Linguistics for Instruction in Language Arts and Writing

Using a rich grammar implementation to teach and evaluate writing skills

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DELPH-IN Summit

Language Arts and Writing at EPGY

- Education Program for Gifted Youth (EPGY) at Stanford
- LA&W for grades 2–6 (7–12 year-old native English speakers)
- Now used in classrooms in public schools (not only “gifted”)
- Goal: to help students improve writing skills
- Exercise-based course with automatic immediate feedback

Course design

- Four “strands” in each grade
  - Part of Speech
  - Sentence Structure
  - Paragraphs
  - Sentence Composition
- Short lecture for each concept, plus 15-20 exercises
- Progress determined by student performance

Exercise design for Sentence Composition

- Present a few sentences of context
- Ask a question
- Provide a set of (fully inflected) words, listed by part-of-speech
- Ask the student to compose an answer as a complete sentence
- Evaluate the answer, and if incorrect, identify error where possible
- Ask the student to try again once

3.G.14.01

Sentence Composition

Write a complete sentence that answers the question by clicking on words from the lists.
To remove a word from your answer, click and drag it out of the box. Use RESET to remove all your words.

Ricky stores his toys in his closet.

Where are Ricky's toys?

Verb	Noun	Article	Preposition	Pronoun	Contraction
are	Ricky's	the	in	it	Ricky's
be	desk			they	
	closet			his	
	garden				
	toys				

OK

RESET

Reset | Replay lecture | Give up | Lecture | Comment | End session

Ready

Ready

Some correct student answers (from 865 attempts)

Ricky stores his toys in the closet.

Where are Ricky's toys?

225	Ricky's toys are in the closet
171	Ricky's toys are in his closet
21	They are in his closet
21	They are in the closet
19	His toys are in the closet
11	They are in Ricky's closet
5	His toys are in his closet
5	The toys are in Ricky's closet
4	The toys are in the closet
4	Ricky's are in his closet
3	Ricky's are in the closet
1	Ricky's toys are in Ricky's closet
1	Ricky's toys are in the toys closet
1	His toys are in Ricky's closet
0	The toys are in his closet

Some incorrect student answers

closet
garden Ricky's they his at
his toys in the closet
in in in in Ricky's in Ricky's Ricky's
in his closet
in his toys closet
in Ricky's closet
in Ricky's closet his toys are
in the closet
Ricky's
Ricky's are his closet
Ricky's are his toys in his closet
Ricky's are the closet at
Ricky's closet
Ricky's closet toys
Ricky's closet toys are in it
Ricky's desk are toys

More incorrect student answers

Ricky's toys are closet
Ricky's toys are closet in
Ricky's toys are his closet
Ricky's toys are his in closet
Ricky's toys are his the closet
Ricky's toys are in
Ricky's toys are in closet
Ricky's toys are in garden
Ricky's toys are in his
Ricky's toys are in his desk they are the garden
Ricky's toys are in the
Ricky's toys are in the desk
Ricky's toys are the in closet
Ricky's toys are in the garden
Ricky's toys his in the closet
Ricky's toys in are closet
Ricky's toys in are his closet

An example from Grade 5

Abigail didn't want to go hiking with her parents because she felt too tired and wanted to rest instead.

Why didn't Abigail want to go hiking?

5.G.4.02

Sentence Composition

Write a complete sentence that answers the question by clicking on words from the lists.
To remove a word from your answer, click and drag it out of the box. Use RESET to remove all your words.

Abigail didn't want to go hiking with her parents because she felt too tired and wanted to rest instead.

Why didn't Abigail want to go hiking?

Verb	Preposition	Noun	Adjective	Pronoun	Conjunction	Contraction	Adverb
want	to	Abigail	tired	she	because	didn't	too
was		hike	hungry				
were			sick				
go							
hiking							
hike							

No answer

OK

Please select words from the word lists to write your answer.

RESET

An example from Grade 5

Abigail didn't want to go hiking with her parents because she felt too tired and wanted to rest instead.
Why didn't Abigail want to go hiking?

She was tired.

An example from Grade 5

Abigail didn't want to go hiking with her parents because she felt too tired and wanted to rest instead.
Why didn't Abigail want to go hiking?

She was tired.
She was too tired.

An example from Grade 5

Abigail didn't want to go hiking with her parents because she felt too tired and wanted to rest instead.
Why didn't Abigail want to go hiking?

She was tired.
She was too tired.
She was too tired to.

An example from Grade 5

Abigail didn't want to go hiking with her parents because she felt too tired and wanted to rest instead.
Why didn't Abigail want to go hiking?

She was tired.
She was too tired.
She was too tired to.
She was too tired to go.

An example from Grade 5

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Why didn't Abigail want to go hiking?

She was tired.
She was too tired.
She was too tired to.
She was too tired to go.
She was too tired to hike.

An example from Grade 5

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Why didn't Abigail want to go hiking?

She was tired.
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She was too tired to go.
She was too tired to hike.
She was too tired to go hike.
She was too tired to go hiking.

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She was tired.
She was too tired.
She was too tired to.
She was too tired to go.
She was too tired to hike.
She was too tired to go hike.
She was too tired to go hiking.
She didn't because she was too tired.

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She was too tired to.
She was too tired to go.
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She didn't want to because she was too tired.

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She was too tired to go.
She was too tired to hike.
She was too tired to go hike.
She was too tired to go hiking.
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She didn't want to because she was too tired.
She didn't want to go because she was too tired.
She didn't want to hike because she was too tired.

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Why didn't Abigail want to go hiking?

She was tired.
She was too tired.
She was too tired to.
She was too tired to go.
She was too tired to hike.
She was too tired to go hike.
She was too tired to go hiking.
She didn't because she was too tired.
She didn't want to because she was too tired.
She didn't want to go because she was too tired.
She didn't want to hike because she was too tired.
She didn't want to go hike because she was too tired..

An example from Grade 5

Abigail didn't want to go hiking with her parents because she felt too tired and wanted to rest instead.
Why didn't Abigail want to go hiking?

She was tired.
She was too tired.
She was too tired to.
She was too tired to go.
She was too tired to hike.
She was too tired to go hike.
She was too tired to go hiking.
She didn't because she was too tired.
She didn't want to because she was too tired.
She didn't want to go because she was too tired.
She didn't want to hike because she was too tired.
She didn't want to go hike because she was too tired..
She didn't want to go hiking because she was too tired.

More variants

She **didn't** because she was tired.
She didn't because she was too tired to.
She didn't because she was too tired to go.
She didn't because she was too tired to go hike.
She didn't because she was too tired to go hiking.
She didn't because she was too tired to hike.
She didn't **want to** because she was tired.
She didn't want to because she was too tired to.
She didn't want to because she was too tired to go.
She didn't want to because she was too tired to go hike.
She didn't want to because she was too tired to go hiking.
She didn't want to because she was too tired to hike.
She didn't **want to go** because she was tired.
She didn't want to go because she was too tired to.
She didn't want to go because she was too tired to hike.
She didn't want to go because she was too tired to go hike.
She didn't want to go because she was too tired to go hiking.
She didn't want to go because she was too tired to hike.
She didn't want **to go hike** because she was tired.
She didn't want to go hike because she was too tired to.
She didn't want to go hike because she was too tired to go.
She didn't want to go hike because she was too tired to go hike.
She didn't want to go hike because she was too tired to go hiking.
She didn't want to go hike because she was too tired to hike.
She didn't want **to go hiking** because she was tired.
She didn't want to go hiking because she was too tired to.
She didn't want to go hiking because she was too tired to go.
She didn't want to go hiking because she was too tired to go hike.
She didn't want to go hiking because she was too tired to go hiking.
She didn't want to go hiking because she was too tired to hike.
She didn't want **to hike** because she was tired.
She didn't want to hike because she was too tired to.
She didn't want to hike because she was too tired to go.
She didn't want to hike because she was too tired to go hike.
She didn't want to hike because she was too tired to go hiking.
She didn't want to hike because she was too tired to hike.

And more variants

She didn't because she was tired.
She didn't because she was too tired to.
She didn't because she was too tired to go.
She didn't because she was too tired to go hike.
She didn't because she was too tired to go hiking.
She didn't because she was too tired to hike.
She didn't want to because she was tired.
She didn't want to because she was too tired to.
She didn't want to because she was too tired to go.
She didn't want to because she was too tired to go hike.
She didn't want to because she was too tired to go hiking.
She didn't want to because she was too tired to hike.
She didn't want to go because she was tired.
She didn't want to go because she was too tired to.
She didn't want to go because she was too tired to hike.
She didn't want to go because she was too tired to go hike.
She didn't want to go because she was too tired to go hiking.
She didn't want to go because she was too tired to hike.
She didn't want to go hike because she was tired.
She didn't want to go hike because she was too tired to.
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She didn't want to go hiking because she was too tired to.
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She didn't want to go hiking because she was too tired to hike.
She didn't want to hike because she was tired.
She didn't want to hike because she was too tired to.
She didn't want to hike because she was too tired to go.
She didn't want to hike because she was too tired to go hike.
She didn't want to hike because she was too tired to go hiking.
She didn't want to hike because she was too tired to hike.

Abigail didn't because she was tired.
Abigail didn't because she was too tired to.
Abigail didn't because she was too tired to go.
Abigail didn't because she was too tired to go hike.
Abigail didn't because she was too tired to go hiking.
Abigail didn't because she was too tired to hike.
Abigail didn't want to because she was tired.
Abigail didn't want to because she was too tired to.
Abigail didn't want to because she was too tired to go.
Abigail didn't want to because she was too tired to go hike.
Abigail didn't want to because she was too tired to go hiking.
Abigail didn't want to because she was too tired to hike.
Abigail didn't want to go because she was tired.
Abigail didn't want to go because she was too tired to.
Abigail didn't want to go because she was too tired to hike.
Abigail didn't want to go because she was too tired to go hike.
Abigail didn't want to go because she was too tired to go hiking.
Abigail didn't want to go because she was too tired to hike.
Abigail didn't want to go hike because she was tired.
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Abigail didn't want to hike because she was tired.
Abigail didn't want to hike because she was too tired to.
Abigail didn't want to hike because she was too tired to go.
Abigail didn't want to hike because she was too tired to go hike.
Abigail didn't want to hike because she was too tired to go hiking.
Abigail didn't want to hike because she was too tired to hike.

And still more variants

Because she was tired, she didn't.
Because she was too tired to, she didn't.
Because she was too tired to go, she didn't.
Because she was too tired to go hike, she didn't.
Because she was too tired to go hiking, she didn't.
Because she was too tired to hike, she didn't.
Because she was tired, she didn't want to.
Because she was too tired to, she didn't want to.
Because she was too tired to go, she didn't want to.
Because she was too tired to go hike, she didn't want to.
Because she was too tired to go hiking, she didn't want to.
Because she was too tired to hike, she didn't want to.
Because she was tired, she didn't want to go.
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Because Abigail was too tired to go hiking, she didn't want to hike.
Because Abigail was too tired to hike, she didn't want to hike.

And even more variants

Because she was tired, **Abigail** didn't.
Because she was too tired to, Abigail didn't.
Because she was too tired to go, Abigail didn't.
Because she was too tired to go hike, Abigail didn't.
Because she was too tired to go hiking, Abigail didn't.
Because she was too tired to hike, Abigail didn't.
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Because Abigail was too tired to go, Abigail didn't.
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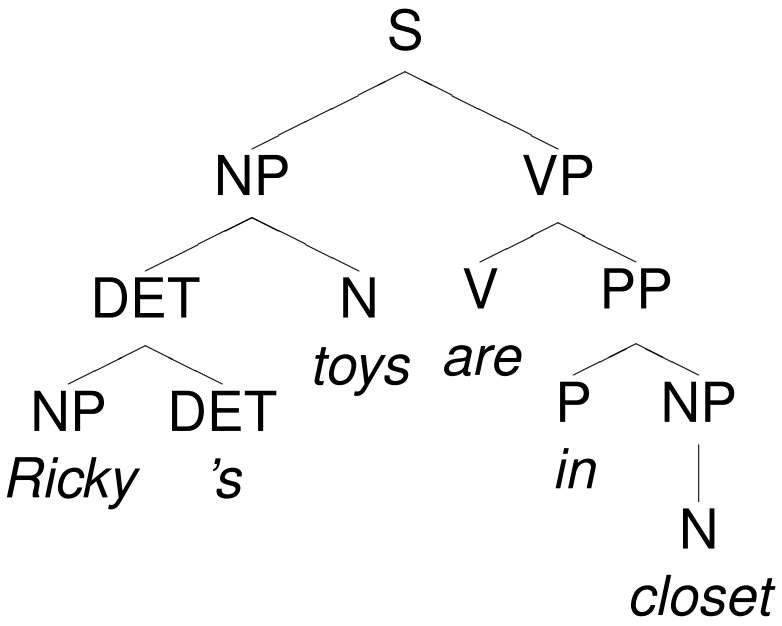
Because Abigail was too tired to hike, Abigail didn't want to hike.

Approach

- Use existing DELPH-IN resources (`www.delph-in.net`)
  - English Resource Grammar (ERG: Flickinger 2000, 2011)
  - Efficient PET parser (Callmeier 2000)
- Adapt 'mal-rule' approach to accept mild ungrammaticality
  - Schneider & McCoy (1998), Bender et al. (2004)
- Parse each novel input and return derivation tree
- Check for `root_robust`, and if so, find `..._rbst` node
- Look up robustness symbol in error code table (grade-specific)
- Present appropriate message to student

An ungrammatical example

Ricky's toys are in closet



Example derivation

```
(sb-hd_mc_c [root_robust_s]
  (sp-hd_n_c
    (sp-hd_hc_c
      (hdn_bnp-pn_c
        (n_sg_ilr (ricky_n1/n_-_pn_le ("ricky" <0:1>))))
      (apostrophe_s_2_lex/n_-_cl-poss_le ("'s" <1:2>)))
    (n_pl_olr (toy_n1/n_-_c_le ("toys" <2:3>))))
  (hd-cmp_u_c
    (be_c_are/v_prd_are_le ("are" <3:4>))
    (hd-cmp_u_c
      (in/p_np_i-reg_le ("in" <4:5>))
      (bare_np_sg_rbst
        (n_sg_ilr (closet_n1/n_-_c_le ("closet" <5:6>)))))))
```

Example derivation

```
(sb-hd_mc_c [root_robust_s]
  (sp-hd_n_c
    (sp-hd_hc_c
      (hdn_bnp-pn_c
        (n_sg_ilr (ricky_n1/n_-_pn_le ("ricky" <0:1>))))
      (apostrophe_s_2_lex/n_-_cl-poss_le ("'s" <1:2>)))
    (n_pl_olr (toy_n1/n_-_c_le ("toys" <2:3>))))
  (hd-cmp_u_c
    (be_c_are/v_prd_are_le ("are" <3:4>))
    (hd-cmp_u_c
      (in/p_np_i-reg_le ("in" <4:5>))
==>   (bare_np_sg_rbst
        (n_sg_ilr (closet_n1/n_-_c_le ("closet" <5:6>)))))))
```

English Resource Grammar (ERG)

- 7000 types in multiple-inheritance monotonic hierarchy
- 975 leaf lexical types
- 35,000 manually constructed lexemes
- 200 syntactic rules
- 70 morphological rules (inflection and derivation)

- Online demo: `lingo.stanford.edu/erg`

Changes to the general-purpose grammar

Extensions

- **Mal-rules** for inflection, syntax

  e.g. bare singular NP, or bare 3sg-present verb

- **Mal-types** for lexicon

  e.g. subj-equi with base VP: **Ricky likes go to the park*

Reductions to avoid some ambiguity

- Rules

  For example, block noun-noun compound rules

  Ricky's* **closet toys *are in the closet*

- Lexicon

  For example, block the verb *flower*

  Art and science **flowered** *during the 17th century.*

Mal-rule example: bare_np_sg_rbst

Accept a complete noun phrase headed by a singular count noun still missing its normally obligatory specifier (an article such as *the*).

Example: *Ricky's toys are in* **closet**.

$$\begin{bmatrix} \text{PHRASE} & \begin{bmatrix} \text{HEAD} & \boxed{1}\textit{noun} \\ \text{SPR} & \langle\ \rangle \\ \text{COMPS} & \boxed{2}\langle\ \rangle \\ \text{SEM} & \langle\ \textit{quant_rel}\ \rangle \end{bmatrix} \\ \text{HEAD-DTR} & \begin{bmatrix} \text{HEAD} & \boxed{1} \\ \text{SPR} & \langle \begin{bmatrix}\text{OPT} & -\end{bmatrix}\rangle \\ \text{COMPS} & \boxed{2} \\ \text{AGR} & \begin{bmatrix}\text{PN} & \text{3sing} \\ \text{DIV} & -\end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Error messages

Your answer is not grammatical.	*He are be was dog*
Your answer is not a complete sentence.	*In the park*
Your answer is grammatical but awkward.	*They saw in the lake a duck*
Your answer cannot be a question.	*Did she go to the beach*
You are missing an article before the word $X.	*She went to house*
Remember to use "an" only before a vowel.	*He ate an sandwich*
Don't use "a" before a vowel.	*She saw a owl*
Don't put "the" before a name.	*The Katherine eats breakfast*
You are missing the preposition "on" before $X.	*They watched movies Tuesday*
You are missing "to" before $X.	*She told her brother borrow her book*
Don't put "to" before $X.	*She let her brother to borrow her book*
The verb $X needs an object.	*She let borrow her book*
You are missing a noun.	*His chased the cat*
You have an extra noun in your answer.	*The children ate a lunch pizza*
Use an adverb like "well" or "poorly" instead of "bad".	*He did bad on his test*
Use "its" instead of "it's" to show ownership.	*The dog is in it's house*
Remember to use "this" only before a singular noun.	*He said he like this mittens*
Don't use "did/does/do" in your answer.	*The dog did go for a walk*
You have the wrong form of the verb.	*The boy be late for school*
Your subject doesn't agree with the verb $X.	*Alex write a letter*

Overview of correct answers parsed with ERG

Success in parsing					
Length	**total items** ♯	**word string** ϕ	**lexical items** ϕ	**total results** ♯	**overall coverage** %
10 – 14	474	10.66	91.38	472	99.6
5 – 9	4781	6.61	67.69	4738	99.1
1 – 4	1354	3.52	47.53	1335	98.6
Total	**6609**	**6.27**	**65.26**	**6545**	**99.0**

(generated by [incr tsdb()] at 9-jul-2010 (14:51 h))

Efficiency in parsing					
Length	**items** ♯	**etasks** ϕ	**filter** %	**edges** ϕ	**time** ϕ (s)
10 – 14	474	6493	98.0	1306	0.36
5 – 9	4781	1970	98.0	418	0.12
1 – 4	1354	812	97.8	158	0.06
Total	**6609**	**2057**	**97.9**	**429**	**0.13**

(generated by [incr tsdb()] at 9-jul-2010 (15:19 h))

Ambiguity: Parse selection via statistics

- Statistical model trained on normal data, no mal-rules
- Some constructions excluded to improve disambiguation

  That child *my sister told a story*
- Cannot just try mal-rules when no good parse

  She told the boy **read** *a story*

Style and dialect

Style

- Interleaved PP and NP complements

  She gave Mary **on Saturday** *a really nice gift.*

- Topicalization

  That movie, *he just doesn't want to see.*

- Preposition stranding

  The friend who they sent the invitation **to** *lives in Paris.*

Style and dialect

Style

- Interleaved PP and NP complements
- Topicalization
- Preposition stranding

Dialect variation

- *This car needs washed / washing*
- *We might could go to the park*
- *He be angry at them*

Usage of LA&W in Memphis

Sentences composed by 25,000 students in 2010:

	Correct		Incorrect		All
	1st attempt	*2nd attempt*	*1st attempt*	*2nd attempt*	
	1,446,253	190,729	709,489	509,995	
Total	1,636,982 57.3%		1,219,484 42.7%		2,856,466
Distinct	12,137		180,795		192,932
Unique	2,323 19.1%		79,580 41.2%		

LA&W Initiative A: Semantic Error Analysis

- Confirm correct but 'novel' answers where semantics is identical

  My sister has a fluffy fluffy cat.

- Identify semantic errors where answer is grammatical

  The pizza ate my cat.

- Diagnose the most frequent semantic errors automatically

LA&W Initiative B: Expanded Use of Composition

- Increased use of student writing in other LA&W strands
- Inclusion of whole paragraph composition

LA&W Initiative C: Increased Use of Audio

- More detailed instructions where performance is suffering
- Addition of audio hints after failed first attempt
- Addition of tutorial dialogues to guide corrections