

A Targeted Syntactic Evaluation of Language Models: Supplementary Materials

A.1 All of the lexical items

1. *Determiners*: the, some
2. *Complementizers*: that
3. *Other quantifiers*: most, many, no, few
4. *Main subjects (animate)*: author(s), pilot(s), surgeon(s), farmer(s), manager(s), customer(s), officer(s), teacher(s), senator(s), consultant(s)
5. *Main subjects (inanimate)*: movie(s), book(s), game(s), song(s), picture(s), painting(s), novel(s), poem(s), show(s)
6. *Embedded subjects*: security guard(s), chef(s), architect(s), skater(s), dancer(s), minister(s), taxi driver(s), assistant(s), executive(s), parent(s)
7. *Main verbs (animate)*: laugh(s), swim(s), smile(s), is/are tall, is/are old, is/are young is/are short
8. *Main verbs (inanimate)*: is/are good, is/are bad, is/are new, is/are popular, is/are unpopular, bring(s) joy to people, interest(s) people
9. *Long main verbs*: know(s) many different foreign languages, like(s) to watch television shows, is/are twenty three years old, enjoy(s) playing tennis with colleagues, write(s) in a journal every day
10. *Reflexive main verbs*: hurt, injured, congratulated, embarrassed, disguised, hated, doubted
11. *NPI verbs (animate)*: be/been popular, be/been famous, have/had children
12. *NPI verbs (inanimate)*: be/been seen, be/been appreciated, be/been ignored, get/gotten old
13. *Embedded verbs*: like(s), admire(s), hate(s), love(s)
14. *Prepositions (animate)*: next to, behind, in front of, near, to the side of, across from
15. *Auxiliaries*: have, will
16. *NPIs*: ever
17. *Prepositions (inanimate)*: from, by
18. *Sentential complement subjects*: mechanic(s), banker(s)
19. *Sentential complement verbs*: said, thought, knew
20. *Conjunctions*: and
21. *Anaphors*: himself, herself, themselves

A.2 All of the templates (single-task, multi-task)

1. SUBJECT-VERB AGREEMENT
 - (a) Simple:
 - i. Singular:
the author laughs/*laugh. : (0.93, 1.0)
 - ii. Plural:
the authors laugh/*laughs. : (0.96, 1.0)
 - (b) In a sentential complement:

- i. Plural / Singular:
the mechanics said the author laughs/*laugh. : (0.98, 0.86)
 - ii. Singular / Singular:
the mechanic said the author laughs/*laugh. : (0.98, 0.87)
 - iii. Plural / Plural:
the mechanics said the authors laugh/*laughs. : (1.0, 1.0)
 - iv. Singular / Plural:
the mechanic said the authors laugh/*laughs. : (1.0, 1.0)
- (c) Short VP coordination:
- i. Plural:
the authors laugh and swim/*swims. : (0.87, 0.91)
 - ii. Singular:
the author laughs and swims/*swim. : (0.94, 0.88)
- (d) Long VP coordination:
- i. Singular:
the author knows many different foreign languages and enjoys/*enjoy playing tennis with colleagues. : (0.56, 0.82)
 - ii. Plural:
the authors know many different foreign languages and enjoy/*enjoys playing tennis with colleagues. : (0.66, 0.80)
- (e) Across a prepositional phrase:
- i. Singular (animate) / Plural:
the author next to the security guards smiles/*smile. : (0.08, 0.37)
 - ii. Singular (inanimate) / Plural:
the movie from the security guards smiles/*smile. : (0.12, 0.41)
 - iii. Plural (animate) / Singular:
the authors next to the security guard smile/*smiles. : (0.33, 0.48)
 - iv. Plural (inanimate) / Singular:
the movies from the security guard smile/*smiles. : (0.46, 0.57)
 - v. Singular (inanimate) / Singular:
the movie from the security guard smile/*smiles. : (0.84, 0.86)
 - vi. Singular (animate) / Singular:
the author next to the security guard smile/*smiles. : (0.85, 0.91)
 - vii. Plural (animate) / Plural:
the movies from the security guards smiles/*smile. : (0.98, 1.0)
 - viii. Plural (inanimate) / Plural:
the authors next to the security guards smiles/*smile. : (1.0, 1.0)
- (f) Across a subject relative clause:
- i. Singular / Plural:
the author that likes the security guards laughs/*laugh. : (0.05, 0.50)
 - ii. Plural / Singular:
the authors that like the security guard laugh/*laughs. : (0.30, 0.52)
 - iii. Singular / Singular:
the author that likes the security guard laughs/*laugh. : (0.89, 0.95)
 - iv. Plural / Plural:
the authors that like the security guards laugh/*laughs. : (1.0, 1.0)
- Across an object relative clause:
- i. Plural (animate) / Singular:
the authors that the security guard likes laugh/*laughs. : (0.18, 0.36)

- ii. Plural (inanimate) / Singular:
the movies that the security guard likes are/*is good. : (0.25, 0.53)
 - iii. Singular (inanimate) / Plural:
the movie that the security guards like is/*are good. : (0.47, 37)
 - iv. Plural (animate) / Plural:
the authors that the security guards like laugh/*laughs. : (0.50, 0.73)
 - v. Singular (animate) / Plural:
the author that the security guards like laughs/*laugh. : (0.51, 0.30)
 - vi. Plural (inanimate) / Plural:
the movies that the security guards like are/*is good. : (0.54, 0.74)
 - vii. Singular (inanimate) / Singular :
the movie that the security guard likes is/*are good. : (0.73, 0.78)
 - viii. Singular (animate) / Singular:
the author that the security guard likes laughs/*laugh. : (0.83, 0.77)
- (g) Across an object relative (no *that*)
- i. Plural (inanimate) / Singular:
the movies the security guard likes are/*is good. : (0.30, 0.42)
 - ii. Plural (animate) / Singular:
the authors the security guard likes laugh/*laughs. : (0.33, 0.43)
 - iii. Plural (animate) / Plural:
the authors the security guards like laugh/*laughs. : (0.41, 0.52)
 - iv. Plural (inanimate) / Plural:
the movies the security guards like are/*is good. : (0.45, 0.50)
 - v. Singular (inanimate) / Plural:
the movie the security guards like is/*are good. : (0.58, 0.59)
 - vi. Singular (animate) / Plural:
the author the security guards like laughs/*laugh. : (0.60, 0.54)
 - vii. Singular (inanimate) / Singular :
the movie the security guard likes is/*are good. : (0.71, 0.60)
 - viii. Singular (animate) / Singular:
the author the security guard likes laughs/*laugh. : (0.75, 0.60)
- (h) In an object relative clause:
- i. Singular (inanimate) / Singular :
the movie that the security guard likes/*like is good. : (0.69, 0.88)
 - ii. Singular (animate) / Singular:
the author that the security guard likes/*like laughs. : (0.74, 0.92)
 - iii. Plural (inanimate) / Singular:
the movies that the security guard likes/*like are good. : (0.79, 0.94)
 - iv. Plural (animate) / Singular:
the authors that the security guard likes/*like laugh. : (0.81, 0.97)
 - v. Plural (animate) / Plural:
the authors that the security guards like/*likes laugh. : (0.87, 0.84)
 - vi. Singular (animate) / Plural:
the author that the security guards like/*likes laughs. : (0.91, 0.81)
 - vii. Plural (inanimate) / Plural:
the movies that the security guards like/*likes are good. : (0.92, 0.88)
 - viii. Singular (inanimate) / Plural:
the movie that the security guards like/*likes is good. : (0.96, 0.90)
- (i) In an object relative (no *that*)

- i. Singular (inanimate) / Singular :
the movie the security guard likes/*like is good. : (0.42, 0.65)
- ii. Plural (animate) / Singular:
the authors the security guard likes/*like laugh. : (0.48, 0.89)
- iii. Singular (animate) / Singular:
the author the security guard likes/*like laughs. : (0.50, 0.67)
- iv. Plural (inanimate) / Singular:
the movies the security guard likes/*like are good. : (0.51, 0.89)
- v. Plural (animate) / Plural:
the authors the security guards like/*likes laugh. : (0.91, 0.86)
- vi. Singular (animate) / Plural:
the author the security guards like/*likes laughs. : (0.94, 0.84)
- vii. Plural (inanimate) / Plural:
the movies the security guards like/*likes are good. : (0.97, 0.88)
- viii. Singular (inanimate) / Plural:
the movie the security guards like/*likes is good. : (0.98, 0.92)

2. REFLEXIVE ANAPHORA

- (a) Simple:
 - i. Singular:
the author injured himself/*themselves. : (0.67, 0.73)
 - ii. Plural:
the authors injured themselves/*himself. : (0.99, 1.0)
- (b) In a sentential complement:
 - i. Plural / Singular
the mechanics said the author hurt himself/*themselves. : (0.71, 0.60)
 - ii. Singular / Singular
the mechanic said the author hurt himself/*themselves. : (0.80, 0.78)
 - iii. Singular / Plural
the mechanic said the authors hurt themselves/*himself. : (0.93, 0.96)
 - iv. Plural / Plural
the mechanics said the authors hurt themselves/*himself. : (1.0, 1.0)
- (c) Across a relative clause:
 - i. Singular / Plural:
the author that the security guards like injured himself/*themselves. : (0.10, 0.09)
 - ii. Plural / Singular:
the authors that the security guard likes injured themselves/*himself. : (0.33, 0.45)
 - iii. Singular / Singular:
the author that the security guard likes injured himself/*themselves. : (0.82, 0.75)
 - iv. Plural / Plural:
the authors that the security guards like injured themselves/*himself. : (0.93, 0.94)

3. NEGATIVE POLARITY ITEMS

- (a) Simple:
 - i. Past tense:
no/*most authors have ever been famous. : (0.35, 0.42)
 - ii. Future tense:
no/*most authors will ever be famous. : (0.45, 0.55)
- (b) Across a relative clause:

- i. Past tense:
 - no authors that the security guards like have ever been famous. (grammatical)
 - vs. *the authors that no security guards like have ever been famous. (intrusive) : (0.37, 0.73)

- ii. Future tense:
 - no authors that the security guards like will ever be famous. (grammatical) : (0.44, 0.75)

A.3 Details of human experiment

We constructed ten lists of minimal pairs. Each list had 76 minimal pairs: one representative of each of the 67 conditions, and nine additional Simple Agreement pairs included to detect participants who did not understand the task. Both versions of a minimal pair were shown on the screen at the same time; participants were asked to judge which one of them was more acceptable. The precise instructions were as follows:

In each trial, you will be presented with two sentences. You will read each sentence carefully and decide which of the two is more "acceptable" than the other. For instance, if the sentences were "The dogs in the park are happy" and "The dogs in the park is happy", then you would choose the first sentence, since it does not contain a grammatical error. You make click the sentence to choose it, or you may press the 1 or 2 key to choose. To ensure that your submission is accepted, be sure to read each sentence and choose your response carefully. Your goal should be accuracy, not speed.

The order of the two members of the minimal pair was randomized: the grammatical sentence was shown above the ungrammatical one in half of the cases and below the ungrammatical one in the other half.

We recruited 100 participants on Amazon Mechanical Turk. Ten participants were assigned to each list, such that we collected ten judgments for each minimal pair. We excluded participants who made more than one error on the ten Simple Agreement sentences (16 participants).

A.4 Word probabilities over the course of a sentence

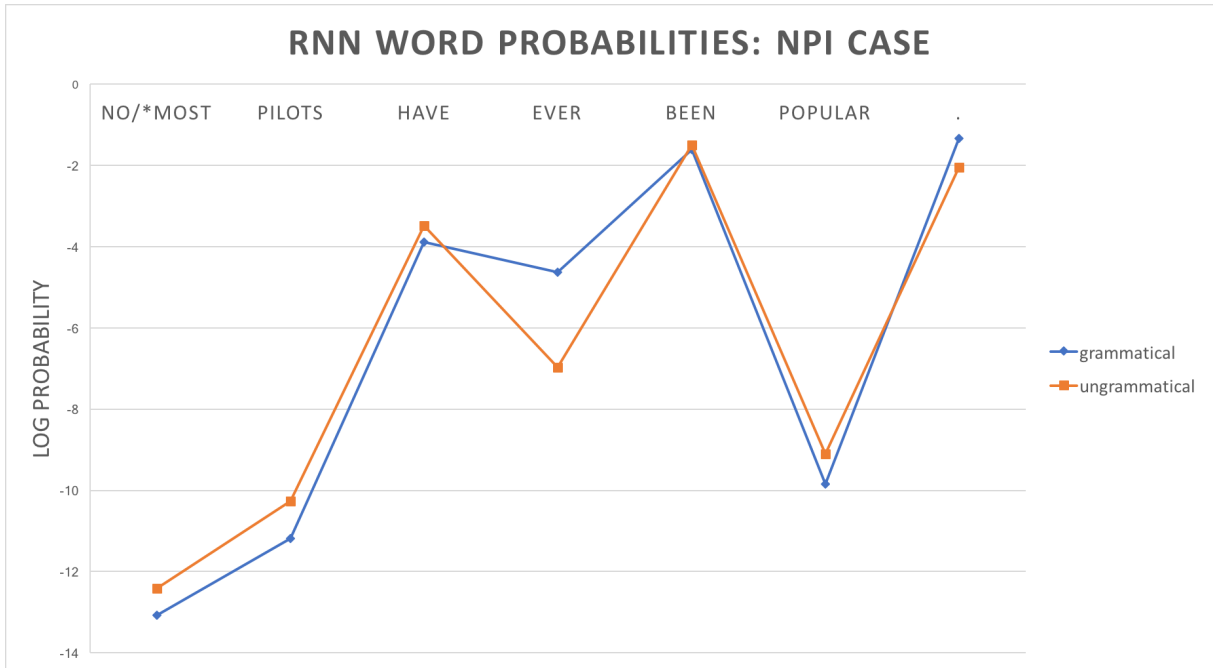


Figure A.1: The log probabilities for each word in the “simple NPI” case, as assigned by the single-task RNN.

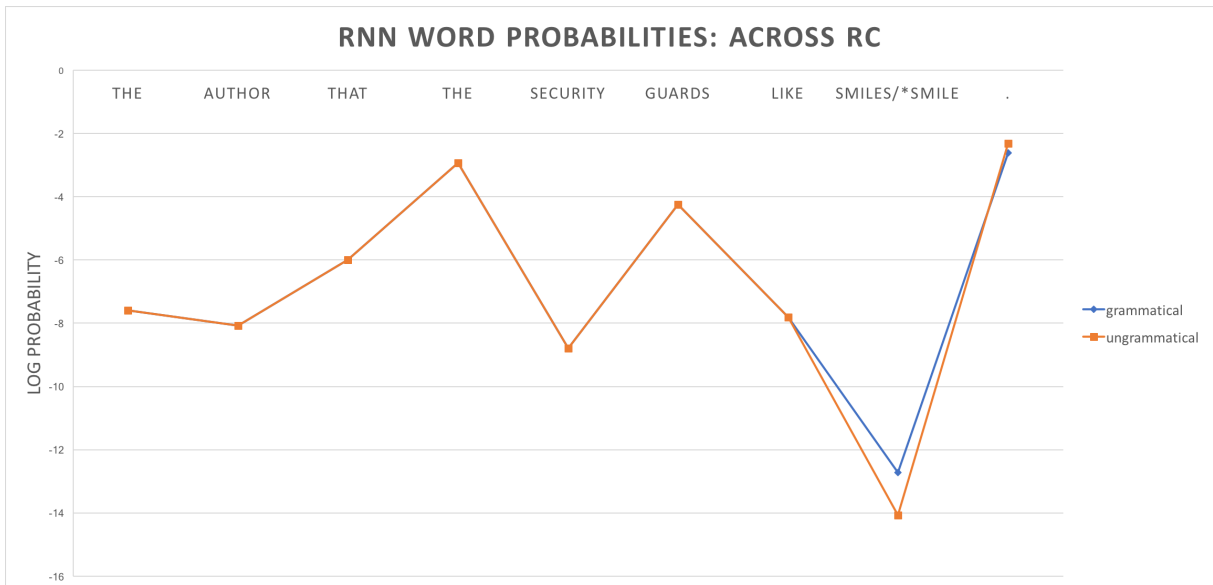


Figure A.2: The log probabilities for each word in the “across an object relative clause” case, as assigned by the single-task RNN.

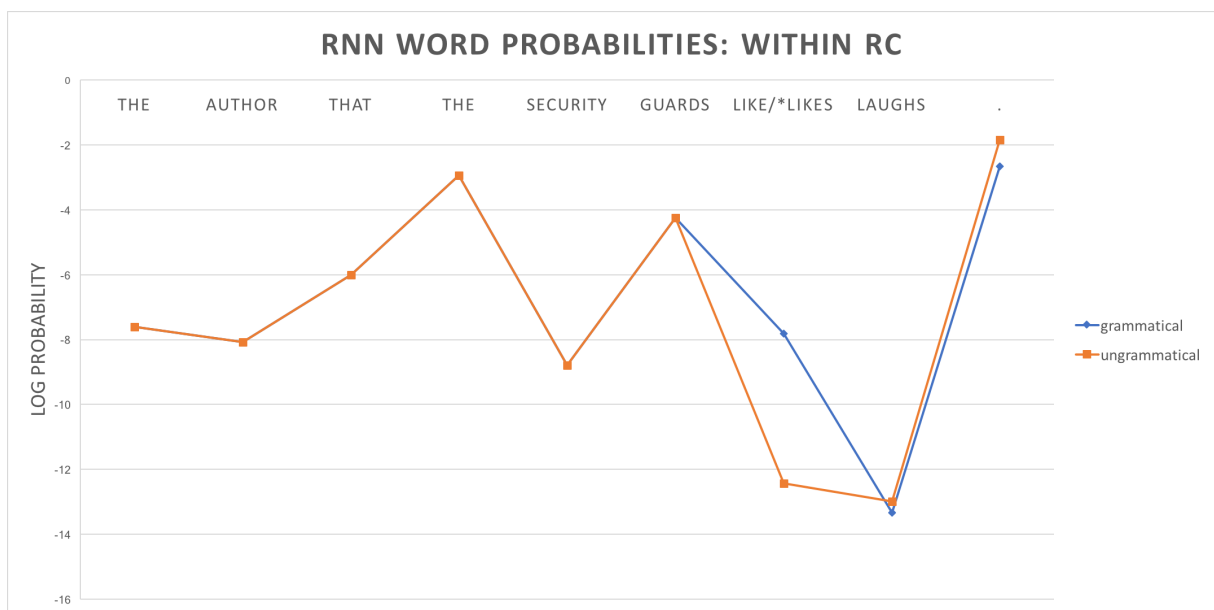


Figure A.3: The log probabilities for each word in the “in an object relative clause” case, as assigned by the single-task RNN.