Cohesion, Semantics and Learning in Reflective Dialog

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Outline
- Motivation: why study cohesion?
  - A way to study Interactivity in tutorial dialog
  - Previous work: automatic “lexical” cohesive ties
    - now try more sophisticated measure
- Tag Definitions: Set of “semantic” cohesive ties
- Corpus: Pre/post-tests & transfer questions
- Applying the Tags
- Results
  - Abstraction & Specialization important for learning
    - And transfer

Interactivity in Tutorial Dialog
- Human tutoring is very effective (Bloom 1984; Cohen Kulik & Kulik 1982) Why?
- Maybe because it is interactive (Chi et al. 2001, 2008; Graesser et al. 1995)
- What specific interactive mechanisms help?
  - Other ways to study interactivity in dialog

Cohesive Ties
- Cohesion: how a text “hangs together”
  - Measurable using “cohesive ties” (Halliday & Hasan 1976)
    - Repetition of words, use of pronouns, ellipsis, etc...
  - Previous work
    - Counted cohesive ties between tutor & student (Ward & Litman 2006, 2008)
    - Repetition of words, word stems, hyponym/hyponyms (identified using WordNet)
    - Correlated with learning, Automatically computable

Cohesive Ties
- Current work
  - Manually tag for cohesive ties not automatically identifiable
    - In a different corpus
  - Like before, focus on when tutor and student refer to each other’s contributions
    - Lexical ties (eg word repetition, like before)

Cohesive Tag Set
- Exact: word or word stem repetition
- Synonym: two words with similar meanings
- Paraphrase: phrase repetition w/substitution
- Pronoun: pronominal reference (“she” “it”)
- Superordinate-class: more general referring term
- Class-member: more specific referring term
- Collocation: complementarity (“up-down”)
- Negation: direct contradiction
The Corpus

- Reflec
ti
ve tutoring dialogs with a human tutor (Katz et al. 2003)
- After problem solving in Andes (vanLehn et al. 2005)
- Study procedure:
  - 16 Students solved 12 physics problems each
  - Answered 3-8 reflection questions
- Resulting corpus has 953 reflective dialogs
  - 2,218 student turns
  - 2,136 tutor turns
- Counter-balanced pre & post-tests
  - 9 quantitative mechanics questions
    - similar to Andes problems
  - 27 qualitative physics questions
    - new questions, not like Andes problems
    - "far transfer" questions
  - Students learned significantly by both measures

Cohesion Tag Example

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<thead>
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<th>Student:</th>
<th>Velocity is in the same direction as acceleration so the ball is faster coming down.</th>
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<td>paraphrase</td>
</tr>
<tr>
<td>velocity</td>
<td>horizontal components of the velocity</td>
<td>Class-member</td>
</tr>
<tr>
<td>same</td>
<td>unchanged</td>
<td>synonym</td>
</tr>
<tr>
<td>coming down</td>
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Tagging the Corpus

- Training: 518 student & turns
  - Refining tag definitions
- Initial tagging pass
  - Lexical features only
  - Spans agreed by discussion
- Final tagging pass
  - Re-evaluated 3 tags, using contextual features:
    - "superordinate-class," "class-member," "collocation"
  - Eliminated ties that didn't make sense
  - Mis-matched topics or referents
  - Didn't seem to involve knowledge construction
  - 2nd tagger re-tagged random 10%
  - Kappa = .57

Final Tagging Example

S: "yes, because gravity pulls the firecracker down and gives it motion in the 'y' direction.

T: "Good, that's right. What about in the horizontal directions? for example the 'x' direction on your diagram?"

In first pass: tagged *lexical relations*
- without reference to semantic context
- "down" is a specific "direction"
- so tag down-direction as "superordinate-class"
Final Tagging Example

- S: “yes, because gravity pulls the firecracker down and gives it motion in the ‘y’ direction.
- T: “Good, that’s right. What about in the horizontal directions? for example the ‘x’ direction on your diagram?”
- In second pass:
  - notice that student already used “direction”
  - Tutor did not do new generalization
  - remove the tag

Analysis

- Linear Model for each cohesion tag
  - Predict post-test score from:
    - pre-test score
    - because correlated with post-test score
    - Standardized math score
    - useful predictor of learning in Andes
    - Tag count
    - normalized by #of student or tutor turns
  - Separate models for:
    - high pre-testers, low pre-testers, all students
    - qual (“near”), quant (“far”) & all questions

Analysis

- Linear Model for each cohesion tag
  - Example for “student superordinate-class” tag
  - All students, all questions

Results

<table>
<thead>
<tr>
<th>Tag</th>
<th>Students</th>
<th>Questions</th>
<th>Tag pVal</th>
<th>Mod pVal</th>
<th>R^2</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>S Super-Ord</td>
<td>All</td>
<td>All</td>
<td>0.054</td>
<td>0.065</td>
<td>0.64</td>
<td>16</td>
</tr>
<tr>
<td>T Super-Ord</td>
<td>All</td>
<td>Far Trans</td>
<td>0.005</td>
<td>0.002</td>
<td>0.71</td>
<td>15</td>
</tr>
<tr>
<td>T Class-mem</td>
<td>All</td>
<td>Far Trans</td>
<td>0.015</td>
<td>0.005</td>
<td>0.65</td>
<td>16</td>
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<tr>
<td>T Class-mem</td>
<td>High Pre</td>
<td>Far Trans</td>
<td>0.032</td>
<td>0.059</td>
<td>0.75</td>
<td>9</td>
</tr>
<tr>
<td>T Class-mem</td>
<td>Low Pre</td>
<td>Near Trans</td>
<td>0.050</td>
<td>0.153</td>
<td>0.47</td>
<td>7</td>
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“T” = Tutor “S” = Student
“Super-Ord” = superordinate-class “Class-mem” = class-member

Discussion

- Previous work showed that automatic measures of cohesion correlated with learning
- Current work suggests
  - cohesion also correlates in new corpus
  - abstraction/specialization seem to be important cohesive mechanisms in tutoring
  - “semantic” ties correlate
  - no results for “exact” in this corpus
  - span identification is the hardest part

Span Identification is Hard

- Example
  - S: “No, the force the airbag exerts back on the man after he goes into is one.”
  - T: “The airbag force and the force of the person on the airbag is such a pair. Good. All forces come in such pairs! What is the reaction force for the driver’s weight?”

- Overlapping spans:
  - “force”-“forces”: exact
  - “force the airbag exerts” - “airbag force”: paraphrase
  - “force the airbag exerts back on the man” - “pair”: superordinate class
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Future Work

- Investigate automatic detection
  - maybe don’t need accurate spans?

- Could improve student models by detecting student abstraction

- Could improve tutoring by including more tutor abstraction/specialization at appropriate places
  - what’s an appropriate place?

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Thanks

- Learning Research & Development Center
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