More than words - speakers are sensitive to the frequency of four-word phrases

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Abstract

What are the building blocks of language? In a series of studies, we show that speakers are faster to recognize higher frequency compositional 4-word phrases even when the frequency of the substrings is controlled. This happens across the frequency range and is better modeled using a continuous measure of frequency and not a binary one (high/low). These findings suggest that (a) speakers store information about multi-word phrases, (b) not just very frequent ones or non-compositional ones, and (c) every time counts: the more often a sequence occurs, the faster it is recognized. We discuss implications for models of the lexicon.

Introduction and Background

Do speakers represent compositional multi-word phrases?

- Contrast generative and usage-based views of language.
  - Generative: atomic elements and rules or constraints (Chomsky, 1981; Jackendoff, 2002)
  - Usage-based: Complementary representations at different grain-sizes (Bod, 1998; Bybee, 1998; Goldberg, 2006; Langacker, 1987)
- Add multi-word phrases to the units speakers are sensitive to
  - Expand the units whose frequency influences processing (words, constructions, etc.)
  - Call for lexical models that can capture co-occurrence patterns beyond the bigram

How to assess representation?

- Look for phrase-frequency effects when substring frequency is controlled for
  - Speakers have a memory trace of the complex unit (drawing on morphological literature on regular inflected forms (Taft 1979, Baayen, 2007))

Previous findings

- Few studies look beyond the bigram. Of those, most look only at very frequent phrases (Bybee & Schiebman, 1999), or don't control fully for substring frequency (Underwood et al., 2004)

What we did

- Two reaction time experiments, three frequency bins (different cutoff points between high and low)
- Meta-analysis of reaction times

Is *don't have to worry* (same first 3-gram) recognized faster than *don't have to wait*? Matched for final word and transition frequencies

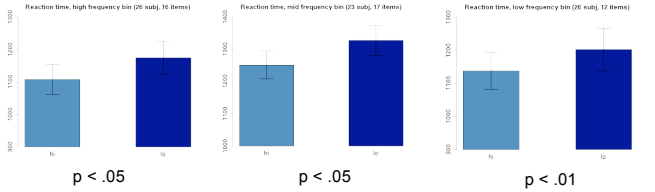
Procedure: Phrasal decision

Is this sequence a phrase of English? don't have to wait / I saw man the ...

Experimental Results

Design: 2 (4-gram frequency hi/lo) x 1, within subjects

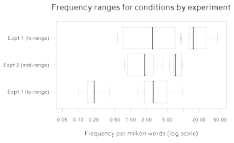
3 frequency cutoffs to define hi and lo (10/mil, 5/mil, 1/mil in Fisher corpus)



p < .05 p < .05 p < .01

Results: analyzed with linear mixed effects regression with model comparison

high frequency recognized **faster** than **low** frequency

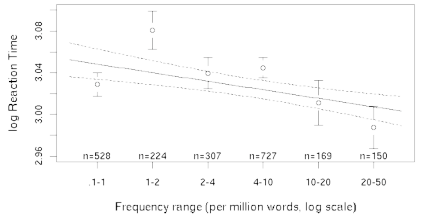


Sample materials

	High	Low
High bin:	a lot of places 10.45 i don't know why 35.15	a lot of days 0.55 i don't know who 7.00
Mid bin:	it takes a lot 7.35 all over the country 9.55	It takes a little 1.25 all over the house 0.85
Low bin:	i want to say 3.6	i want to sit 0.2

Meta-analysis

Experiments 1 & 2 and model fit



Analysis: linear mixed effects regression with model comparison. **Dependent variable**: log(reaction time)

Controls: log(unigram3), log(unigram4), log (bigram1), and log (trigram1)), block-order, number-of-letters, random effects of subject and item

Results for factors of interest:

- Log (frequency) is better fit than than a binary measure.
  - log(4gram frequency) p < .005
  - frequency > 10/mil p > .3

Result summary

- More frequent compositional phrases processed faster than low frequency ones
- Across the frequency continuum
- Actual frequency is a better predictor than hi/lo bin

Implications

- Speakers store information about compositional complex units
  - Doesn't entail that those units area accessed as a whole or that they are unanalyzed
- Processing latencies are affected by the frequency of fully realized multi-word phrases
- Need a language model to account for that
  - Theory of representation where speakers represent linguistic units at multiple grain-sizes (words, multi-word phrases, constructions)
  - An implementation that can capture and predict when such frequency effects arise (e.g. Bod, 2006)

Future work

- How detailed is their internal structure?
- The relation of the smaller and larger units?
- How do different grain-sized units interact in processing?