
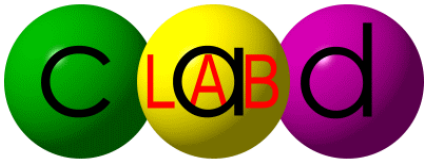


# Non-Syntactic Word Prediction for AAC

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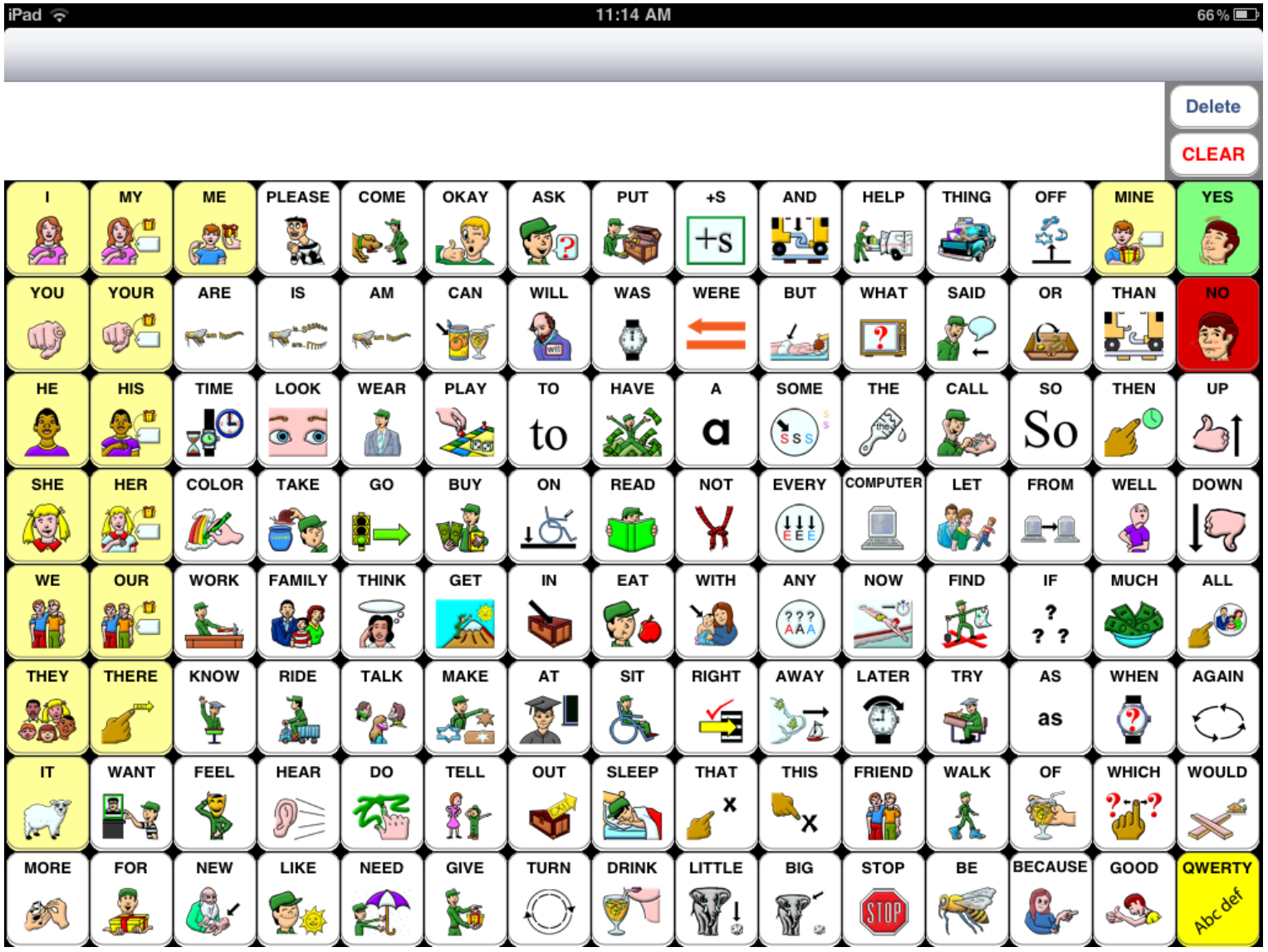
# Target Systems: Example 1

# Target Systems: Example 2



# Background

- Based on written language
- Users currently select letters, words, or icons in syntactically correct order*
- Non-syntactic input usually results in non-syntactic output

*H. Van Balkom and M. Welle Donker-Gimbrere. 1996. A psycholinguistic approach to graphic language use. Augmentative and alternative communication: European Perspectives, pages 153–170.

# Observations

- Speed of communication is important
- Complete/correct utterances are important
- Language style may be important
- There are existing strategies for:
  - Completing words
  - Completing syntactic utterances
  - Detecting missing letters of words

# Prior and Related Work

- Missing function words (Compansion)
  - McCoy et al., 1998
- Missing content words (memory-based language models using trigrams)
  - Van Den Bosch et al., 2006 and 2009
- Word relationships and disambiguation based on grammatical characteristics (IR)
  - Tzoukermann et al., 1997; Allan and Raghavan, 2002

# Prior and Related Work

- Word relationships based on semantic characteristics and roles (IR)
  - Westerman and Cribbin, 2000; Fang and Zhai, 2006; Hemayati et al., 2007
- Word relationships based on distance and collocation (IR)
  - Lin and Hovy, 2003; Lv and Zhai, 2009
  - Matiasek and Baroni, 2003 (moving window)
  - Jarvelin et al., 2007 (s-grams)

# Motivation

- Current completion and prediction strategies rely on syntactic input and word distance
- N-gram statistics are widely available for well-ordered input
- If the input isn't syntactically correct or well-ordered, can complete utterances still be predicted?

# Exemplar

"I like to play chess with my brother."
"My brother and I play video games."
"I play chess with my dad."

Input: like, play, chess, i, brother
Input: play, video games, i, brother
Input: play, chess, i, dad
Input: i, brother, ...

How can we track these relationships?

# Possible approach

- Sentences are one of the smallest units of language that are:

  - Semantically coherent
  - Semantically cohesive
  - Syntactically demarcated

  ... could be leveraged for prediction ...

# Semantic Grams

- A multiset of words that appear together in the same sentence.

Sentence: "I like to play chess with my brother."

| | |
|---|---|
| brother, chess (1) | brother, i (1) |
| brother, like (1) | brother, play (1) |
| chess, i (1) | chess, like (1) |
| chess, play (1) | i, like (1) |
| i, play (1) | like, play (1) |

# More on Sem-grams

- Sentence Boundary Detection is fast and relatively accurate (> 98.5%)
- Sentence-level co-occurrence with uniform weight applied to all relationships in a sentence
- Order-independent and no null elements

# Technical Problem Definition

Given:

- Multiset of existing words E
- Set of candidate words C

Output:

- Most likely (argmax) candidate word $c \in C$

  - or -

- Ranked list of candidate words $c \in C$

# Four Prediction Algorithms

- S1: Conditional independence of existing words to each other (naive Bayes)
- S2: Random drawing of sem-grams from an existing pool
- N1: Copy of S1, but with unordered n-grams; reward adjacency next to all existing words
- N2: Reward adjacency next to at least one existing word (strength of n-grams?)

# Corpus

- Blog Authorship Corpus
  - 140 million words
  - 19,320 bloggers in August 2004
  - Age range of 13 - 48
  - Equally divided between males and females
- Pre-processing:
  - Split sentences and words
  - Remove stop words
  - Stem words
  - Check stems for dictionary membership
- Split by authors: 80% training, 20% testing
- Plus-one smoothing on trained sem-grams and n-grams (bigrams)

# Method

For every test sentence:

1. Process (split, stop, stem, and check)
2. Shuffle stems
3. Remove one (target)
4. Ask each algorithm to predict the missing stem by providing a ranked list of guesses

Evaluation (random 2000 sentences):

- Score = position of target word; lower scores are better

# Method

- Test sentences truncated to 20 words
- N-gram algorithms seeded with top 10 unordered n-grams for each input word
- Sem-gram algorithms seeded with top 10 sem-grams for each input word
- Maximum of 190 candidate words to rank
- Ranked lists truncated to 100; otherwise, considered a "failure to predict"

# Results: Sample 1

**Original Sentence:**

"but i went to church yesterday with the fam."

**Target Stem:** went

**Input Stems:** yesterday, church

**N1 Candidate List:** went, morn, today, go, attend, work, afternoon, church, got, day, ...

**S1 Candidate List:** went, go, church, today, got, day, like, time, just, well, one, get, peopl, ...

# Results: Sample 2

**Original Sentence:**

"This semester Im taking six classes."

**Target Stem:** class

**Input Stems:** take, semest, six

**N1 Candidate List:** next, month, class, hour, last, second, week, year, first, five, flag, ...

**S1 Candidate List:** class, month, year, last, time, one, go, day, get, school, will, first, ...

# Results: Sample 3

**Original Sentence:**

> “Hey, they’re in first, by a game and a half over the Yankees.”

**Target Stem:** game

**Input Stems:** yanke, hey, first, half

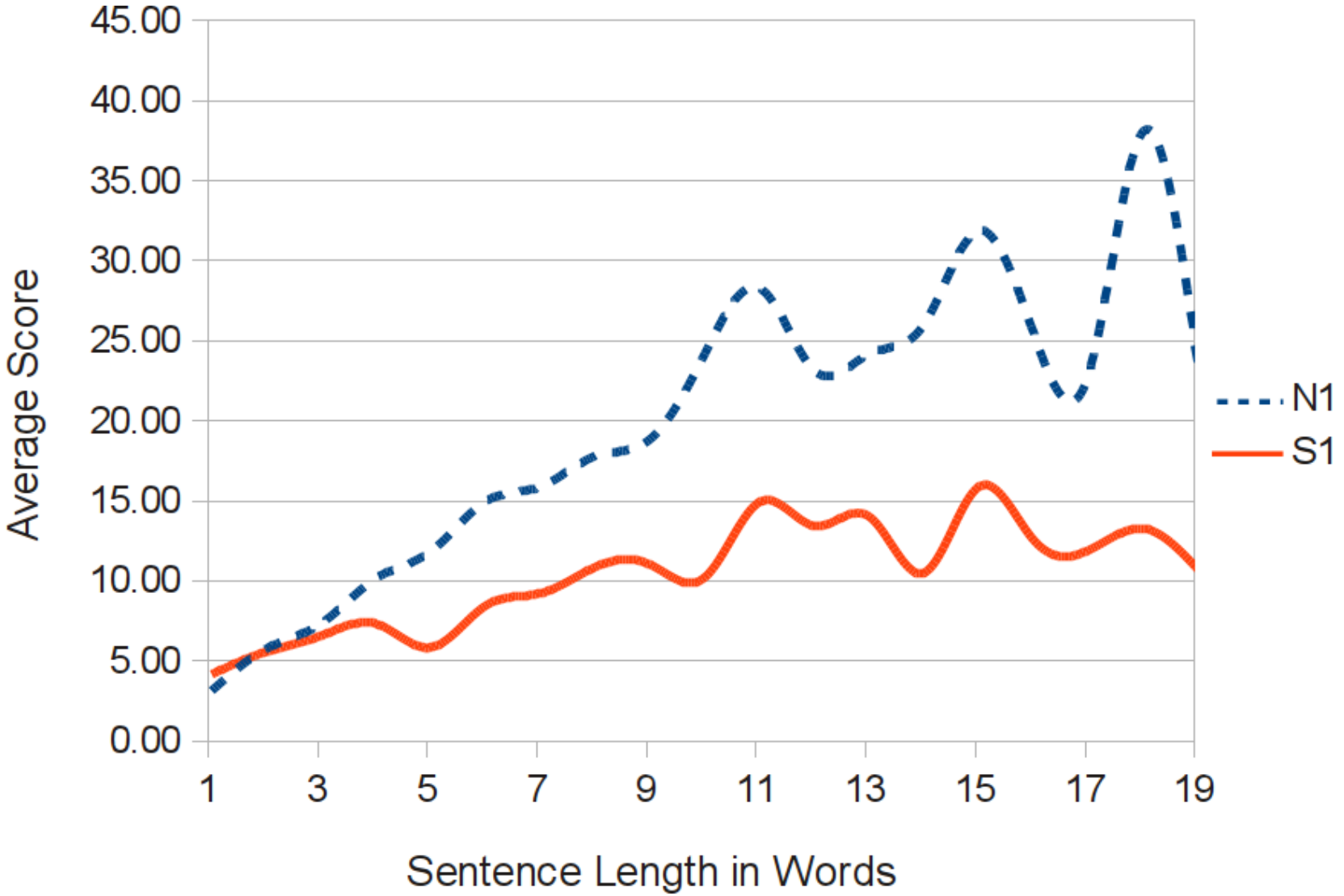
**N1 Candidate List:** game, stadium, like, hour, time, year, day, guy, hey, fan, say, one, two, ...

**S1 Candidate List:** game, got, like, red, time, play, team, sox, hour, go, fan, one, get, day, ...

# Summary of Results

| | N1 | N2 | S1 | S2 |
|---|---|---|---|---|
| **# of Sentences** | 2000 | 2000 | 2000 | 2000 |
| **# Predicted** | 647 | 649 | 435 | 435 |
| **Average Score** | 16.26 | 19.70 | 9.04 | 12.67 |

# Results by Sentence Length



# Issues and Future Directions

- Accuracy vs. Coverage
- Use of bigrams
- Seeding the candidate list
- Computational requirements

- Hybrid approaches:
  - Identical seed lists
  - Smooth from n-gram prediction to sem-gram prediction based on sentence length
  - Merge prediction lists

- BAC provides age, gender, and occupation

# Application: Single-Page App

# Application: Multi-Page App

# Summary

- Unordered/non-syntactic prediction is possible
- N-grams can provide broad coverage
- Sem-grams may provide better accuracy
- Sem-grams may inform system behavior

Thank you!