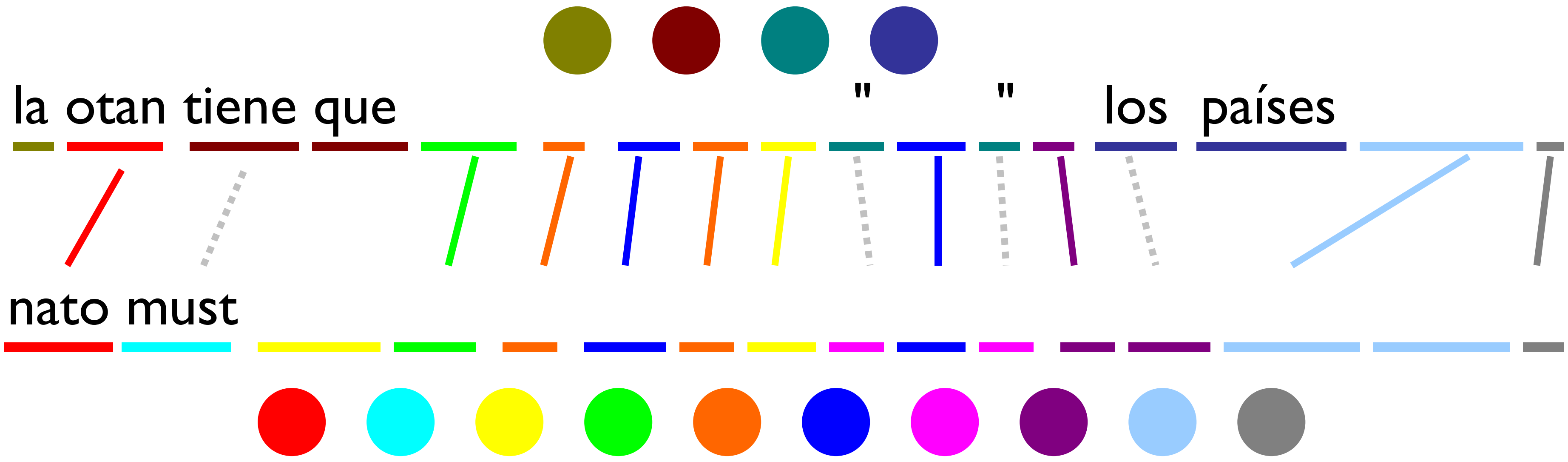

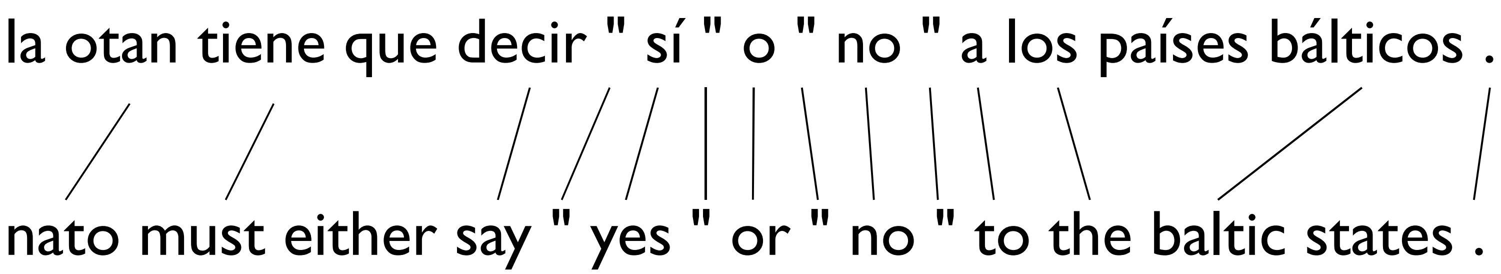

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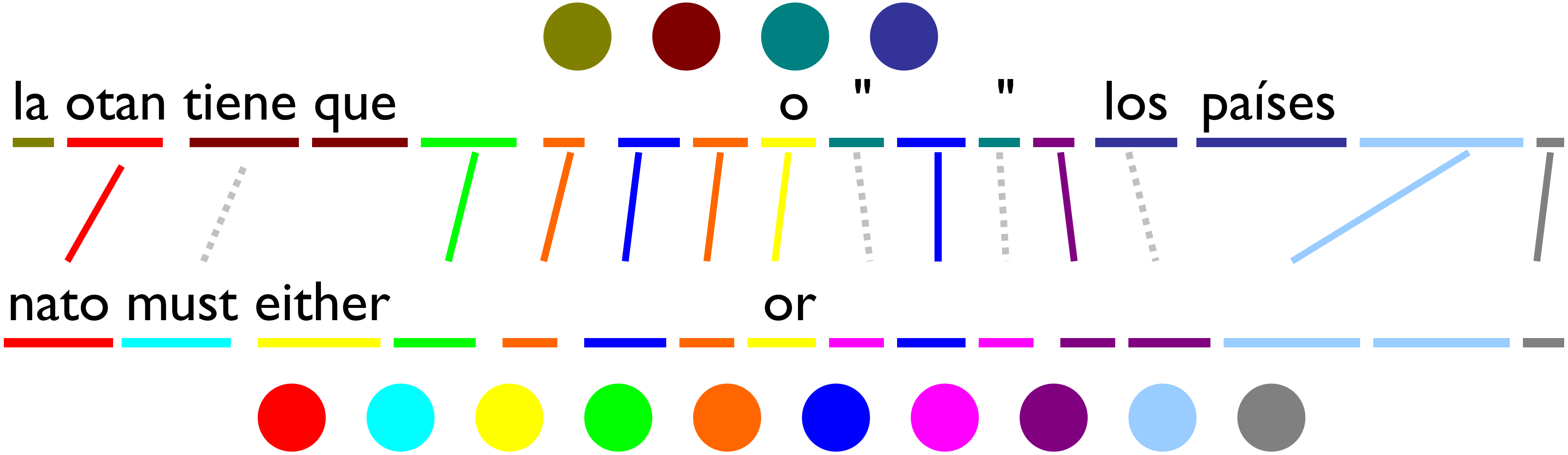

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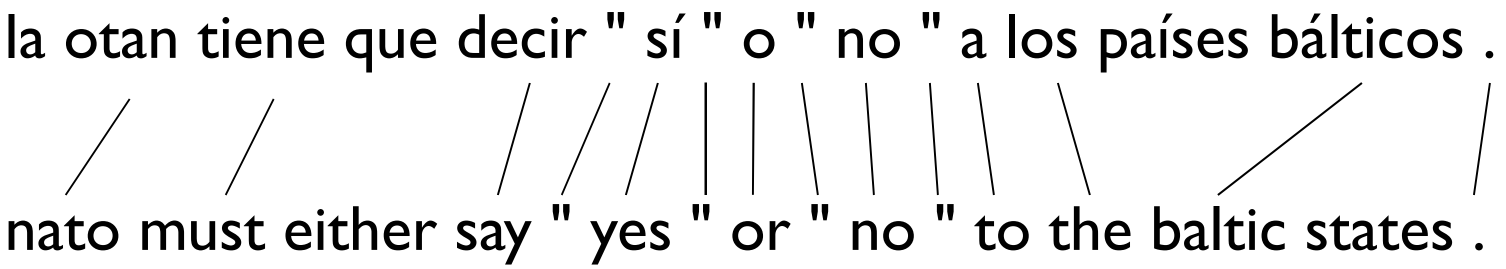

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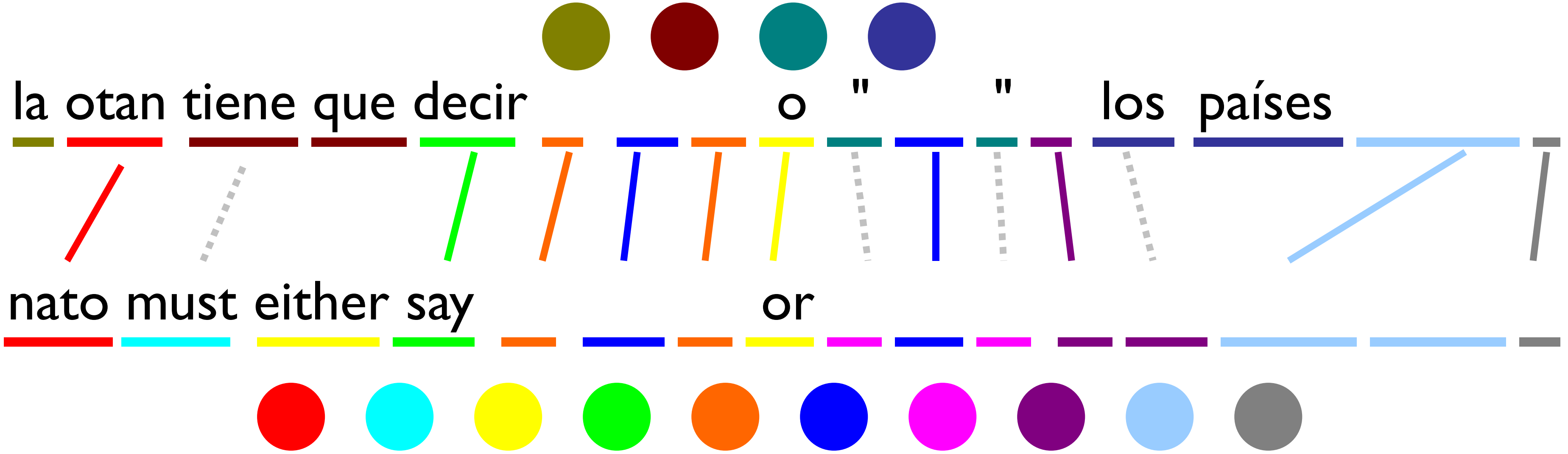

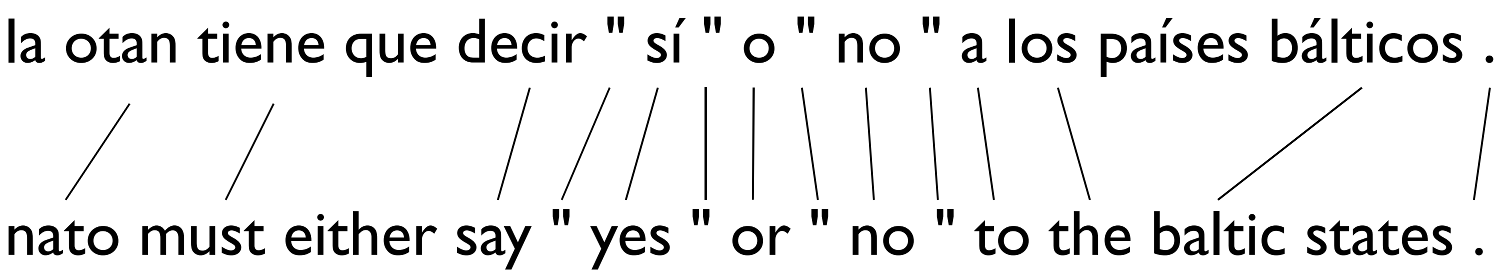
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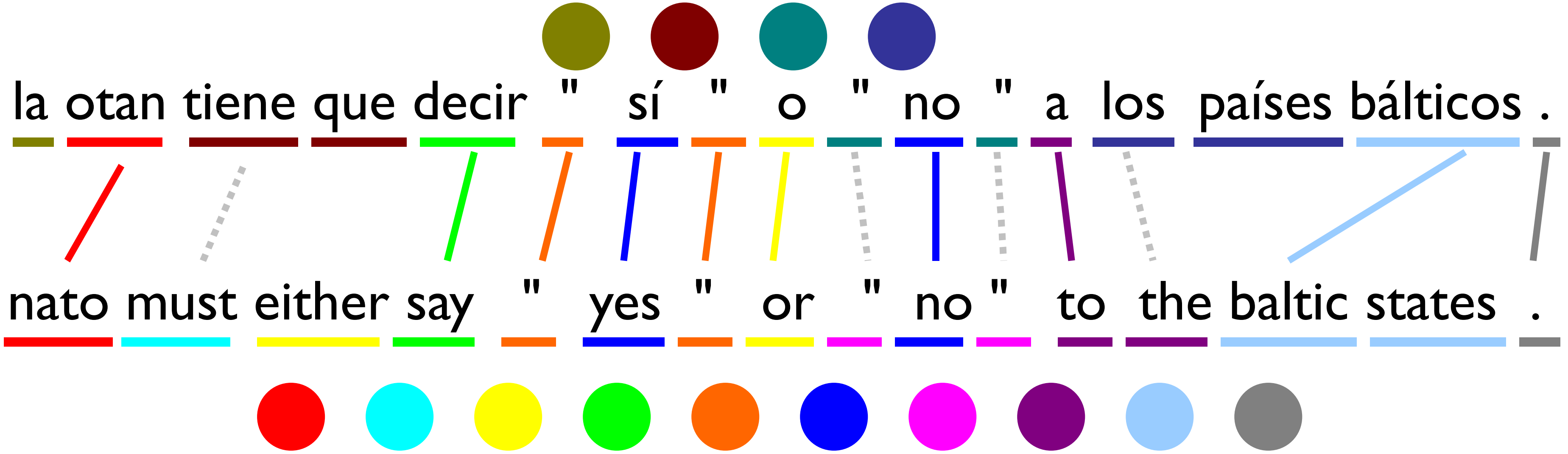
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Inference with Bilingual Pattern Models

- Gibbs sampler similar to monolingual model, with a few extra moves (see paper and code)
- Inference run for 300 iterations
- Examples:

we must(debemos)	they __ their(sus)
we are(estamos)	their(sus) __ their(sus)
we can(podemos)	he __ his(sus)
either __ or(o)	it __ its(sus)

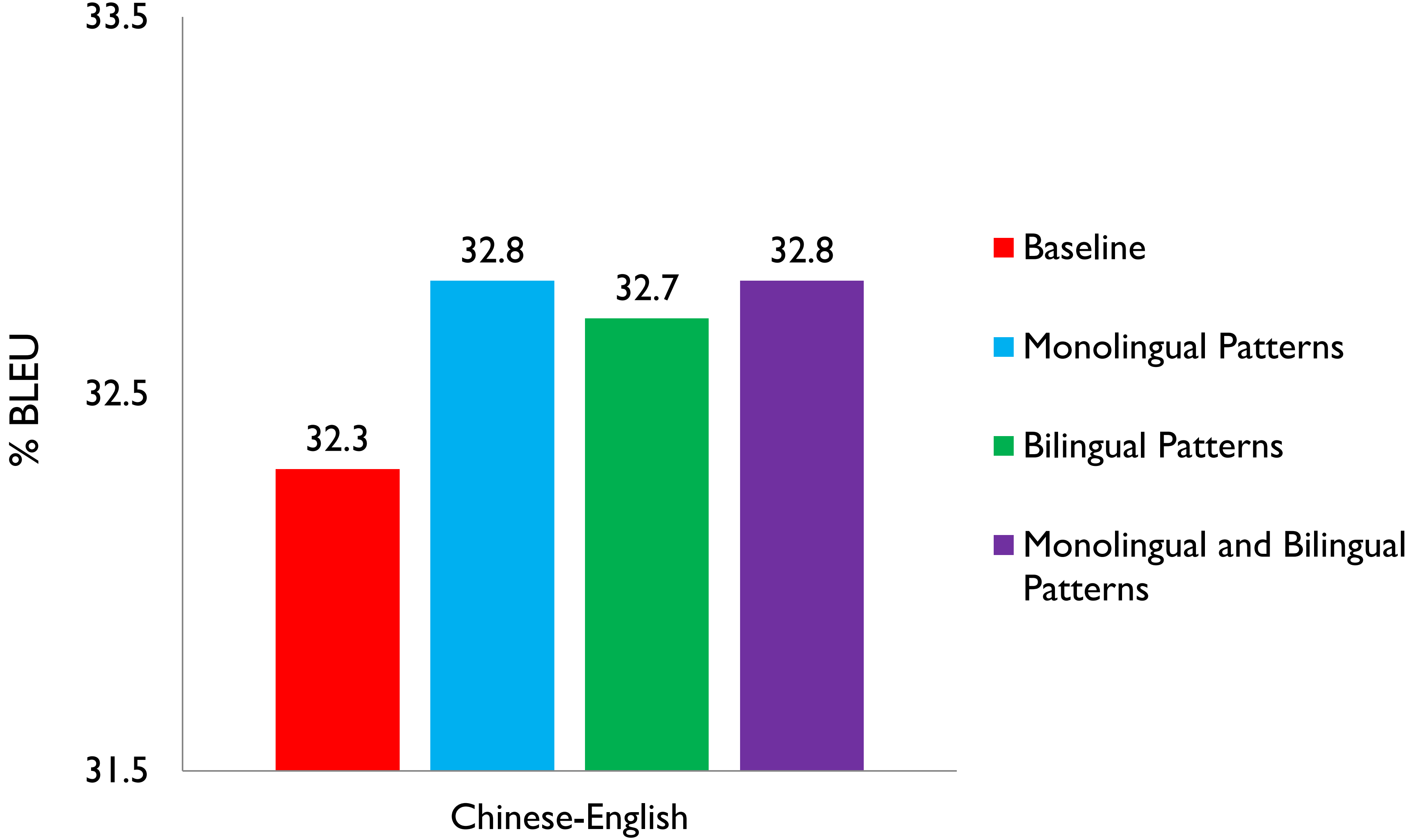
Experiments

- We added count features for individual patterns
- Monolingual patterns:
  - □ 10k lexical patterns
  - □ 15k patterns on Brown clusters
- Bilingual patterns:
  - □ 5k word/word, 5k word/cluster, 5k cluster/cluster
- Features are **non-local** since they can match anywhere in the derivation
- Features incorporated via cube pruning of phrase lattices
- Trained using a MIRA-like procedure (simplified from that of Chiang et al., 2009)

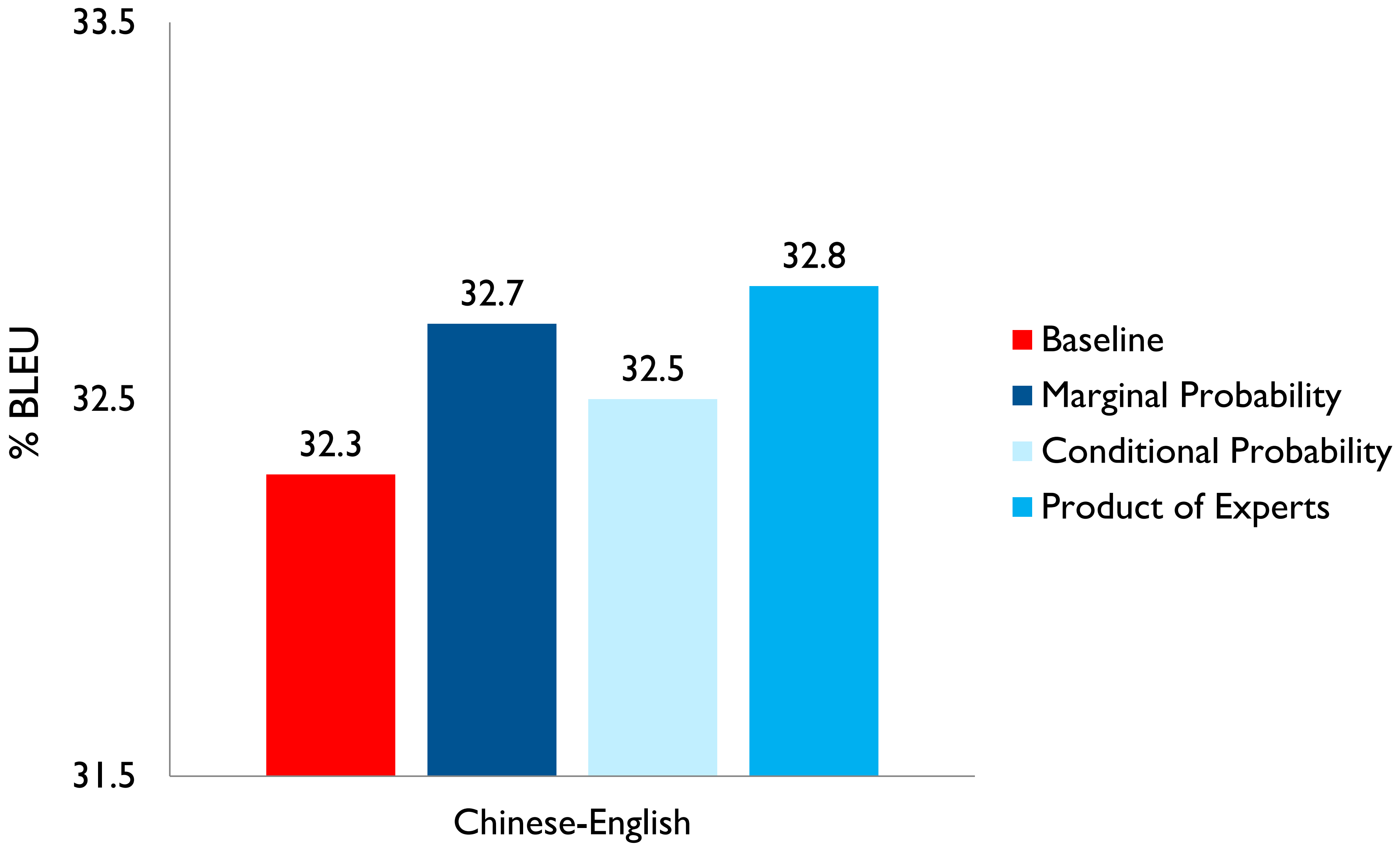
Experiments

- Chinese-English
  - 300k sentence pairs from FBIS corpus
  - Tuned on MT03, tested on MT05
  - Trigram LM estimated from English side of parallel corpus + 200M words of Gigaword data
- Spanish-English
  - No improvement; experiments reported in paper

Adding Pattern Features



Comparing Ways of Ranking Patterns



ARK lti Carnegie Mellon

Most Highly-Weighted Features

said that __ the

however , __ the

agence france __ presse

's __ , __ 's

us __ iraq

reported __ the

of __ million

, __ likely

said that __ and

added __ "

- __ -

rate __ percent

the __ {media, school, university, election, bank} __ {made, established, given, taken, reached}

{said, stressed, stated, indicated, noted} that __ in

{meeting, report, conference, reports, summit} __ {1, july, june, march, april}

{news, press, spokesman, reporter, consultative} {meeting, ...} __ {1, july, june, march, april}

{news, press, spokesman, reporter, consultative} __ {1, july, june, march, april}

the __ {enterprises, companies, students, customers, others} __ {enterprises, companies, ...}

{japan, russia, europe, 2003, 2004} __ {us, japanese, russian, u.s., british}

Conclusions

- We presented models for discovering gappy patterns in monolingual and parallel text
- Validation of patterns qualitatively and quantitatively in a phrase-based MT system
- Code implementing inference for our models is available: `www.ark.cs.cmu.edu/MT`

Thanks!