



# AN INTRODUCTION TO NATURAL LANGUAGE GENERATION

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*64-419 Integriertes Seminar Sprachverarbeitung  
slides by Konstantin S. M. Möllers*

” How can we produce **well-formed** (i.e. readable, not just from simple text blocks composed) **texts automatically?**

-Prof. Michael Hess, University of Zürich

**WHY NOT USE BLOCKS?**

# WHY NOT USE BLOCKS?

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```
const tmpl = `The temperature will be between ${x.low}
and  ${x.high} degrees.`;
```

# WHY NOT USE BLOCKS?

---

```
const tmpl = `The temperature will be between ${x.low}
and ${x.high} degrees.`;
```

```
{
  "date":      "2016-06-08",
  "high":     18,
  "low":      13,
  "feelsLike": 14
}
```

```
{
  "date":      "2016-06-09",
  "high":     15,
  "low":      15,
  "feelsLike": 15
}
```

The temperature will be between 18 and 13 degrees.

The temperature will be between 15 and 15 degrees.





# WHY NOT USE BLOCKS?

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```
{  
  "date":      "2016-06-08",  
  "high":     18,  
  "low":      13,  
  "feelsLike": 14  
}
```

```
{  
  "date":      "2016-06-09",  
  "high":     15,  
  "low":      15,  
  "feelsLike": 15  
}
```

You: „Will it be warmer tomorrow?“

```
if (today.high < tomorrow.high)  
  return "It's going to be warmer.";
```



**What problems do you expect with this technique?**

*In groups, 3 minutes.*

# WHY NOT USE BLOCKS?

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```
{  
  "date":      "2016-06-08",  
  "high":     18,  
  "low":      13,  
  "feelsLike": 14  
}
```

```
{  
  "date":      "2016-06-09",  
  "high":     15,  
  "low":      15,  
  "feelsLike": 15  
}
```

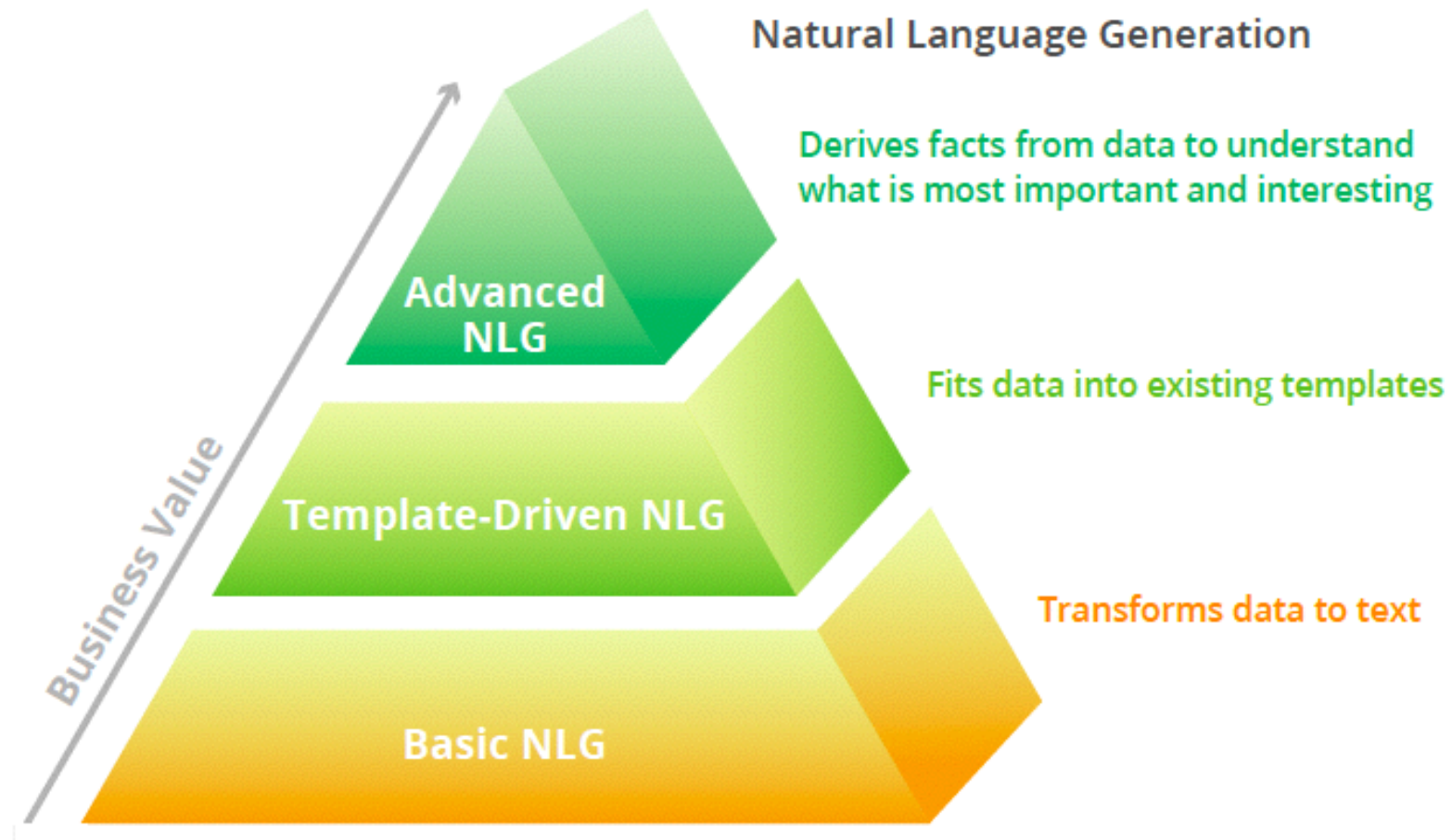
You: „Will it be warmer tomorrow?“

```
if (today.high < tomorrow.high)  
  return "It's going to be warmer.";
```

Computer: „For my CPU it's colder, but you will feel warmer!“

# WHY NOT USE BLOCKS?

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- automated earning reports
- statement of benefits generation
- weather forecasts
- personalized advertising messages

[Glascott15]



# OUTLINE

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1. ~~Motivation~~ ✓

2. How it works

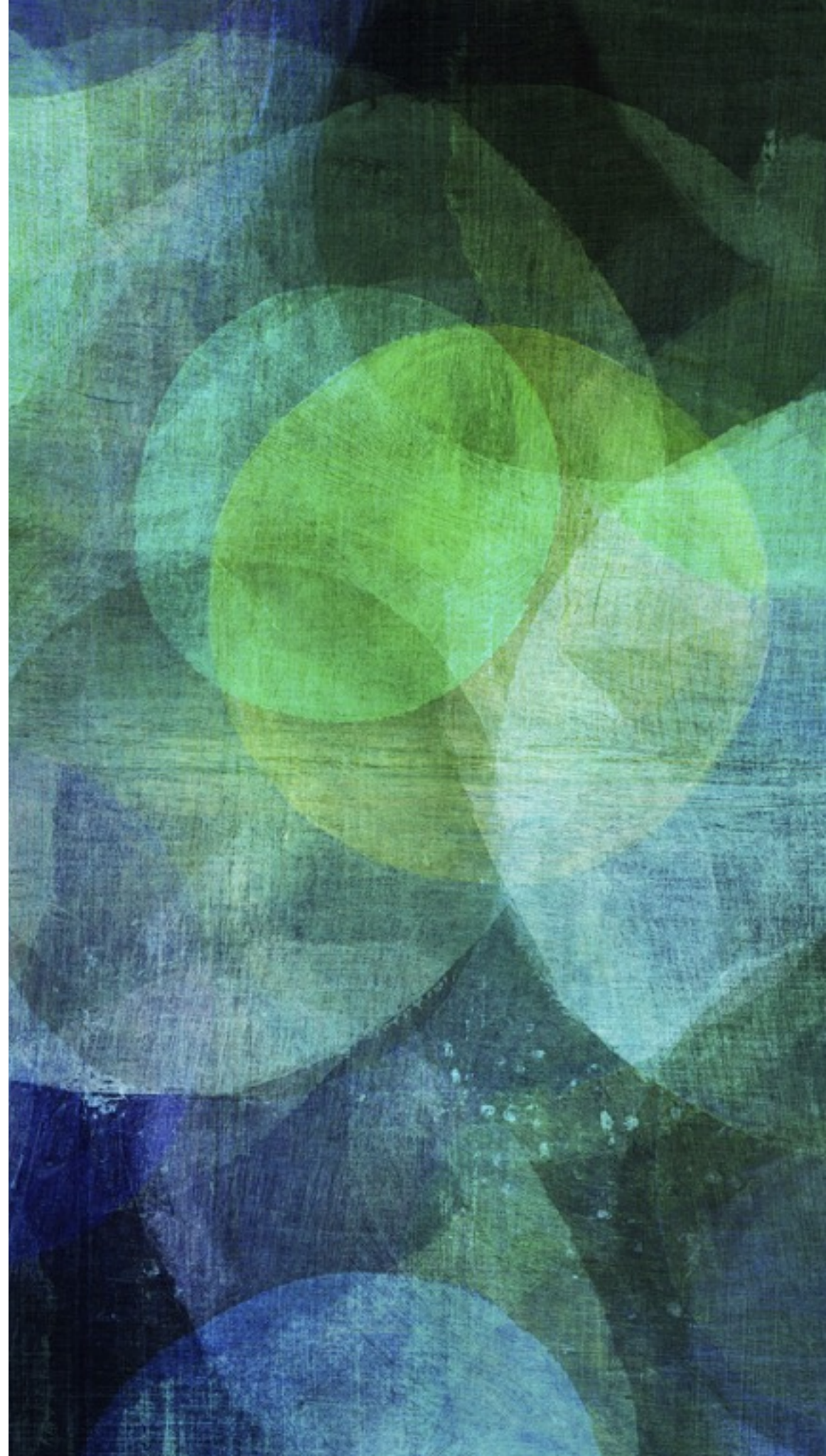
3. Realizations

4. Conclusion



# HOW IT WORKS

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## STRATEGIC COMPONENT

What should be said?



## TACTICAL COMPONENT

How should it be said?

[Hess05]



# PLANNING A DISCOURSE – LOCATION PLAN

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**?** Imagine you write a location planner. What of the following points is strategic or tactical? Imagine some points of your own!  
*In groups, 5 minutes.*

Select Landmarks on the Way

Use Nominalization

Inform the User Where she/he Currently is

Tell that there is a Traffic Light

Merge two Similar Sentences

Ensure the User that she/he is Still on the Right Way

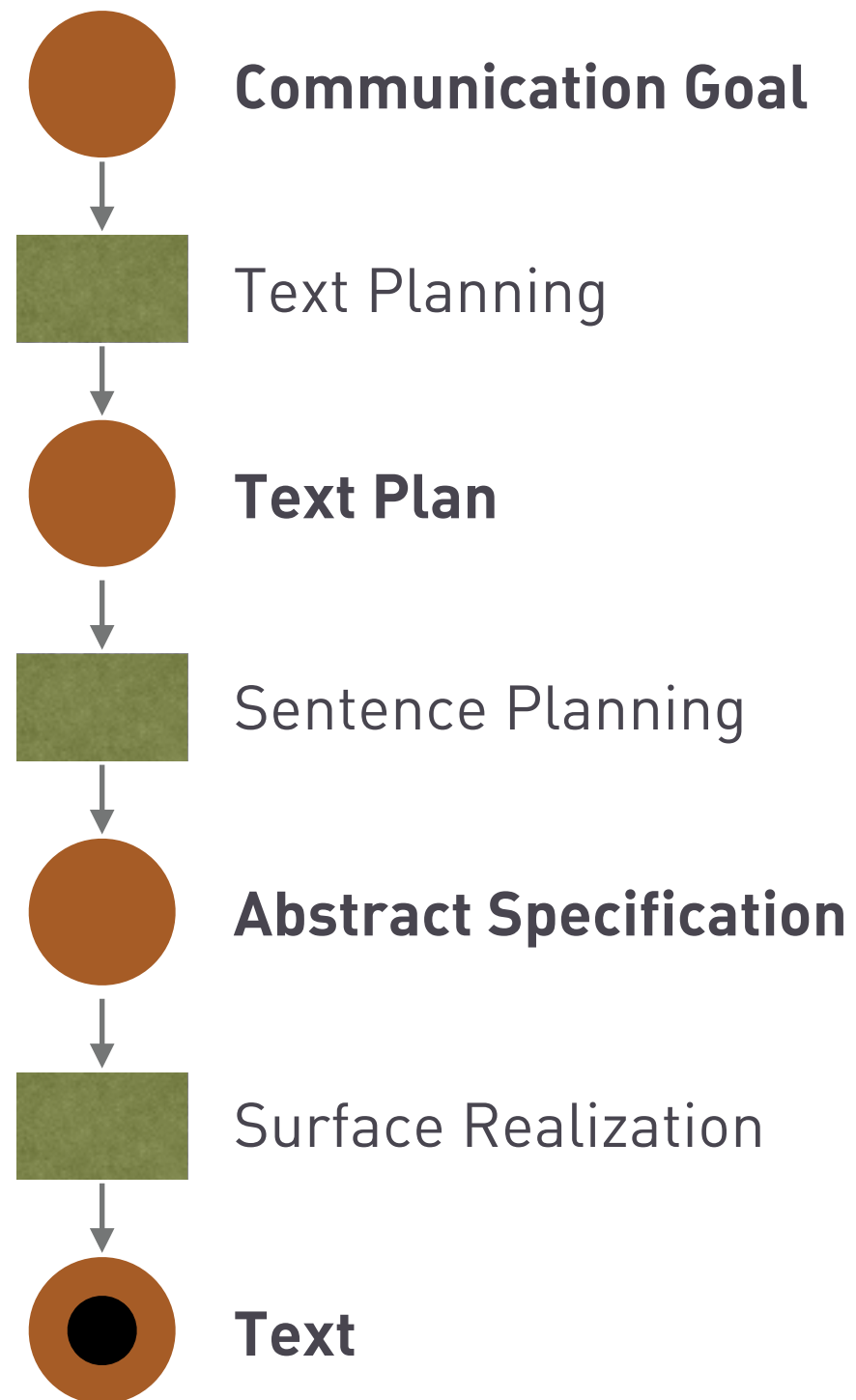
**STRATEGY**

**TACTIC**



# DEFAULT NLG ARCHITECTURE

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[Horacek10]

# TEXT GENERATION SITUATION

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A **text generation situation** can be described by a quadruple  $\langle k, c, u, d \rangle$ , where

- $k$  is the **knowledge base**,
- $c$  the **communication goal**,
- $u$  the **user model** and
- $d$  the **discourse history**.

[Reiter+00]

# TEXT PLANNING

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```
const c = Describe(Route, A, B);  
  
const k = [  
  At(User, A),  
  Path(A, C), Path(C, D), Path(D, B),  
  Left(Path(A, C), Path(C, D)),  
  Straight(Path(C, D), Path(D, B)),  
  Type(C, "church"),  
  Type(D, "town-hall"),  
  Property(D, "big"),  
  ...  
];
```

```
const l = [  
  be(User, at(A)),  
  
  go(User, from(A), to(C)),  
  go(User, from(C), to(D)),  
  go(User, from(D), to(B)),  
  
  turn(User, at(C), direction(left)),  
  turn(User, at(D), direction(none)),  
  
  church(C), town_hall(D), big(D), ...  
];
```

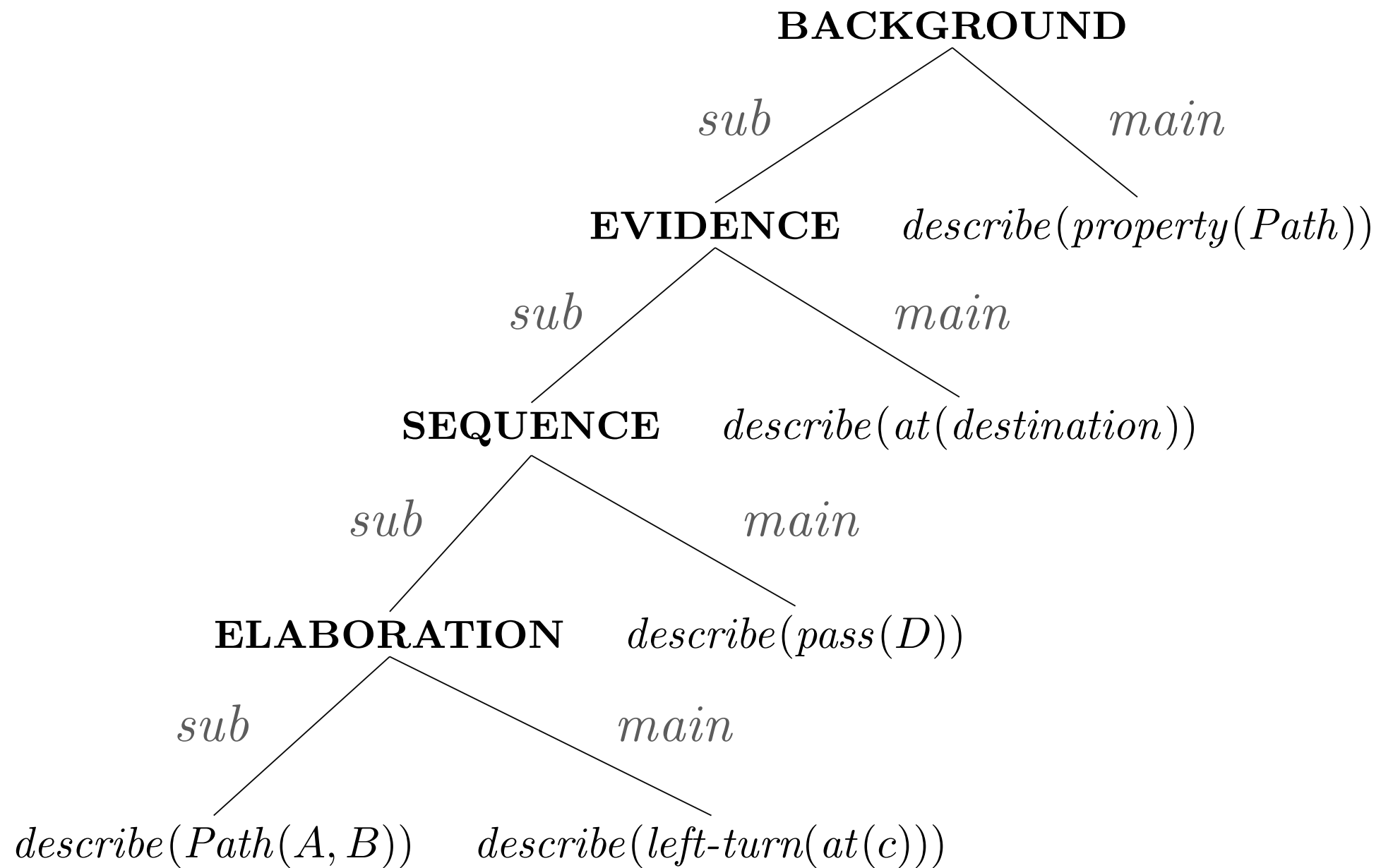
- *define* a concept
- *compare* two objects
- *describe* available information

[Horacek10, McKeown85]



# TEXT PLANNING RESULT

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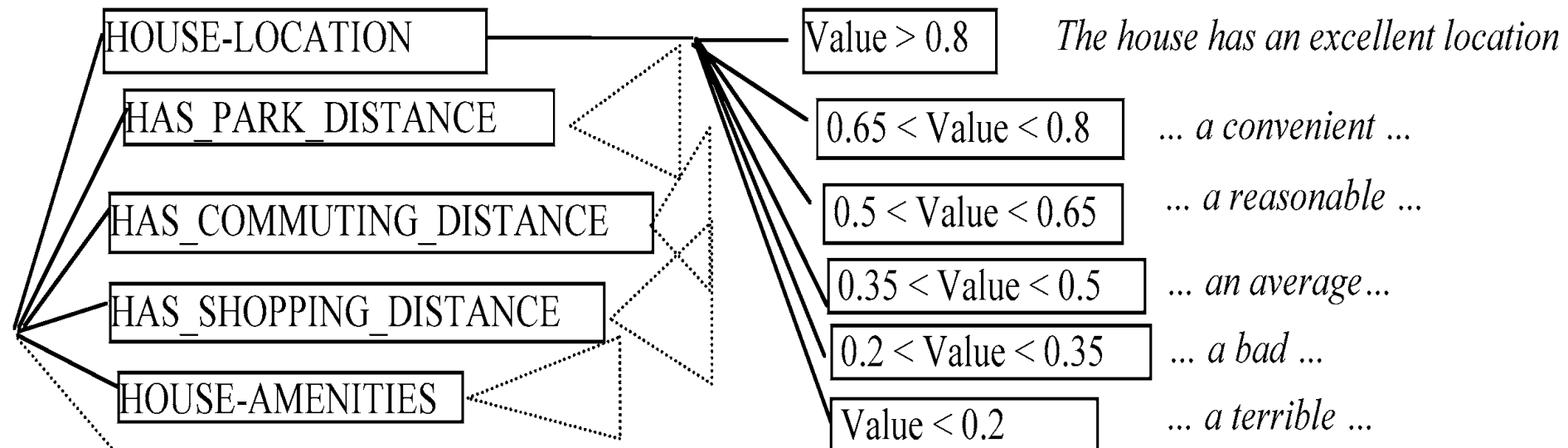


[Horacek10, McKeown85]

# SENTENCE PLANNING

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- **lexicalization:** find lexical elements to represent predicates



- **aggregation:** gaining sentence representations out of clauses

```
const clauses = [  
  boil(Hans, Water),  
  bake(Hans, Pie),  
];  
→  
assertEquals(aggregate(closures), [  
  Hans,  
  and(boil(Water), bake(Pie)),  
]);
```

- **reference expressions:** identify an and inform about objects

here    the latter / former    the Church    [Carenini+06, Horacek10, Shaw98]

# SURFACE REALIZATION

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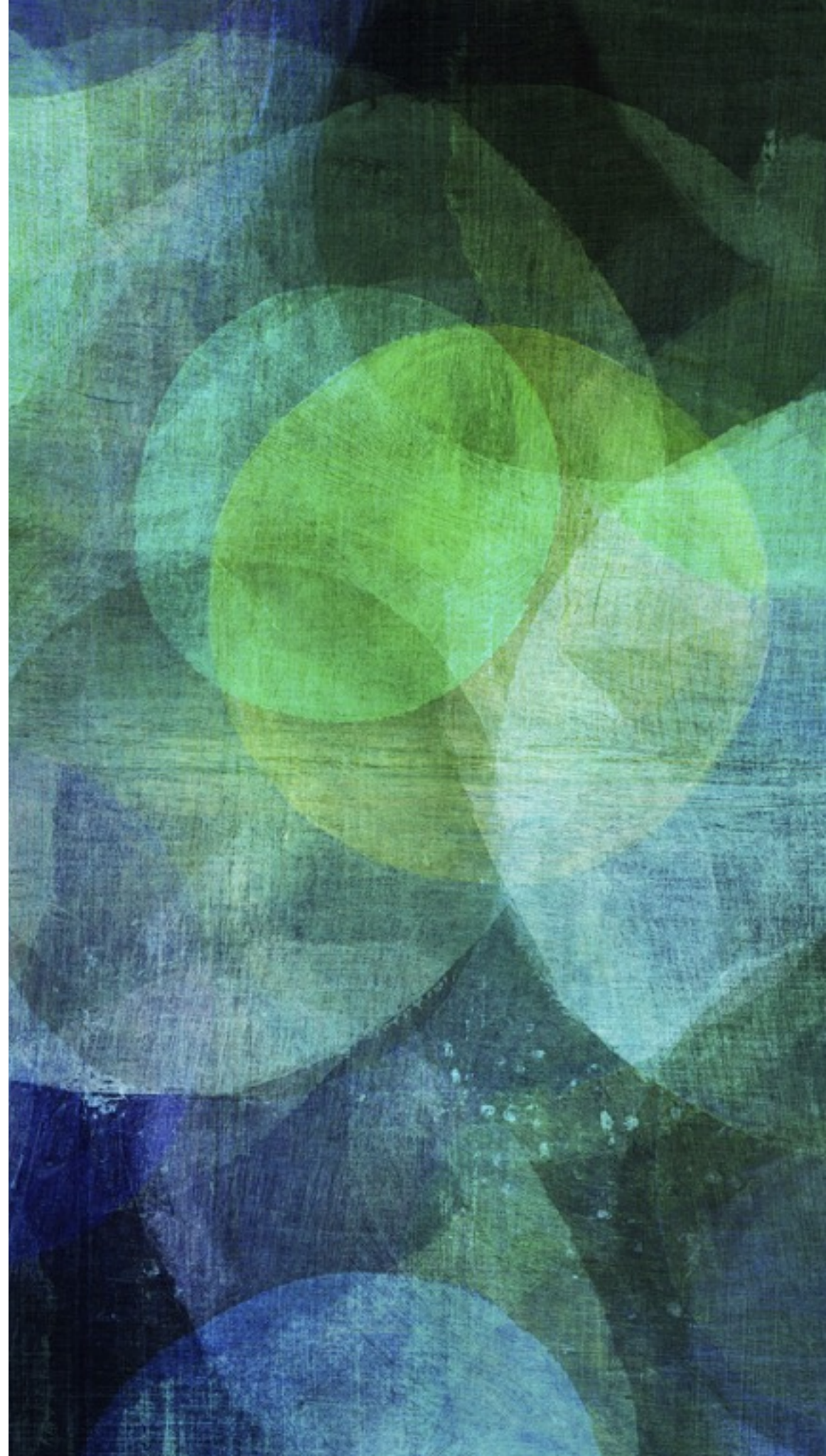
- **structure-driven:** using a grammar
  - *Direction free:* like Prolog, interpretation agnostic
  - *Top-down:* left-recursive resolution of the input
- **lexeme-driven:** using a lexicon
  - *Shake-and-bake:* try every combination of lexicon entries and check grammar
  - *Chart generation:* subsumes lexicon entries under input

[Horacek10]



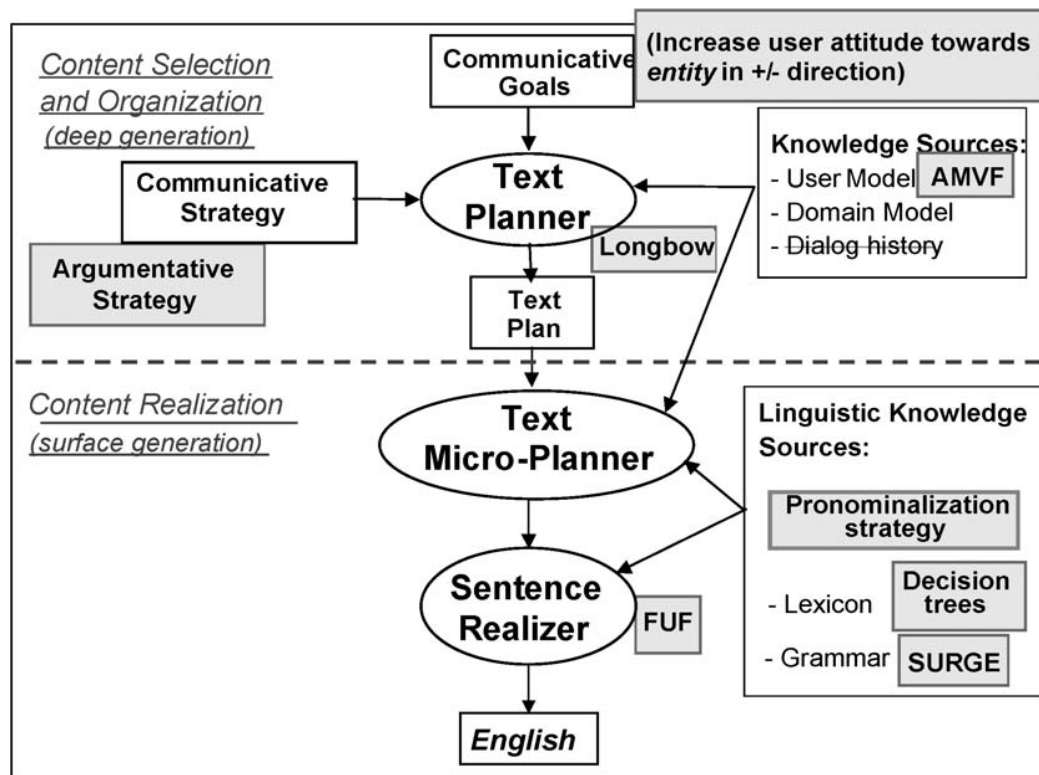
# REALIZATIONS

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# USING ARGUMENTATION THEORY

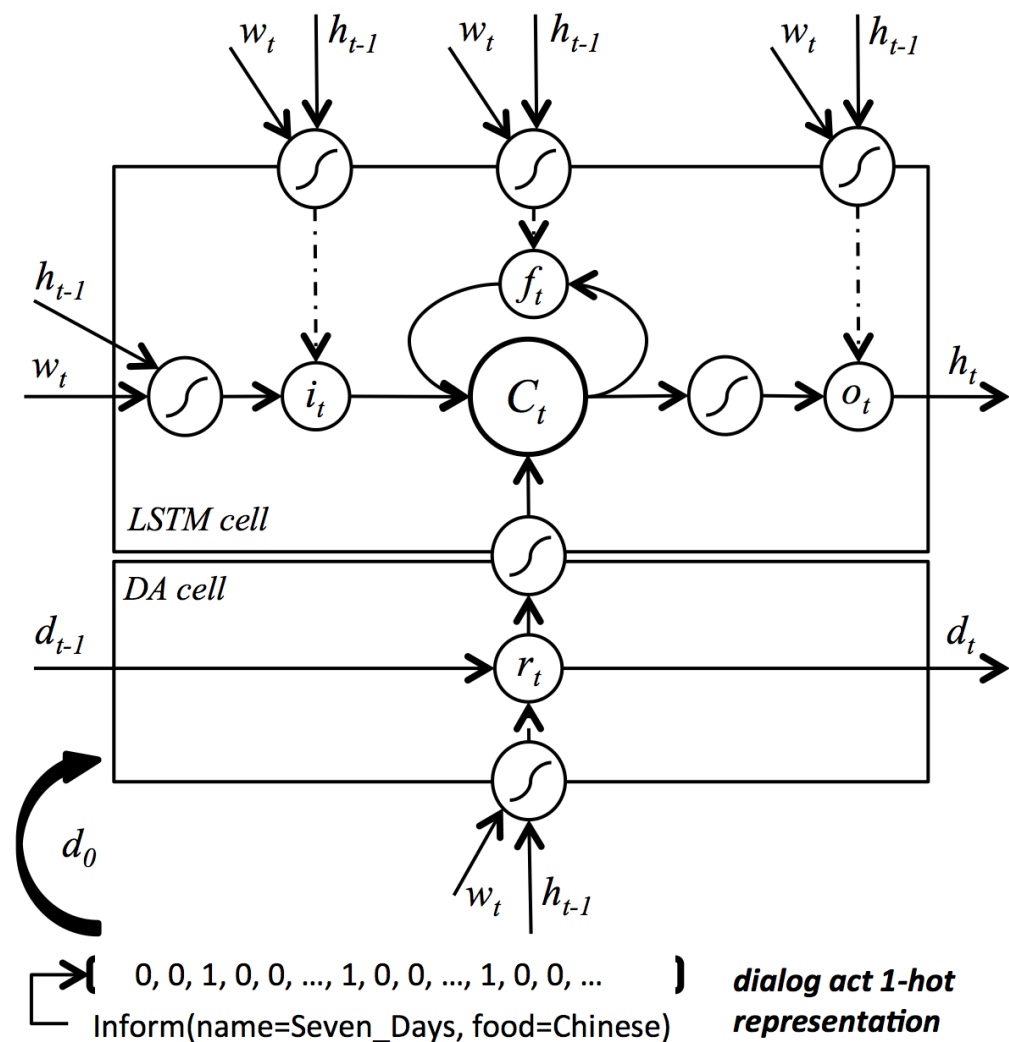
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- **GEA:** evaluative argument generator
  - for doctors to advise patients
  - for salesman to advise customers
- using rhetoric means
- domain specific model extracted
- evaluation using empirical means

[Walker+04, Carenini+06]

# USING NEURAL NETWORKS



- LSTM: long short-term-memory
- trained from unaligned data
- jointly optimizes



Sentence Planning



Surface Realization

[Wen+15]



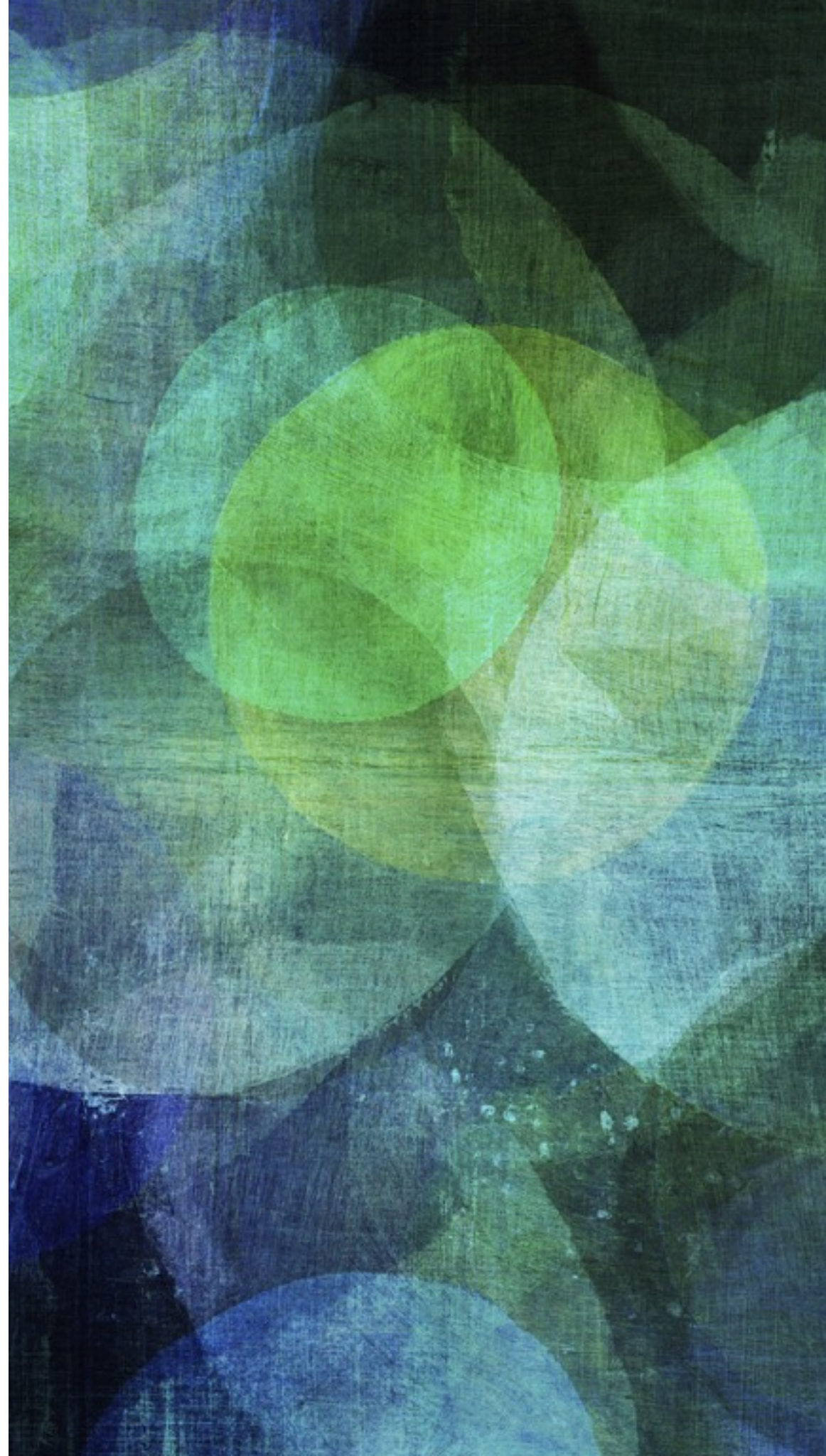
# USING NEURAL NETWORKS



#	Example Dialogue Acts and Realizations from SF Restaurant Domain
1	<p>inform(name="red door cafe", goodformeal="breakfast", area="cathedral hill", kidsallowed="no")</p> <p><i>red door cafe is a good restaurant for breakfast in the area of cathedral hill and does not allow children .</i></p> <p><i>red door cafe is a good restaurant for breakfast in the cathedral hill area and does not allow children .</i></p> <p><i>red door cafe is a good restaurant for breakfast in the cathedral hill area and does not allow kids .</i></p> <p><i>red door cafe is good for breakfast and is in the area of cathedral hill and does not allow children .</i></p> <p><i>red door cafe does not allow kids and is in the cathedral hill area and is good for breakfast .</i></p>
2	<p>informonly(name="dosa on fillmore and kiss seafood", pricerange="expensive", near="lower pacific heights")</p> <p><i>there is no place other than dosa on fillmore and kiss seafood that are expensive near to lower pacific heights .</i></p> <p><i>dosa on fillmore and kiss seafood is the only expensive restaurant near lower pacific heights .</i></p> <p><i>the only listed restaurant near lower pacific heights in the expensive price range is dosa on fillmore and kiss seafood .</i></p> <p><i>i apologize , dosa on fillmore and kiss seafood is the only expensive restaurant near lower pacific heights .</i></p> <p><i>i apologize , dosa on fillmore and kiss seafood are the only expensive restaurants near lower pacific heights .</i></p>
#	Example Dialogue Acts and Realizations from SF Hotel Domain
3	<p>inform(type="hotel",count="182",dogsallowed="dontcare")</p> <p><i>there are 182 hotels if you do not care whether dogs are allowed .</i></p> <p><i>there are 182 hotels if you do not care whether they allow dogs .</i></p> <p><i>182 hotels are available if dogs allowed or not is not an issue .</i></p> <p><i>there are 182 hotels if allowing dogs or not is not an issue .</i></p> <p><i>there are 182 hotels if whether dogs are allowed does not matter .</i></p>
4	<p>informonly(name="red victorian bed breakfast",acceptscreditcards="yes",near="haight",hasinternet="yes")</p> <p><i>red victorian bed breakfast is the only hotel near haight and accepts credit cards and has internet .</i></p> <p><i>red victorian bed breakfast is the only hotel near haight and has internet and accepts credit cards .</i></p> <p><i>red victorian bed breakfast is the only hotel near haight that accept credit cards and offers internet .</i></p> <p><i>the red victorian bed breakfast has internet and near haight , it does accept credit cards .</i></p> <p><i>the red victorian bed breakfast is the only hotel near haight that accepts credit cards , and offers internet .</i></p>

# CONCLUSION

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# SUMMARY

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- well-formed text generation has high interest in economy
- flexibility for heterogenous domain, like in dialog systems
- strategic („what“) vs. tactical („how“) component
- default NLG architecture:
  1. text planning
  2. sentence planning
  3. surface realization
- Carenini and Moore use rhetoric to generate evaluative arguments
- Wen et al. use recurrent neural networks to optimize the generated natural language w.r.t. its variation



# REFERENCES

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- **[Shaw98]** Shaw, J.: Clause Aggregation Using Linguistic Knowledge. In: *Proc. of the 9th International Workshop on Natural Language Generation (INLGW-98)*, S. 138-147.
- **[Walker+04]** Walker, M.; Whittaker, S.; Stent, A.; Maloor, P.; Moore, J.; Johnston, M. & Vasireddy, G.: Generation and evaluation of user tailored responses in multimodal dialogue. In: *Cognitive Science* 28 (2004), Nr. 5, S. 811–840.
- **[Wen+15]** Wen, T.-H.; Gašić, M.; Mrkšić, N.; Su, P.-H.; Vandyke, D. & Young, S.: Semantically Conditioned LSTM-based Natural Language Generation for Spoken Dialogue Systems. In: *Conference of Empirical Methods in Natural Language Processing 2015* (2015).



# IMAGE SOURCES

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- <http://www.fm-base.co.uk/forum/attachments/football-manager-2015-tactics/906447d1411399654-what-tactic-should-i-use-1296131-27915488-1600-900.jpg>
- <https://upload.wikimedia.org/wikipedia/en/4/42/Strategy.jpg>
- <https://uberflip.cdntwrk.com/files/aHViPTU2NzMzJmNtZD1pdGVtZWVpdG9yaW1hZ2UmZmlsZW5hbWU9aXRlbWVkaXRvcmltYWdlXzU1ZTQ4Nzc2MWJjMTIucG5nJnZlcnNpb249MDAwMCZzaWc9ZTMzNzBiZDM4MTM1NDI1MGYwOWYwNzM3ZWYwYTliNGQ%253D>
- [https://en.wikipedia.org/wiki/Long\\_short-term\\_memory#/media/File:Long\\_Short\\_Term\\_Memory.png](https://en.wikipedia.org/wiki/Long_short-term_memory#/media/File:Long_Short_Term_Memory.png)