Evaluating Answers to Reading Comprehension Questions in Context: Results for German and the Role of Information Structure

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- Data sets used

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- Annotation
- Alignment
- Classification Features

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- Overall results
- Detailed evaluation

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- Givenness filter
- Alternative question problem
- From Givenness to Focus
- Towards annotating focus

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Long-term research questions

- What **linguistic representations** can be used robustly and efficiently in automatic meaning comparison?
- What is the role of **context** and how can we utilize knowledge about it in comparing meaning automatically?
  - Context here means questions and reading texts in reading comprehension tasks.

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Aims of this talk

- Present first content assessment approach for German
- Explore impact of
  - question types and
  - ways of encoding information in the text
- Discuss the importance of explicit language-based context
  - here: information structure of answers given questions and text

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Connection to RTE and Textual Inference

- What is Content Assessment?
  - The task of determining whether a response actually answers a given question about a specific text.
- Two possible perspectives in connection with RTE:
  1. Decide whether reading text *T* supports student answer *SA*, i.e., whether *SA* is entailed by *T*.
  2. Decide whether student answer *SA* is paraphrase of target answer *TA*. ⇒ bi-directional entailment

In this talk, we focus on the second perspective.

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Example from our corpus

T: *(Reading comprehension text)*

Q: **Was sind die Kritikpunkte, die Leute über Hamburg äußern?**

'What are the objections people have about Hamburg?'

TA:	**Der**	**Gestank**	**von**	**Fisch**	**und**	**Schiffsdiesel**	**an den Kais**	**.**
	The	stink	of	fish	and	fuel	on the quays	.

SA:	**Der**	**Geruch**	**zon**	**Fish**	**und**	**Schiffsdiesel**	**beim**	**Hafen** **.**
	The	smell	of_{err}	$fish_{err}$	and	fuel	at the port	.

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Data source: CREG

Corpus of **R**eading Comprehension **E**xercises in **G**erman

- Consists of
  - reading texts,
  - reading comprehension questions,
  - target answers formulated by teachers,
  - student answers to the questions.

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- Consists of
  - reading texts,
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  - target answers formulated by teachers,
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- Is being collected in two large German programs in US
  - The Ohio State University (Prof. Kathryn Corl)
  - Kansas University (Prof. Nina Vyatkina)

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- Is being collected in two large German programs in US
  - The Ohio State University (Prof. Kathryn Corl)
  - Kansas University (Prof. Nina Vyatkina)
- Two research assistants independently rate each student answer with respect to meaning.
  - Did student provide meaningful answer to question?
  - Binary categories: adequate/inadequate
  - Annotators also identify target answer for student answer

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Data sets used

- From the corpus in development, we took a snapshot
  - with full agreement in binary ratings,
  - and with half of the answers being rated as *inadequate* (random base line = 50%).
- Resulted in one data set for each of the two sites
  - No overlap in exercise material

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	KU data set	OSU data set
Target Answers	136	87
Questions	117	60
Student Answers	**610**	**422**
# of Students	141	175
SAs per question	5.21	7.03
avg. Token #	9.71	15.00

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General CoMiC Approach

(Bailey & Meurers 2008; Meurers, Ziai, Ott & Bailey 2011)

The overall approach has three phases:

1. **Annotation** uses NLP to enrich the student and target answers, as well as the question text, with linguistic information on different levels and types of abstraction.
2. **Alignment** maps elements of the learner answer to elements of the target response using annotation.
   - Global alignment solution computed by Traditional Marriage Algorithm (Gale & Shapley 1962)
3. **Classification** analyzes the possible alignments and labels the learner response with a binary content assessment and a detailed diagnosis code.

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Annotation

NLP Components

Annotation Task	**NLP Component**
Sentence Detection	OpenNLP http://incubator.apache.org/opennlp
Tokenization	OpenNLP
Lemmatization	TreeTagger (Schmid 1994)
Spell Checking	Edit distance (Levenshtein 1966) igerman98 word list http://www.j3e.de/ispell/igerman98
Part-of-speech Tagging	TreeTagger (Schmid 1994)
Noun Phrase Chunking	OpenNLP
Lexical Relations	GermaNet (Hamp & Feldweg 1997)
Similarity Scores	PMI-IR (Turney 2001)
Dependency Relations	MaltParser (Nivre et al. 2007)

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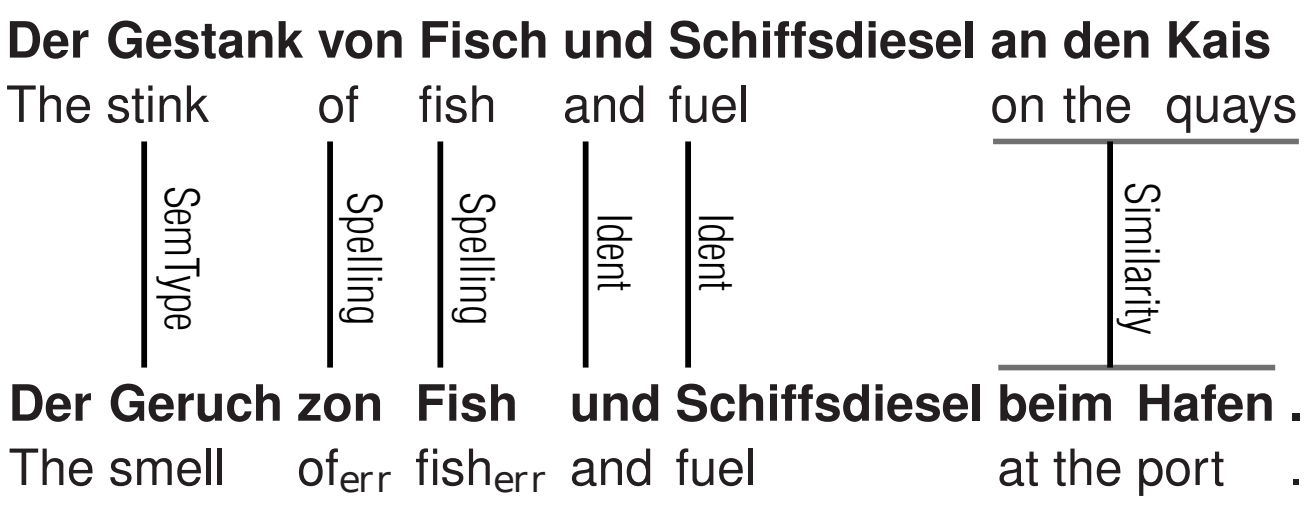
Alignment

Example

Q: **Was sind die Kritikpunkte, die Leute über Hamburg äußern?**

'What are the objections people have about Hamburg?'



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Classification

Features

- Content Assessment is based on 13 features:

  % of Overlapping Matches:

  - keyword (head)
  - target/learner token
  - target/learner chunk
  - target/learner triple

  Nature of Matches:

  - % token matches
  - % lemma matches
  - % synonym matches
  - % similarity matches
  - % sem. type matches
  - match variety

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  Nature of Matches:

  - % token matches
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  - % similarity matches
  - % sem. type matches
  - match variety

- We combined the evidence with memory-based learning (TiMBL, Daelemans et al. 2007)
  - Trained seven classifiers using different distance metrics, overall outcome obtained through majority voting.
  - Used *leave-one-out* testing: For each test item train on all answer pairs except the test item itself.

Experiment

Overall results

	KU data set	OSU data set
# of answers	610	422
Accuracy	**84.6%**	**84.6%**

- Remarkable similarity of results across completely different data sets
- Same overall results when macro-averaging over individual questions
- Competitive with results obtained for English (78%) in Bailey & Meurers (2008) and related results of C-Rater for short answer scoring (Leacock & Chodorow 2003).

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Detailed Evaluation

- Global accuracy scores do not tell us how well the system fares, e.g., in terms of question types.
- First step towards deeper analysis of results: manual annotation of reading comprehension question properties
- Annotation scheme follows Day & Park (2005) guidelines for development of reading comprehension questions
  - Comprehension Types:
    - nature & depth of comprehension required by learner to answer the question
    - in our data: “Literal”, “Reorganization” and “Inference”
  - Question Forms:
    - Surface-based question classes such as “yes/no” or “who” questions

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Detailed Evaluation

Accuracy by question form and comprehension

	Literal	Reorganization	Inference	Total
Alternative	0 (1)	– (0)	66.67 (6)	57.14 (7)
How	85.71 (126)	83.33 (12)	100 (7)	86.21 (145)
What	87.04 (247)	74.19 (31)	83.33 (6)	85.56 (284)
When	85.71 (7)	– (0)	– (0)	85.71 (7)
Where	88.89 (9)	– (0)	– (0)	88.89 (9)
Which	92.35 (183)	100 (14)	83.33 (6)	92.61 (203)
Who	73.91 (23)	94.44 (18)	– (0)	82.93 (41)
Why	80.47 (128)	57.14 (14)	84.38 (32)	79.31 (174)
Yes/No	– (0)	100 (5)	– (0)	100 (5)
Several	82.11 (95)	68.42 (38)	75 (24)	77.71 (157)
Total	85.96 (819)	78.03 (132)	81.48 (81)	84.59 (1032)

- Answer counts shown in brackets
- Error bars indicate 95% confidence intervals

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Most important results

Comprehension types

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- “Literal” questions (86.0%) seem to be easier than “Reorganization” (78.0%) and “Inference” (81.5%).

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Most important results

Question forms: easy case

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- Accuracy for *wh*-questions based on concrete information from text is rather high, e.g., 92.6% for “which” questions.

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Question forms: hard case

	Literal	Reorganization	Inference	Total
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- "why" questions are difficult (79.3%): Asking for reasons/causes supports more answer variation.

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Most important results

Question forms: a puzzle

	Literal	Reorganization	Inference	Total
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- “Alternative” questions are near random level (57.1%).
  - Why?

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Information Structure

- Information Structure (IS) research investigates:
  - How is the meaning of a sentence integrated into the discourse?
- One relevant notion is **Givenness**:
  - "A constituent C counts as Given if there is a salient antecedent A for C, such that A either
    - co-refers with C,
    - is a synonym of C or
    - is a hyponym of C." (Büring 2006)
- Our system as a first approximation excludes all words from alignment that appear in the question.
  - Motivation: Mentioned lexical material typically does not contain new information answering the question.
- However, in some interesting cases, the answer to a question does include given information.
  - Example: "Alternative" questions

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Alternative question example

Q: Ist die Wohnung in einem Neubau oder einem Altbau?

'Is the flat in a new building or in an old building?'

TA: Die Wohnung ist in einem Neubau .
The flat is in a new building

SA: Die Wohnung ist in einem Neubau
The flat is in a new building

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From Givenness to Focus

- The IS notion of a **Focus** as the expression which addresses an explicit or implicit question under discussion (Krifka 2004) helps address the issue.
  - → Given information is relevant when it is part of the focus.

- Making the focus explicit can also help in cases such as:

Q: Was muss die Meerjungfrau erleiden, wenn sie Menschenbeine haben will?

'What must the mermaid suffer if she wants to have human legs?'

TA: Die Meerjungfrau muss schreckliche Qualen erleiden bei jedem Schritt .
The mermaid must horrible torment suffer with every step .

SA: Sie erleidt bei jedem Schritt.
She suffer with every step.

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Towards annotating focus

- Idea: Integrate an automatic focus identification component into CoMiC.
- Approach should be informed by manual approaches to annotating information structure aspects:
  - Those targeting focus are moderately successful (Dipper et al. 2007; Calhoun et al. 2010).
  - In the CREG corpus, the explicit linguistic context (text, question) may support more reliable focus identification.
  - Information Status (Given vs. New) of referential expressions (Riester et al. 2010) may help as “backbone”.

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Conclusion

- We presented the first content assessment system for German, CoMiC-DE
  - accuracy of 84.6% on authentic classroom data
  - competitive with results for English
- Detailed evaluation by question form and comprehension type
  - clear differences in performance
  - identifies avenues for future research improving analysis for specific question forms and comprehension types
- To identify which parts of an answer are most relevant for content assessment, information structure distinctions should be integrated.
  - manual annotation of the focus of an answer is a first step
  - explicit language-based context of task is crucial

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Thank you!

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