Language redundancy effects on f0:
A preliminary controlled study

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Aim

To investigate the relationship between measures of **language redundancy**

- lexical frequency, bigram frequency

and f0 markers of **prosodic structure**

- prosodic prominence, boundary tone

Introduction

- Lindblom (1990) proposed that **more predictable elements** (e.g. segments, syllables, words) require **less "explicit signal information"** for successful recognition than less predictable elements.
- The **Smooth Signal Redundancy Hypothesis** (*SSRH*, Aylett & Turk 2004; Turk 2010) proposes that **prosodic structure** is used to control the **relative acoustic salience** of words based on their **language redundancy** (= relative predictability).

Hypothesis

- Words with **lower language redundancy** (less predictable) are more likely to be associated with **greater phrasal prominence**, and stronger boundaries.
- Findings for **duration** are consistent with this hypothesis (e.g. Bell et al., 2009), but the SSRH's **prosodic interface** view makes predictions that *__all__* correlates of prosodic structure, including F0 should be affected by relative predictability.

Previous studies

- Turnbull (2017) found that contextual plausibility (i.e., a measure of language redundancy) affected f0 values as predicted by the SSRH for spontaneous AmE: lower redundancy yielded overall higher f0 values.
- However, discourse mention and focus status showed less clear results, suggesting that redundancy might affect f0 differently from duration.
- Tang & Shaw (2021) found effects of forward and backward predictability on f0 in Mandarin.

Methods

- **Recordings**:
  11 speakers produced 14 sets of quadruplets, originally designed for a duration study
  - Each utterance contains a Verb-Adjective-Noun (V-A-N) sequence. Each quadruplet contains four different combinations of frequent**(f)** and infrequent**(i)** Vs and Ns. E.g.:

ff:	Whatever you **make**$_f$ **clean fields**$_f$ should be a priority
fi:	Whatever you **make**$_f$ **clean fiefs**$_i$ should be a priority
if:	Whatever you **rake**$_i$ **clean fields**$_f$ should be a priority
ii:	Whatever you **rake**$_i$ **clean fiefs**$_i$ should be a priority

  - Each utterance can have two readings, VA%N or V%AN. We only analysed V%AN since it accounts for 86% of the dataset.
- **F0 measures**:
  - Sonorant interval for V or N
  - Divided into 3 equal portions for analyses:
    - *initial third* – an indication of pitch accent
    - *second third* – a transitional section
    - *final third* – an indication of boundary tone
- **Frequency measures**:
  - Lexical frequency: The verbs and the nouns were either frequent (f) or infrequent (i)

V_f > 2000	V_i < 200	from *WebCelex's Cobuild Corpus*
N_f > 3000	N_i < 100	

  - Bigram frequency:
    $Freq_{(VA)}$ vs $Freq_{(AN)}$

$Freq_{(VA)} > Freq_{(AN)}$	$Freq_{(VA)} < Freq_{(AN)}$	from *Google*

  - Ratio of bigram frequencies:
    $RATIO\text{-}BI = Freq_{(VA)} / Freq_{(AN)}$

High > 60%	Low < 40%

Results

- **Tune composition:**
  Most used tune (30% of the dataset) [Fig. 1]:
  V [!H* + H-L%] + **A** [H*] + **N** [!H*] + H-L%

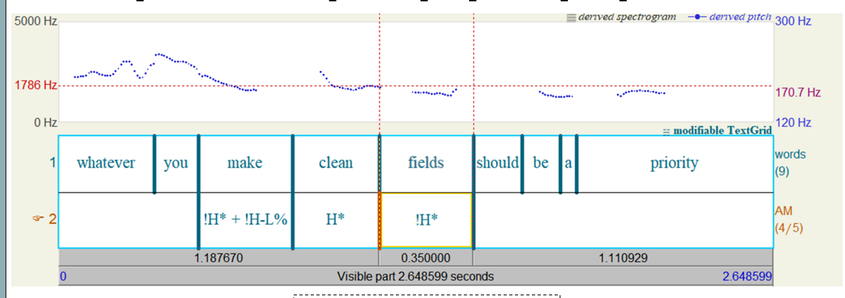

Fig. 1 Example tune

- **Pitch accents:**

	!H*	H*
V	56.8%	43.2%
N	56.4%	43.6%

Note !H* and H* are sometimes difficult to distinguish due to the flat contours

- **Boundary tones:**

V	falling boundary tone !H-L%	flat boundary tone H-L%
	57.8%	42.2%
N	falling boundary tone !H-L%	no boundary tone
	35.7%	64.3%

Predictions

- **Pitch accent:**
  - ❖ H*: higher F0 when infrequent
  - ❖ !H*: prediction is less clear
- **Boundary tones:**
  - ❖ Lower L% boundary tones when infrequent
- Pitch accent and boundary tone effects may be difficult to dissociate when on the same syllable. Boundary tone effects are most likely on final 3rd

Verb

Results:

- Lower V_freq → lower *initial 3rd* of f0 of V
- Lower V_freq → lower *final 3rd* of f0 of V
  - Consistent with the SSRH prediction of a stronger prosodic boundary, i.e. an even lower boundary tone, after a less frequent word

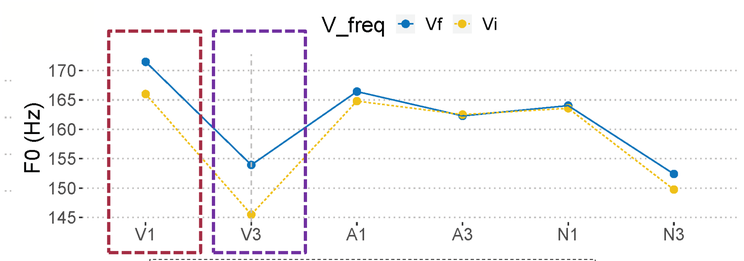

Fig. 2 Mean f0 contours by V_freq

Discussion:

- Short target words in this dataset may have caused V3 (L%) to bring down V1

Noun

Results:

- Lower N_freq → higher *initial 3rd* of f0 of N
  - Suggests an increase in f0 of !H* and H* when N is infrequent

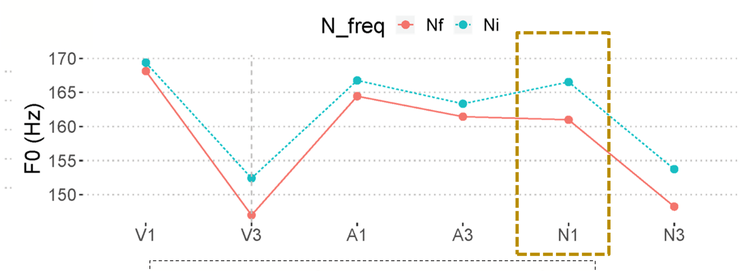

Fig. 3 Mean f0 contours by N_freq

Comparison of V and N:

- In contrast to V1, N1 shows higher f0 on the initial 3rd when infrequent, possibly because of fewer L% boundary tones on N

Conclusions

- Preliminary observations regarding the relationship between **frequency measures** and **f0** in controlled English data
- Some support for the **Smooth Signal Redundancy Hypothesis**: language redundancy affects f0 in some ways
- Results would be easier to interpret on longer words

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Selected References

- Aylett, M. and Turk, A. (2004). The smooth signal redundancy hypothesis: A functional explanation for relationships between redundancy, prosodic prominence, and duration in spontaneous speech. *Language and Speech 47(1):* 31-56.
- Aylett, M. and Turk, A. (2006) Language redundancy predicts syllabic duration and the spectral characteristics of vocalic syllable nuclei," *The Journal of the Acoustical Society of America* 119(5): 3048-3058.
- Bell, A., et al. (2009). "Predictability effects on durations of content and function words in conversational English." *Journal of Memory and Language* 60: 92-111.
- Lindblom, B. (1990). Explaining Phonetic Variation: A Sketch of the H&H Theory. *Speech Production and Speech Modelling*. W. J. Hardcastle and A. Marchal. Dordrecht, Kluwer Academic Publishers. 55: 403-439.
- Tang, K. and Shaw, J. A. (2021). "Prosody leaks into the memories of words." *Cognition* 210: 104601.
- Turnbull, R. (2017). "The role of predictability in intonational variability," *Language and Speech* 60(1): 123-153.
- Bögel, T. and Turk, A. (2019). Frequency effects and prosodic boundary strength. *ICPhS2019*: 1014-1018.

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