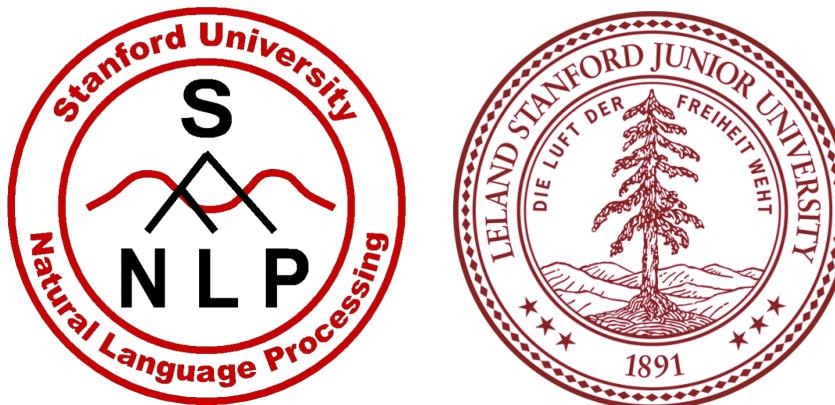


Computational models for the semantic bleaching of English intensifiers



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First International Workshop on Computational Approaches to Historical
Language Change, August 2, 2019

The Phenomenon

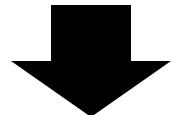
Manner meaning	Intensifier meaning
wildly muttering	That recipe is wildly easy !
stupidly drunk	It's stupidly sunny here in Florence.
terribly written	I'm not terribly interested in spending my money.

The Phenomenon

Basic
meaning

de-adjectival adv = adj + -ly
'in an adj manner'

wild + -ly
stupid+ -ly
terrible+ -ly



Bleached
meaning

intensifying adv (intensifier)
'very/really'

What is bleaching?

- Bleaching is a process in which a word (or morpheme) loses certain semantic features while retaining others (Sweetser, 1989; Heine, 1991)
- Ex: Latin *ad + ripam* ‘to shore’
 - > Vulgar Latin *arripare* ‘to come to shore’
 - > Old French *ariver* ‘to come to land’
 - > English *arrive* ‘to come to’

What is bleaching?

- Bleached terms have a wider range of collocates
(Lorenz, 2002; Hopper and Traugott, 2003)
- Ex: adjectives modified by *terribly* in 1850 vs. 1990

	1850	1990
	negative adjs only	negative <i>and</i> positive adjs
terribly	deformed, diseased, broken, fatal, ...	deformed, diseased, broken, fatal, relieved, important, goodlooking, generous, ...

How does bleaching happen?

- Bleaching is the result of reanalysis, defined as a language user's mapping of a form to a new meaning based on widening collocations

(Bybee et al., 1994)

Some open questions

Part I: Creating computational methods to operationalize the bleaching process

- How similar in meaning are *terribly*, *stupidly*, *wildly*, etc. to a prototypical intensifier (e.g., *very*)?
- How much of their original meanings do they retain?
- How much have they grown in productivity?

Part II: Using these methods to test a theory of reanalysis

- What triggers the reanalysis of de-adjectival adverbs into intensifiers?

Part I



Methods for
operationalizing
bleaching

Verification
of methods

Applying methods
to test a theory of
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Part I

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Part II

Method 1: SimVery

Q: How semantically similar is an adverb becoming to an intensifier?

→ **SimVery:** cosine similarity b/w bleaching adverb, *a*, and “very”

$$\text{SimVery}(a, t) = \text{sim}(a_t, \text{very}_t)$$



Method 2: SimLex

Q: How much does an adverb differ from its original meaning?

→ **SimLex**: cosine similarity between a and lemmas (L) associated with its root meaning

$$\text{SimLex}(a, t) = \frac{1}{|L|} \sum_{l_k \in L} \text{sim}(a_t, l_{k_t})$$

Method 2: SimLex

Adverb	Lemmas from original semantic domain
disgustingly	filthy, filth, repulsive, aversion
beautifully	elegance, elegant, style, gorgeous, beauteous
wildly	savage, rage, fierce, barbarian, uncivilized
remarkably	impact, stun, awe, wonder, amazement, terror

- Lemma sets are comprised of WN and thesaurus synonyms
- Eliminated lemmas undergoing semantic change (compared to set of highly stable lemmas of pronouns and numerals)

Method 3: TypeDiv

Q: How diverse are the adjectives modified by an adverb becoming?

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Q: How diverse are the adjectives modified by an adverb becoming?

→ **TypeDiv(a, t)**: number of unique adjective types modified by an adverb a at time t

Concern: an adverb might modify

- many highly similar (distinct) adjectives
- few semantically distant adjectives

Method 4: Breadth

Q: How semantically broad are the adjectives modified by an adverb becoming?

Method 4: Breadth

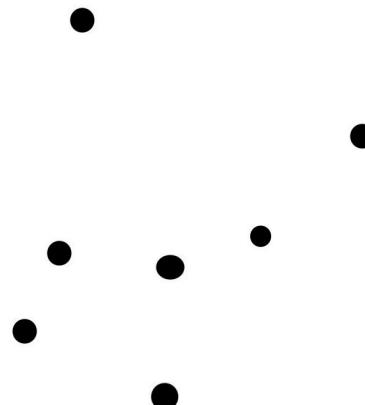
Q: How semantically broad are the adjectives modified by an adverb becoming?

→ **Breadth (B):** average weighted pairwise similarity among the adjectives (A_t) modified by a at time t

Method 4: Breadth

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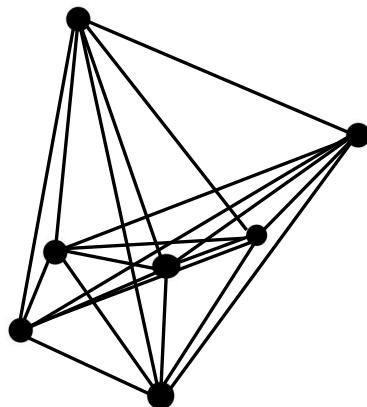
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Method 4: Breadth

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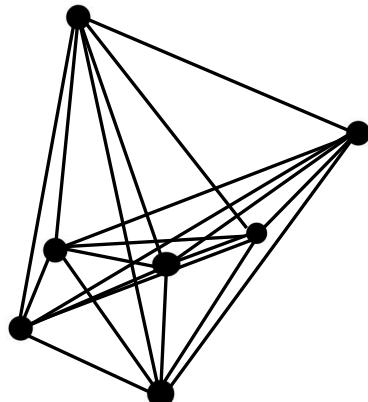


Method 4: Breadth

Q: How semantically broad are the adjectives modified by an adverb becoming?

→ **Breadth (B)**: average weighted pairwise similarity among the adjectives (A_t) modified by a at time t

- Higher similarity → closer together → less broad
- Multiply Breadth by -1 so that greater density → more broad





Methods for
operationalizing
bleaching

Verification of methods

Applying methods
to test a theory of
reanalysis

Data: Two sets of deadjectival adverbs

250 bleaching adverbs, including...

enormously	immensely	abundantly	seriously	thoroughly
strangely	abnormally	marvelously	absolutely	fully
brutally	terribly	abominably	insanely	entirely

178 frequency-matched control adverbs, including...

abruptly	accordingly	frankly	privately	quietly
ironically	locally	loudly	simultaneously	happily
nationally	newly	officially	neatly	originally

We want to test ...

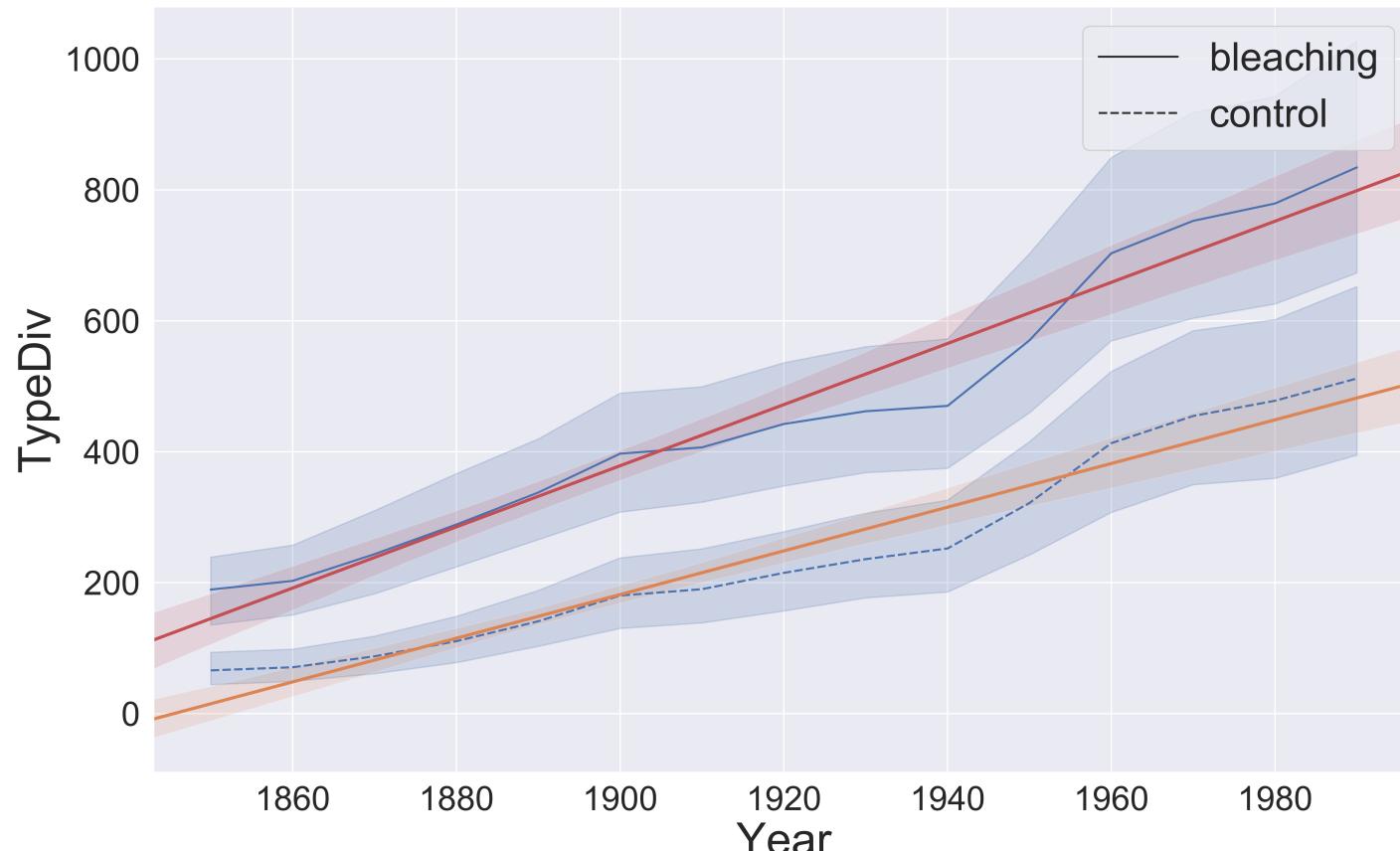
- Changes in values in bleaching metrics over time (i.e., slope)

Predicted slopes		
	Bleaching adverbs	Control adverbs
SimVery	+	- or none
Breadth	+	- or none
TypeDiv	+	- or none
SimLex	-	+ or none

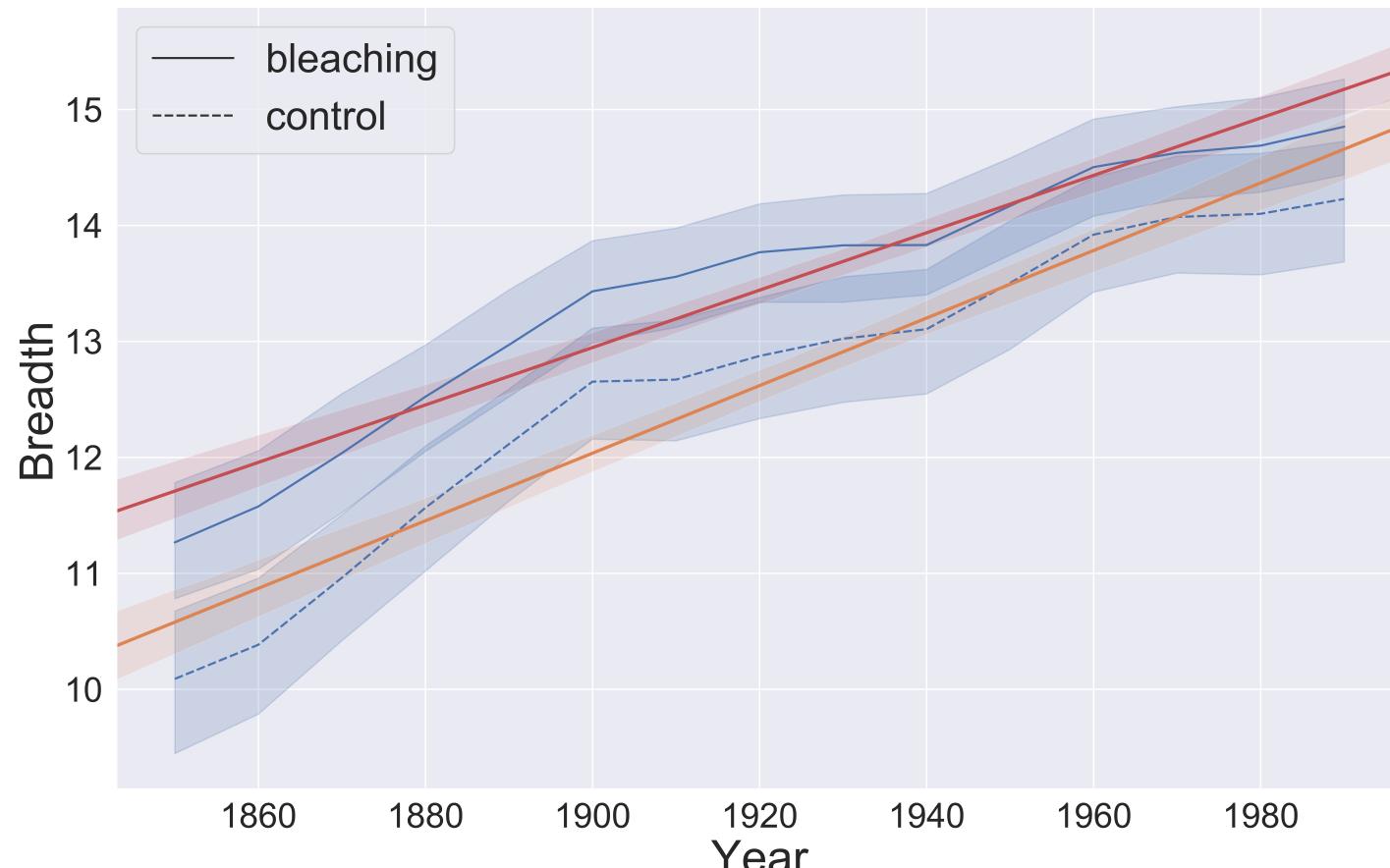
We test predictions using ...

- Linear Regression with:
 - ind. variable: time
 - dep. variable: each of SimVery, SimLex, etc.
- Use HistWords embeddings (Hamilton et al., 2016) to compute similarity metrics
- Use syntactic Google ngrams (Goldberg and Orwant, 2013) corpus for productivity metrics

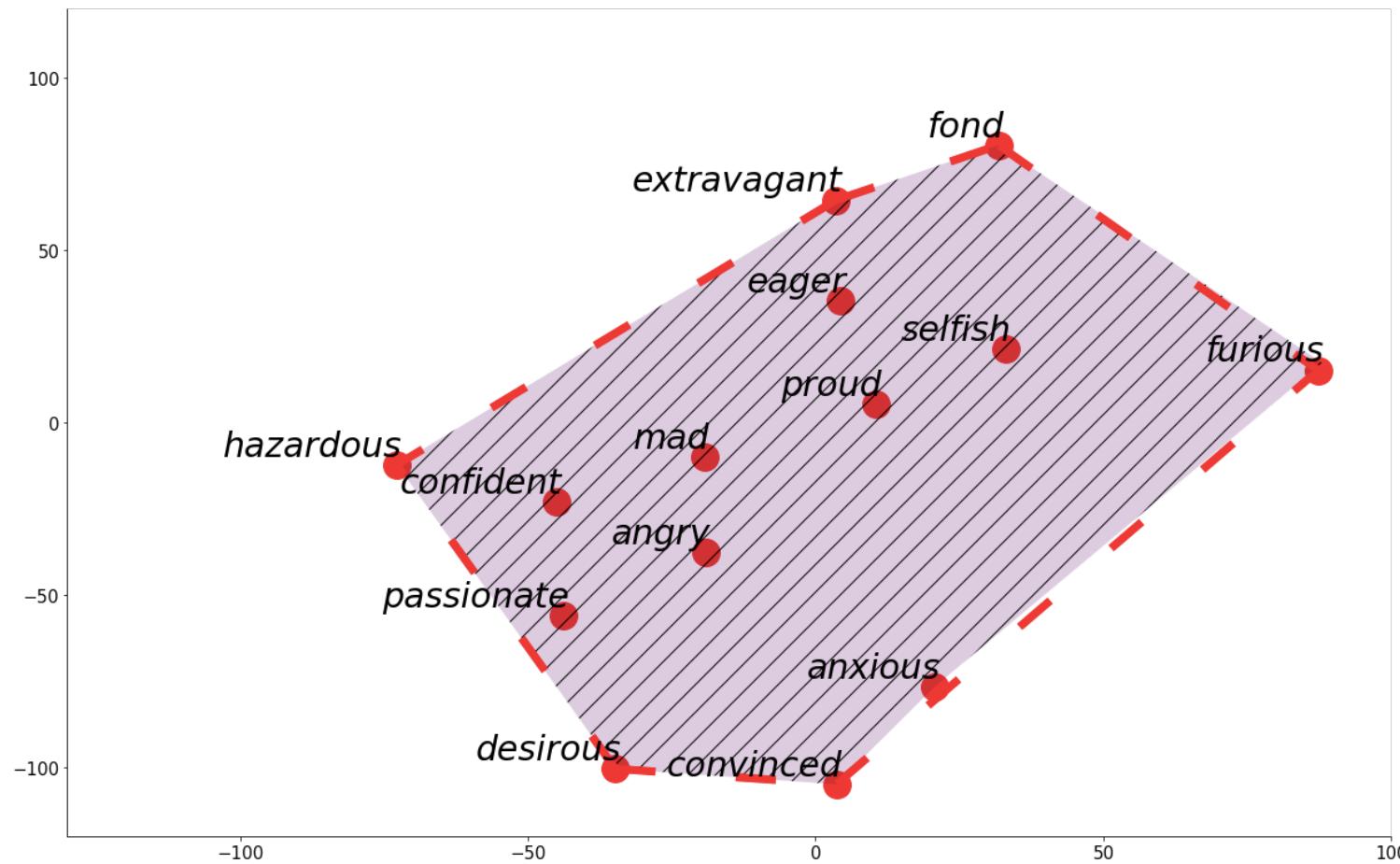
Results: Bleaching and control adverbs both become more productive in TypeDiv



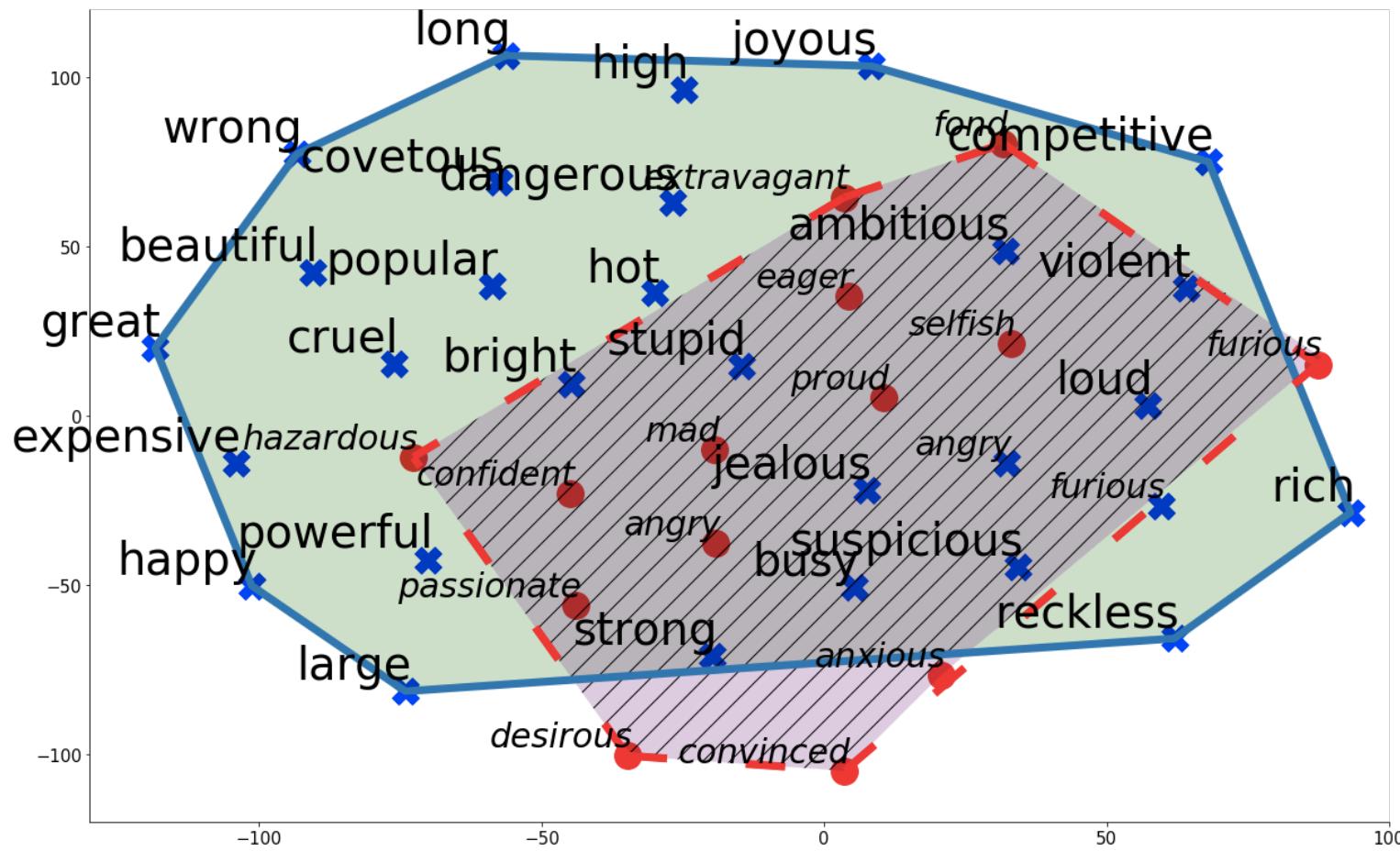
Results: Bleaching and control adverbs both become more productive in Breadth



Adjectives modified by *insanely*, 1850...



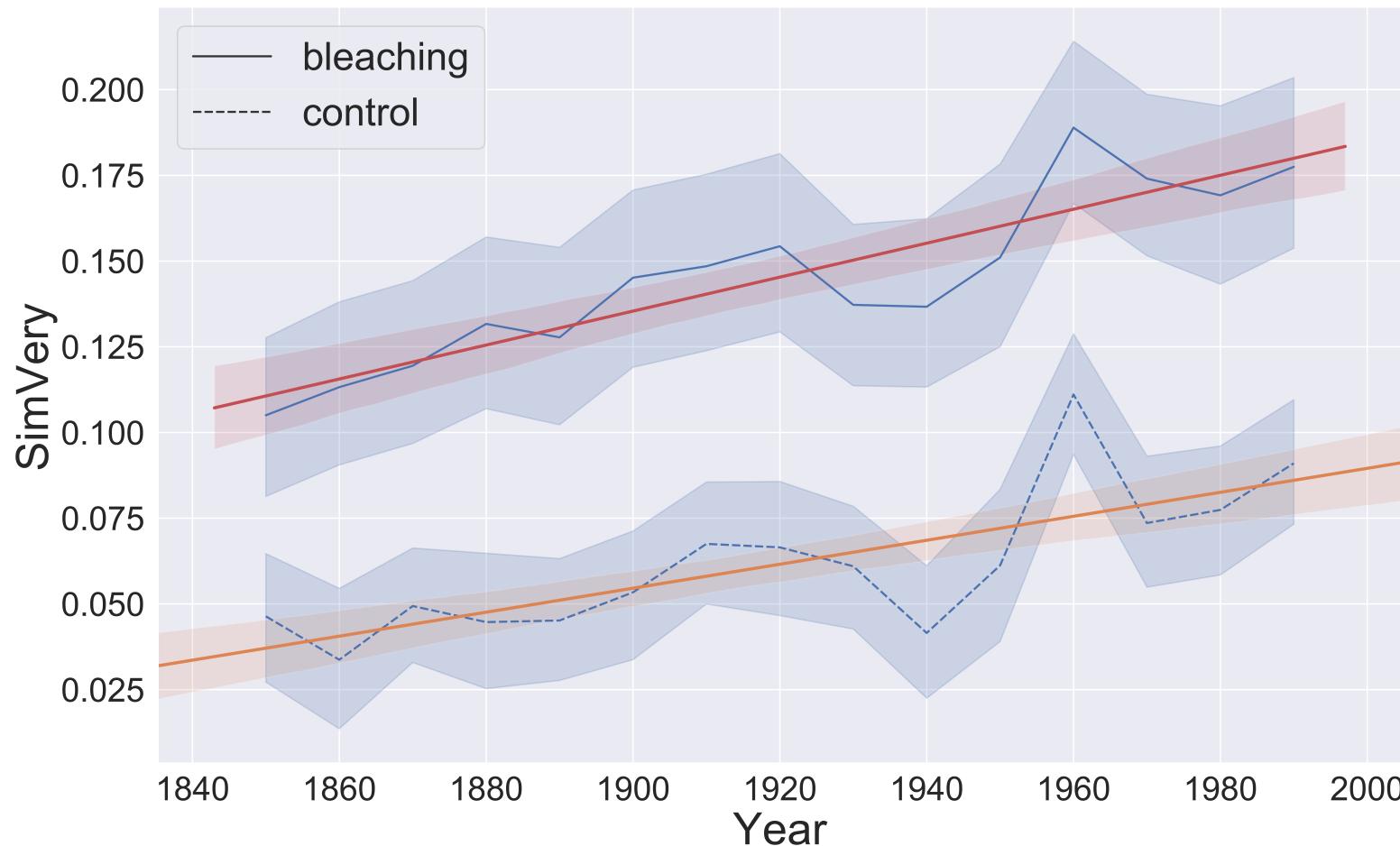
...vs. 1990



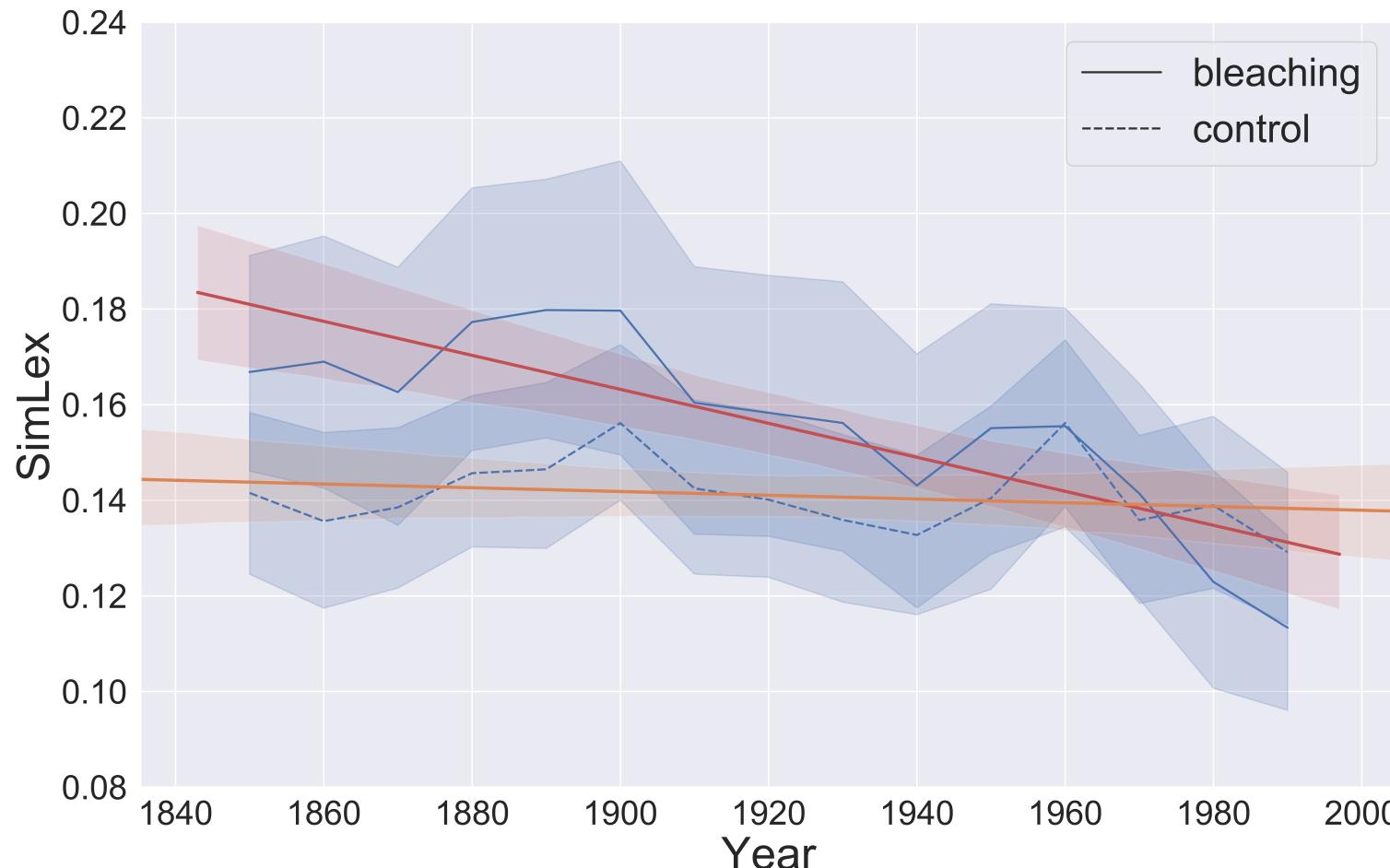
Results: Predictions do not hold for TypeDiv and Breadth

- Found significant increases over time for both bleaching adverbs (expected) and control adverbs (not expected)
- Likely due to increasing corpus size over time: #adjs found in corpus is increasing significantly for all adverbs
- Relative increase for bleaching adverbs obscured

Results: Bleaching adverbs become more similar to “very” than controls



Results: Bleaching adverbs become less similar to their root meaning than control adverbs



Examples of most and least bleached adverbs

	Most bleached	Least bleached
SimVery + W2V	extremely, terribly, awfully, remarkably, seriously	amply, vigorously, richly, heavily, furiously

Examples of most and least bleached adverbs

	Most bleached	Least bleached
Can they modify antonyms?	✓ terribly good ✓ remarkably boring ✓ seriously unimportant	? amply small ? vigorously relaxed ? furiously happy

Interim summary

- Bleaching adverbs show decreasing **SimLex** whereas controls adverbs remain constant, as expected.
- Bleaching adverbs and controls show increasing **SimVery**, though this slope is significantly greater for bleaching adverbs.
 - A viable method when a (frequency-matched) control set is available as a benchmark.
- **Breadth**, **TypeDiv** do not distinguish bleaching adverbs from controls, likely due to increasing corpus size.



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What is the context for intensifier reanalysis?

beautifully picturesque ≈ very picturesque ✓
(≈ *beautiful*)

beautifully asleep ≠ very asleep ✗
(≠ *beautiful*)



Hypothesis: Modifying semantically similar adjectives (to the adverb's root)

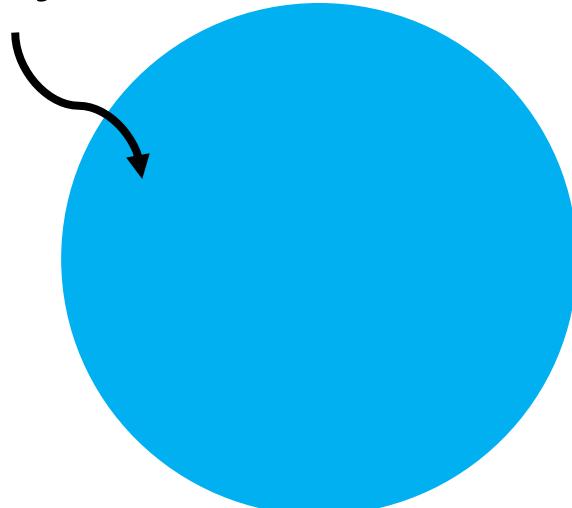
How do we test this hypothesis?

- M' (reanalyzed meaning) becomes conventionalized over time due to regularly occurring “bridging contexts” that support the new interpretation (Bybee et al., 1994; Evans and Wilkins, 2000; Hopper and Traugott, 2003).
beautifully picturesque ≈ very picturesque
- **Prediction:** the more an adverb modifies semantically similar adjectives, the faster it will be reanalyzed into an intensifier, i.e., undergo bleaching.

Testing a quantitative prediction of intensifier reanalysis

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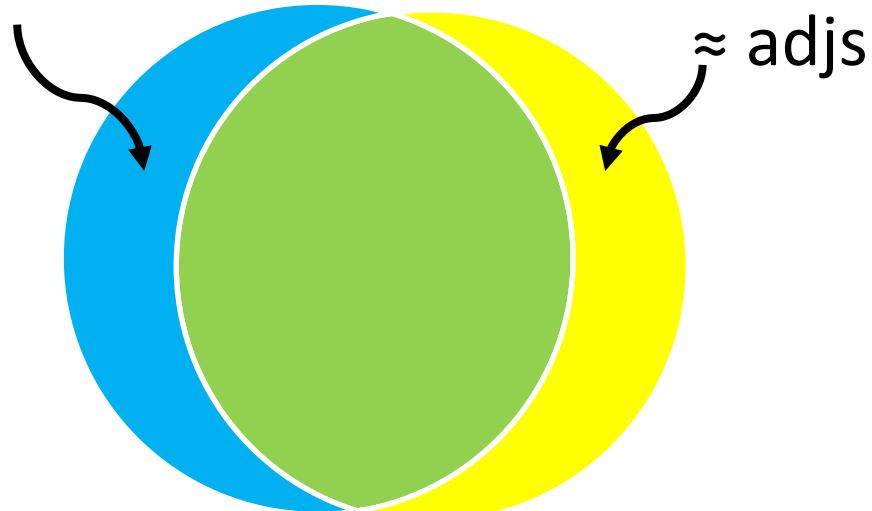
adjs modified



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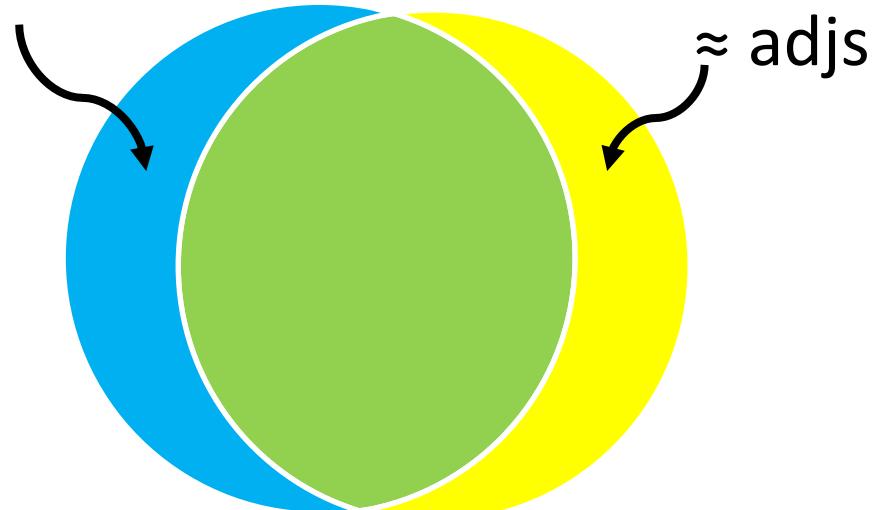
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adjs modified

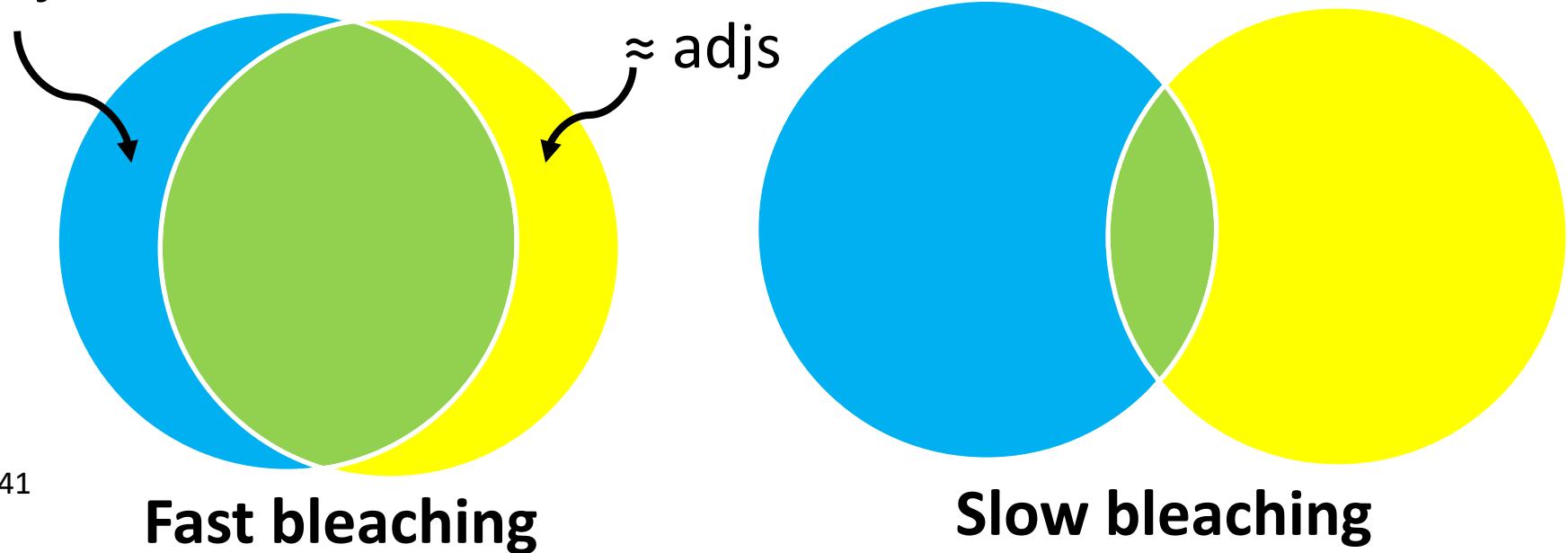


Fast bleaching

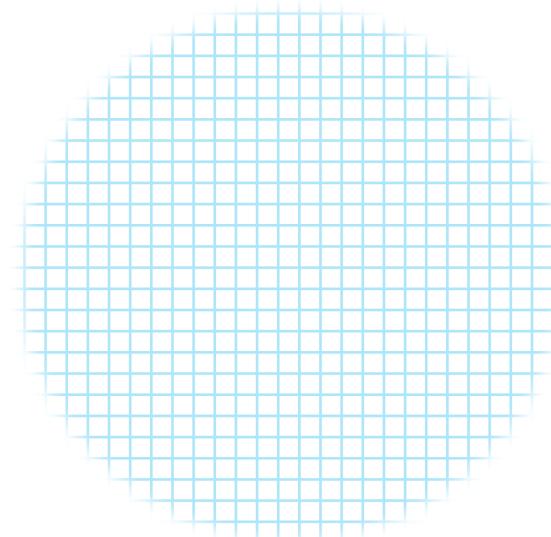
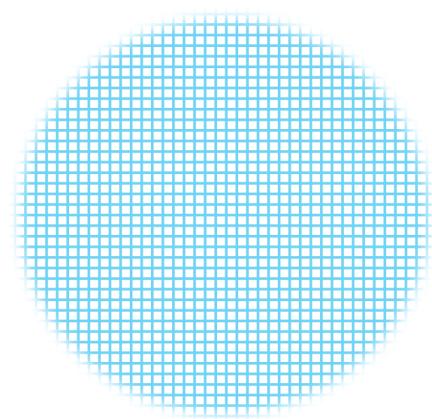
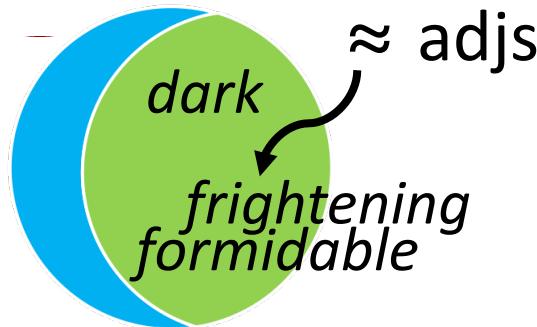
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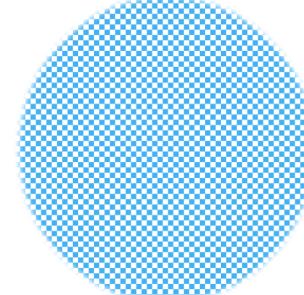
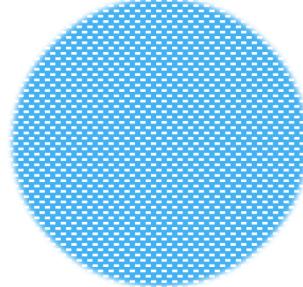
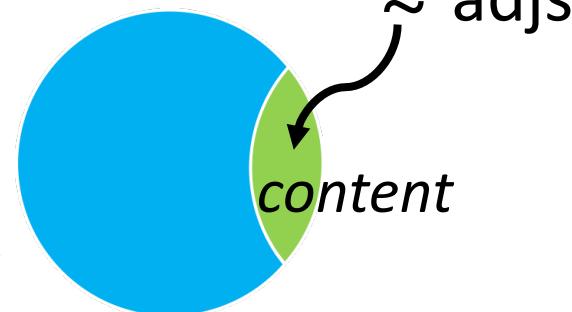
adjs modified



awfully



happily



t₁

t₂

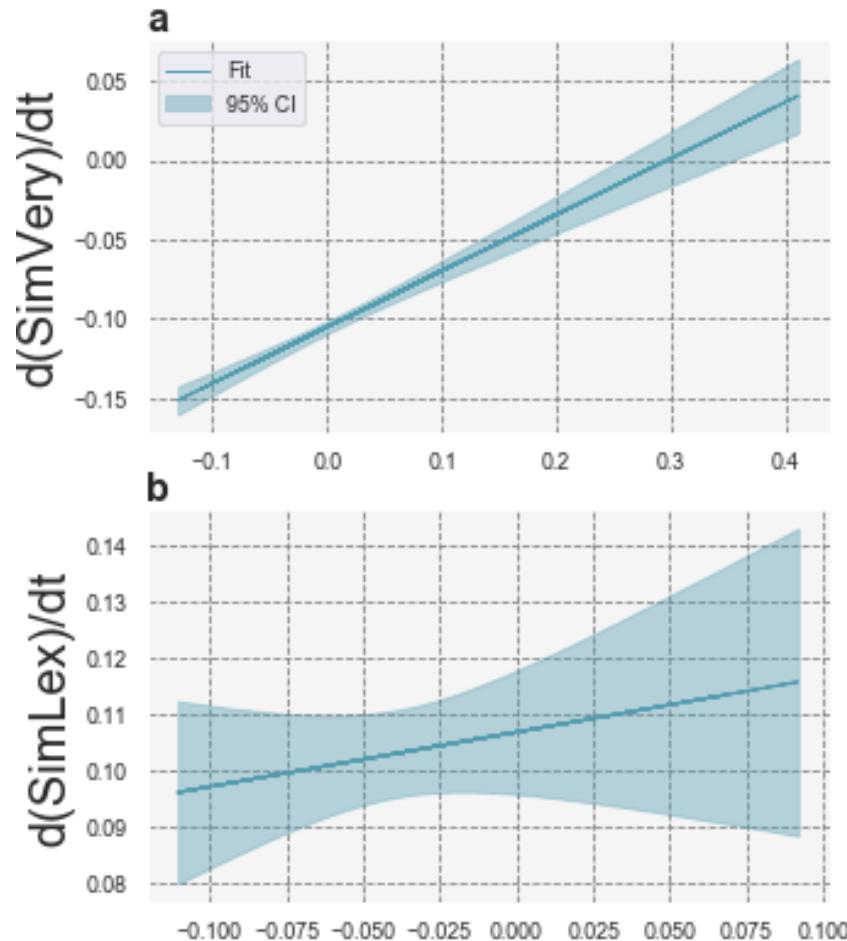
t₃

t₁

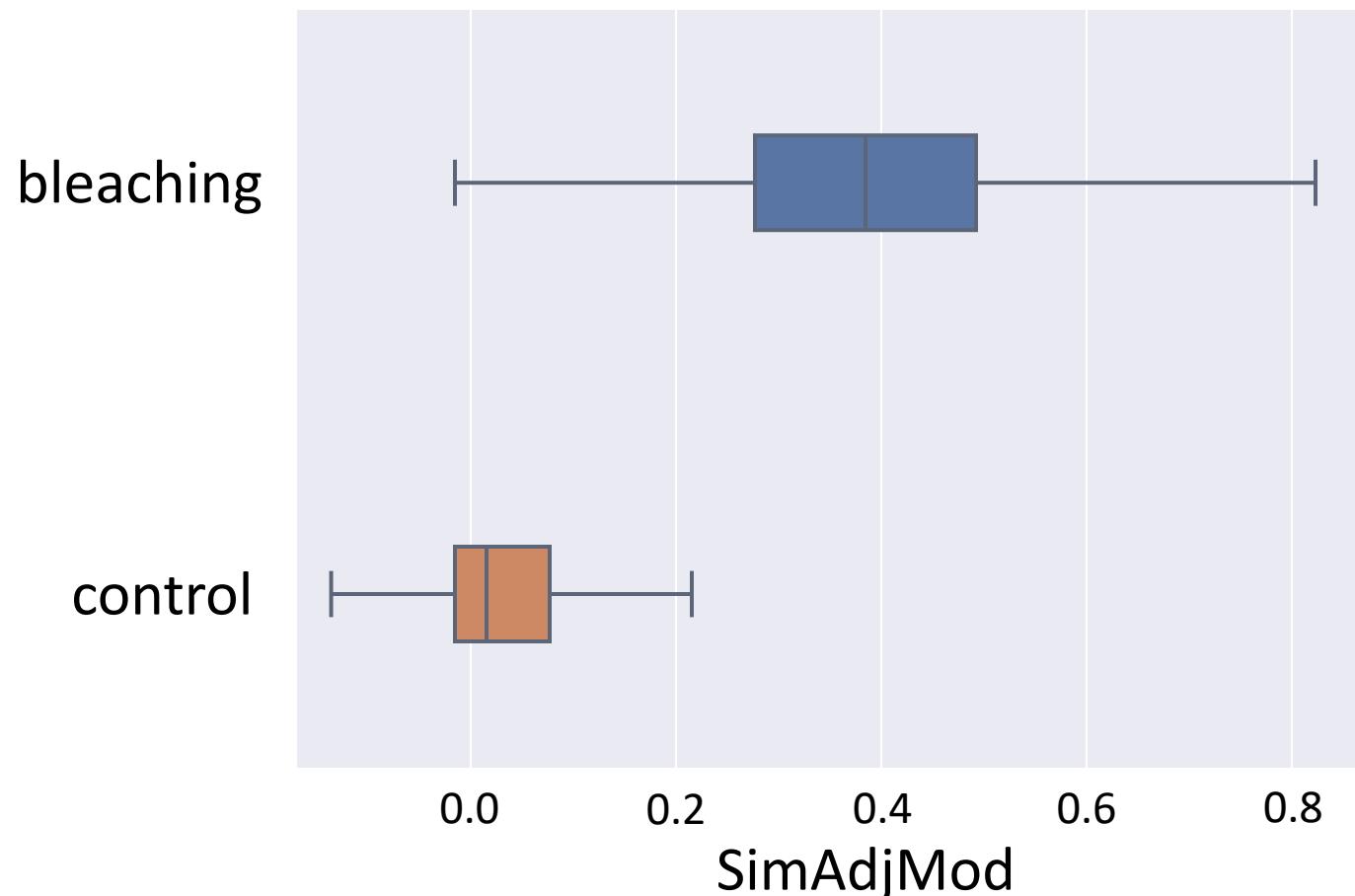
t₂

t₃

Rate of bleaching has (+) correlation with semantic overlap



Bleaching adverbs on average modify higher similarity adjectives



Summary

- Introduced 4 methods that operationalize features of bleaching
- Verified methods: large case study of English bleaching
 - 2 similarity methods successful: increasing similarity to target meaning; decreasing similarity to root meaning
 - 2 productivity methods less effective due to increasing corpus size
- Used methods to show importance of semantic overlap in reanalysis

Future work

- How well do these methods model other cases of bleaching? other languages?
- Within intensifier domain:
 - Improving productivity metrics:
 - different weightings
 - mitigate increasing corpus size
 - What other semantic factors can predict whether an adverb becomes an intensifier?

Thank You! Grazie!

Questions?

References

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Bonus slides

Intensifier data: Bolinger categories

Root adjective type	Examples of derived intensifiers
magnitude	enormously, vastly, immensely, hugely, abundantly
strength	overpoweringly, strongly, exuberantly
singularity	strangely, unusually, abnormally, mysteriously
evaluation	marvelously, brutally, dramatically, luxuriously, terribly, monstrously
irremediability	abominably, pathetically, disastrously
purity/veracity	unquestionably, thoroughly, absolutely, fully, entirely

Method details: Equations

Breadth (B): average weighted pairwise similarity between the adjectives (A_t) modified by a at time t

- $$B(a, t) = -\sum_{a_i \in A_t} \sum_{\substack{a_j \in A_t \\ i \neq j}} sim(a_i, a_j) o(a_i) o(a_j),$$

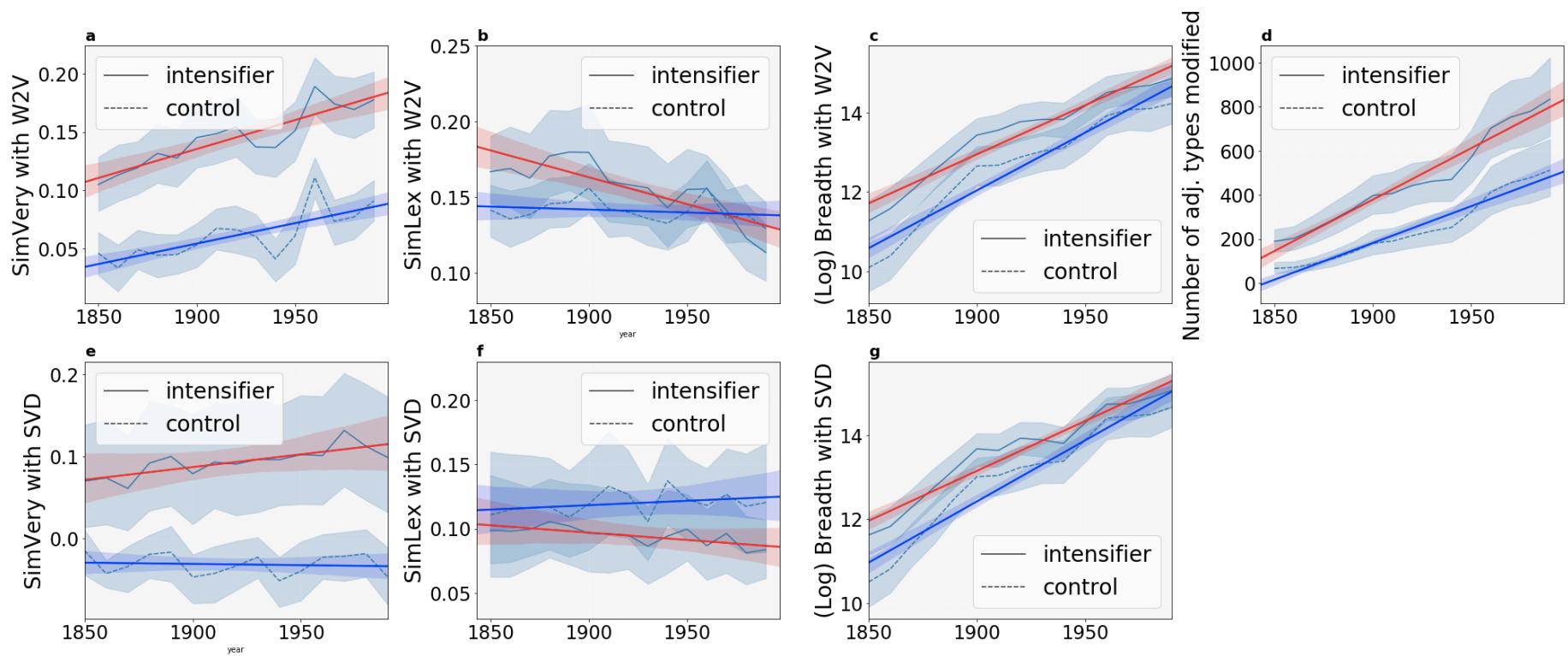
$o(a_k)$ is log odds of kth adjective being modified

Testing reanalysis: details

- Hypothesis: Rate of bleaching, $\frac{d}{dt}(B(K, t))$, is positively correlated with semantic similarity between an adverb and the adjectives that it modifies, $SimAdjMod(K, t)$
- $\frac{d}{dt}(B(K, t)) = \frac{B(K, t+10) - B(K, t)}{10}$
- $SimAdjMod(K, t) = \frac{\sum_{a_i \in A_t} sim(K, a_i) o(a_i)}{|A_t|}$,
 $o(a_i)$ is the odds of modifying a_i

	Most bleached	Least bleached
SimVery	extremely , terribly, truly, awfully, <i>definitely</i> , remarkably, absolutely , precisely, honestly, seriously	amply, vigorously, richly, <i>heavily</i> , violently, mysteriously, profusely, severely, furiously, miraculously
SimLex	entirely, decidedly, <i>heavily</i> , supremely, particularly , sorely, literally, deeply, especially, sharply	pleasantly, abundantly, enthusiastically, intensely, delightfully, <i>definitely</i> , furiously, curiously, <i>evidently</i> , profusely
Breadth	wholly, completely, particularly , deeply, <i>evidently</i> , distinctly, absolutely , extremely , perfectly, clearly	grievously, gorgeously, stupendously, surpassingly, outrageously, miraculously, deliciously, extravagantly, profusely, ludicrously

Intensifiers in bold are most or least bleached according to more than one metric. Intensifiers *in italics* are categorized as most bleached by one metric but least bleached by another.



Example adjectives modified in 1850 vs. 1990

	1850	1990
abundantly	fat, large, flowing, fertile, rejoicing, grateful, ...	available, fraught, intelligible, loud, eager, familiar, ...
enormously	rich, large, high, long, great, fat, wealthy, thick, ...	popular, successful, important, complex, influential, difficult, helpful, ...