

# 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

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## 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? <sup>3</sup>

## 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) <sup>4</sup>
      - Correlated with learning, Automatically computable

## Cohesive Ties

- Current work
  - Manual 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 <sup>5</sup>
  - Lexical ties (eg word repetition, like before)

## Cohesion 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 <sup>6</sup>

## The Corpus

- Reflexive tutoring dialogues 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
    - Example: *the horizontal components of velocity stay unchanged*

## The Corpus

- 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

**Student:** Velocity is in the same direction as acceleration so the ball is faster coming down.

**Tutor:** It slows down going up and it speeds up coming down – but all the time the horizontal components of the velocity stay unchanged. Horizontal components of velocity are unaffected by gravity. OK?

Stud. Span	Tut. Span	Tag
the ball	it	pronoun
faster coming down	speeds up coming down	paraphrase
velocity	horizontal components of the velocity	Class-member
same	unchanged	synonym
coming down	going up	collocation
direction	horizontal	Class-member

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## Cohesion Tag Example

**Tutor:** ...What about the **horizontal components of the velocity?** (of the ball or of the water -either?)

**Student:** **Velocity** is in the same direction as acceleration so the ball is faster coming down.

Tut. Span	Stud. Span	Tag
<b>horizontal components of the velocity</b>	<b>velocity</b>	<b>superordinate-class</b>

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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
  - 2<sup>nd</sup> tagger re-tagged random 10%
    - Kappa = .57

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## 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"

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- 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

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## 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

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## Analysis

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

Coefficients Post-Test = (Intercept) + Pre-Test + Norm Tag Count + Math Score  
 P-Value 0.955 0.061 0.054 0.070

Model R<sup>2</sup>: 0.644  
 Model p\_val: 0.005

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## Results

Tag	Students	Questions	Tag pVal	Mod pVal	R <sup>2</sup>	N
S:Super-Ord	All	All	0.054	0.005	0.64	16
S:Super-Ord	All	Far Trans	0.005	0.002	0.71	16
T:Class-mem	All	Far Trans	0.015	0.005	0.65	16
T:Class-mem	High Pre	Far Trans	0.032	0.059	0.75	9
T:Class-mem	Low Pre	Near Trans	0.050	0.153	0.47	7

"T:" = Tutor "S:" = Student  
 "Super-Ord" = superordinate-class "Class-mem" = class-member

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## 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

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## 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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- Overlapping spans

- Spans often don't correspond to syntactic structures
- words often participate in >1 span

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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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