Language Games and Formal Grammars

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A. Ranta, R. Enache, and G. Détrez. Controlled Language for Everyday Use: the MOLTO Phrasebook. In N. Fuchs and M. Rosner (eds), *Controlled Natural Language 2010*, Springer LNCS/LNAI, vol. 7175, 2012. pp. 115-136.

A. Ranta, Type Theory and Universal Grammar. In *Philosophia Scientiæ. Travaux d'histoire et de philosophie des sciences*, Issue CS 6, pp. 115-131, 2006.

R. Cooper and A. Ranta, Natural Languages as Collections of Resources. In R. Cooper and R. Kempson (eds), *Language in Flux: Dialogue Coordination, Language Variation, Change*, pp. 109-120, College Publications, London, 2008.

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Some keywords

formal grammars, formal semantics, language games, Sapir-Whorf, universal grammar, context, dialogue, ambiguity, disambiguation, translation

Formal grammars

Chomsky, *Syntactic Structures*, 1957

Languages defined by formally precise rules

```
S -> NP VP
```

Formal semantics

Montague, *Formal Philosophy*, 1974

Formally precise rules on formally specified languages

```
s(np,vp)* = np*(vp*)
```

All grammars leak

Sapir, *Language*, 1925

Modern language technology: statistical models (e.g. Google translate)

Language games

"The language is not a formal system, but a family of **language games**"

Wittgenstein, *Philosophical Investigations*, 1953

Stenius, "Mood and Language Game", 1967

Rule systems that relate utterances to other actions

```
if the Master says "brick", bring him a brick
```

Sapir-Whorf

Different languages means different realities

- time for Hopi Indians $\neq$ time for Englishmen $\neq$ time for Frenchmen

A recent result: Hebrew kids learn gender differences earlier than Finnish kids, English kids are somewhere in between

Some claims

We can have formal grammars and formal semantics of language games

We can translate language games

Different games need different kinds of semantics

Finnish kids do learn genders, just a bit later

How to define a language game

Abstract syntax: the pure structure of the **moves** of game

```
fun Like : Person -> Person -> Fact
```

Concrete syntax: how the moves are realized (**linearized**) in different languages

```
lin Like x y = x ++ "likes" ++ y            -- Eng
lin Like x y = x ++ "tycker om" ++ y        -- Swe
lin Like x y = x ++ "pitää" ++ y ++ ":stä" -- Fin
lin Like x y = y ++ "piace" ++ "a" ++ y     -- Ita
```

Grammatical Framework

GF = Logical Framework + concrete syntax

Logical Framework = higher-level type theory

The framework idea: no uniform logic - but a framework for defining special logics

Translation:

1. **parse** in source language to type theory
2. **linearize** type theory to target language

A. Ranta, *Grammatical Framework. Programming with Multilingual Grammars*, CSLI, 2011.

http://www.grammaticalframework.org

Some complications

French, Italian: agreement, rection, clitics (*questo piace a Maria* vs. *questo mi piace* ; *questi mi piacciono*)

```
lin Like x y = y.s ! nominative ++ case x.isPron of {
  True  => x.s ! dative ++ piacere_V ! y.agr ;
  False => piacere_V ! y.agr ++ "a" ++ x.s ! accusative
  }
oper piacere_V = verbForms "piacere" "piace" "piacciono" ...
```

Moreover: contractions (*piace ai bambini*), tenses, mood, ...

The GF Resource Grammar Library

Hide the low-level linguistic details by a grammar library API:

```
lin Like x y = mkCl x (mkV2 (mkV "like")) y           -- Eng
lin Like x y = mkCl x (mkV2 (mkV "tycker") "om") y    -- Swe
lin Like x y = mkCl x (mkV2 (mkV "pitää") elative) y -- Fin
lin Like x y = mkCl y (mkV2 piacere_V dative) x       -- Ita
```

A general resource for all language games.

Currently available for 26 languages.

Semantics?

Baseline: just expressed by abstract syntax trees.

`Trip X Y`

- *from X to Y*
- *a ticket from X to Y*
- *I would like to go from X to Y*
- *can you give me a ticket from X to Y*

All equal as dialogue moves, just diffing in **syntactic sugar**

Semantics in the framework

semantics = abstract syntax

concrete syntax is **compositional**

$$(t(x_1, \ldots, x_n))^* = t^*(x_1^*, \ldots, x_n^*)$$

The MOLTO project

Multilingual On-Line Translation

High-quality domain-specific translation with GF for 15 languages

MOLTO domains:

- mathematics
- patents
- museum object descriptions
- a tourist phrasebook

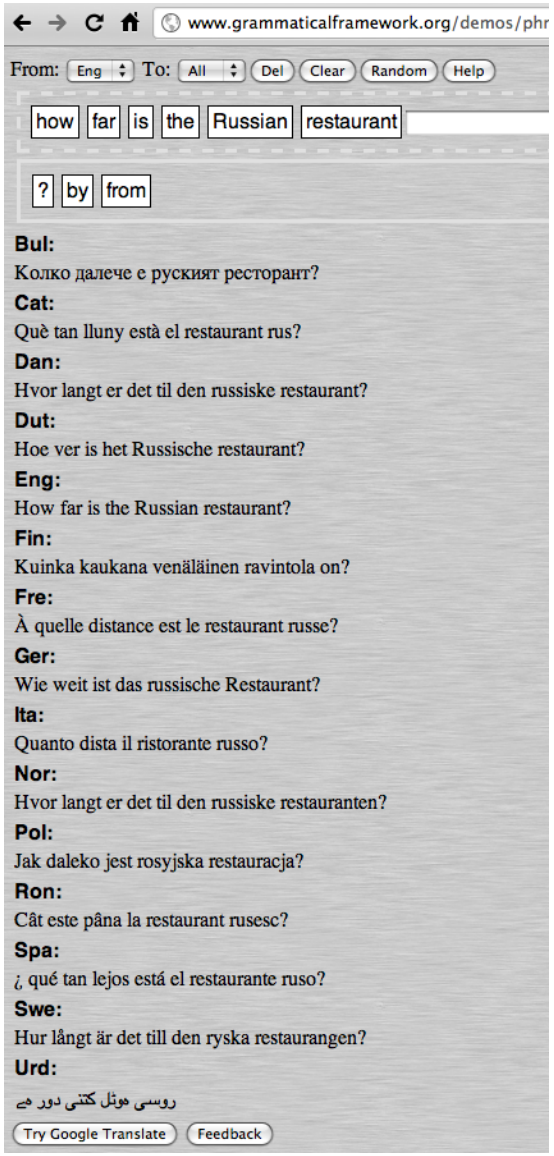
The MOLTO Phrasebook

http://www.grammaticalframework.org/demos/phrasebook/

Touristic phrases in 19 languages

Idiomacy, context dependence, disambiguation

Web application, mobile Android application


www.grammaticalframework.org/demos/phr
From: Eng To: All Del Clear Random Help
how far is the Russian restaurant
? by from
Bul:
Колко далече е руският ресторант?
Cat:
Què tan lluny està el restaurant rus?
Dan:
Hvor langt er det til den russiske restaurant?
Dut:
Hoe ver is het Russische restaurant?
Eng:
How far is the Russian restaurant?
Fin:
Kuinka kaukana venäläinen ravintola on?
Fre:
À quelle distance est le restaurant russe?
Ger:
Wie weit ist das russische Restaurant?
Ita:
Quanto dista il ristorante russo?
Nor:
Hvor langt er det til den russiske restauranten?
Pol:
Jak daleko jest rosyjska restauracja?
Ron:
Cât este pâna la restaurant rusesc?
Spa:
¿ qué tan lejos está el restaurante ruso?
Swe:
Hur långt är det till den ryska restaurangen?
Urd:
روسی ہوٹل کتنی دور ہے
Try Google Translate
Feedback


09:14
PhraseDroid
those pizzas are
Clear
Translate !
Belgian Bulgarian Catalonian Danish
Dutch English Finnish French German
Italian Norwegian Polish Romanian
Russian Spanish Swedish bad boring
cheap cold delicious expensive fresh
good suspect too very warm
quelle pizze sono deliziose .
Say it

The semantics and translation of idioms

Questions:

- What is the meaning of the German phrase *bitte* ?
- What is *bitte* in English?

Bitte

Customer: *Ein Bier bitte.*
Waiter: *Bitte.*
Customer: *Danke.*
Waiter: *Bitte.*

Bitte in English and Swedish

English	Swedish	German
A beer please.	*En öl tack.*	*Ein Bier bitte.*
Here we are.	*Var så god.*	*Bitte.*
Thank you.	*Tack.*	*Danke.*
You're welcome.	*Var så god.*	*Bitte.*

A semantic model

```
cat
  Phrase ; Item
fun
  GivePlease     : Item -> Phrase
  HereWeAre      : Phrase
  ThankYou       : Phrase
  YouAreWelcome  : Phrase
  ABeer          : Item
```

English concrete syntax

```
lin
  GivePlease item = item ++ "please"
  HereWeAre       = "here we are"
  ThankYou        = "thank you"
  YouAreWelcome   = "you are welcome"
  ABeer           = "ein Bier"
```

German concrete syntax

```
lin
  GivePlease item = item ++ "bitte"
  HereWeAre       = "bitte"
  ThankYou        = "Danke"
  YouAreWelcome   = "bitte"
  ABeer           = "ein Bier"
```

Disambiguation

Natural language is ambiguous

Different languages are ambiguous in different ways

Disambiguation

Natural language is ambiguous

Different languages are ambiguous in different ways

But: ambiguity is resolved in context

Disambiguation

Despite the ”hopeless ambiguity” of natural language,

ambiguity can usually be resolved by asking a simple question and getting a simple answer - in the same language!

Politeness and gender

Another case for disambiguation:

Are you Swedish?

What is this in French/German/etc?

French:

YouFamMale:	*Est-ce que tu es suédois ?*
YouFamFemale:	*Est-ce que tu es suédoise ?*
YouPolMale:	*Est-ce que vous êtes suédois ?*
YouPolFemale:	*Est-ce que vous êtes suédoise ?*

German:

YouFamMale, YouFamFemale:	*Bist du schwedisch?*
YouPolMale, YouPolFemale:	*Sind Sie schwedisch?*

Disambiguation grammar

```
concrete DisambPhrasebookEng of Phrasebook = PhrasebookEng -
  [YouFamMale, YouFamFemale, YouPolMale, YouPolFemale]
  ** open SyntaxEng, ParadigmsEng in {
lin
  YouFamMale   = mkNP you_NP (mkAdv "(familiar,male)") ;
  YouFamFemale = mkNP you_NP (mkAdv "(familiar,female)") ;
  YouPolMale   = mkNP you_NP (mkAdv "(polite,male)") ;
  YouPolFemale = mkNP you_NP (mkAdv "(polite,female)") ;
}
```

Displaying the disambiguation to the user

English input:

- *Are you Swedish?*

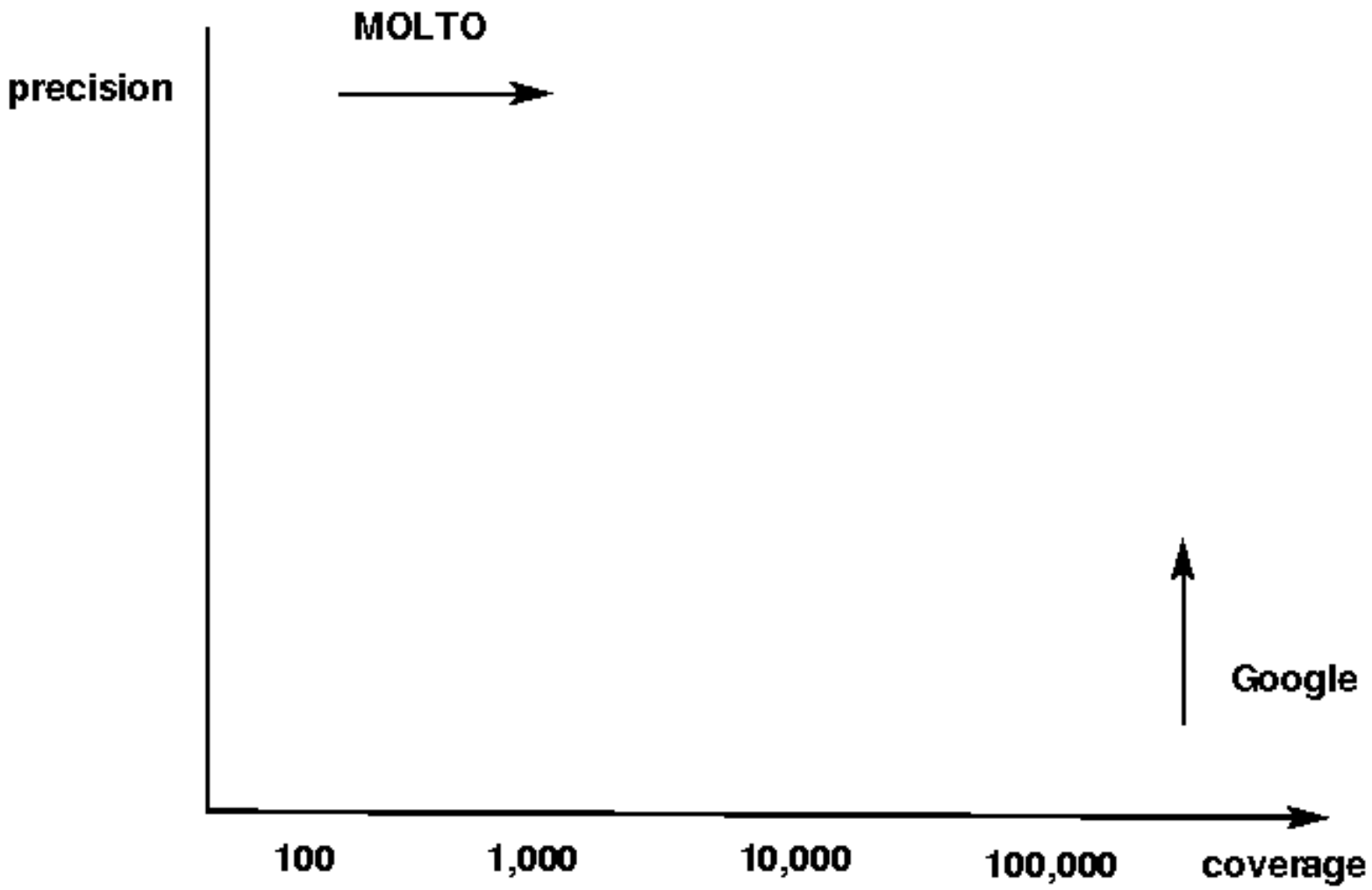
French output:

- *Est-ce que tu es suédois ?* (Are you (Familiar,Male) Swedish?)
- *Est-ce que tu es suédoise ?* (Are you (Familiar,Female) Swedish?)
- *Est-ce que vous êtes suédois ?* (Are you (Polite,Male) Swedish?)
- *Est-ce que vous êtes suédoise ?* (Are you (Polite,Female) Swedish?)

German output:

- *Bist du Schwedisch?* (Are you (Familiar,Male) Swedish? / Are you (Familiar,Female) Swedish?)
- *Sind Sie Schwedish?* (Are you (Polite,Male) Swedish? / Are you (Polite,Female) Swedish?)

Scaling up the language game


MOLTO
precision
Google
100
1,000
10,000
100,000
coverage

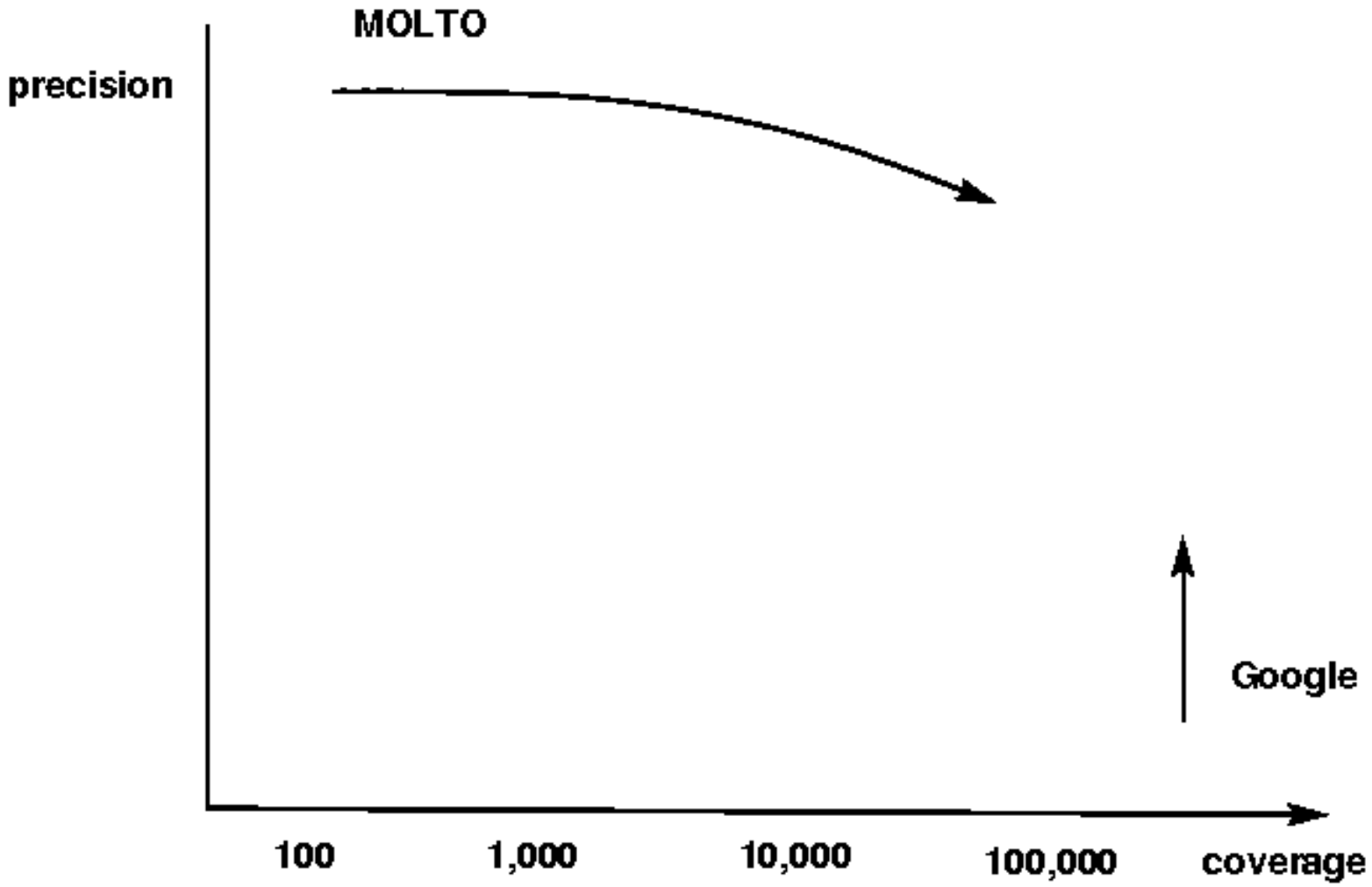
Some more things in the MOLTO Phrasebook

category	**explanation**	**example**
Phrase	complete phrase, unit of translation	*Where are you?*
Greeting	idiomatic greeting	*hello*
Sentence	declarative sentence	*I am in the bar*
Question	question, either yes/no or wh	*where are you*
Proposition	can be used as sentence or question	*this pizza is good*
Object	object of wanting, ordering, etc	*two pizzas and a beer*
Item	a single entity	*this pizza*
Kind	a type of an item	*pizza*
Quality	qualification of an item	*very good*
Place	location	*the bar*
PlaceKind	type of location	*bar*
Person	agent wanting or doing something	*you*
Action	proposition about a Person	*you are here*
Nationality	complex of language, property, country	*Swedish, Sweden*
Language	language (can be without nationality)	*Flemish*
Citizenship	property (can be without language)	*Belgian*
Country	country (can be without language)	*Belgium*
Currency	currency	*Swedish crown*
Number	number expression in words	*two hundred and five*
Price	price (number + currency)	*sixty-five dollars*

arguments	**value**	**examples**
Number, Kind	Object	*five pizzas*
Quality, Kind	Kind	*Italian pizza*
Kind	Item	*this pizza*, *the pizzas*
PlaceKind	Place	*the bar*, *a bar*
Proposition	Sentence	*the bar is open*, *the bar isn't open*
Proposition	Question	*is the bar open*
Action	Proposition	*I speak Polish*
Person, Object	Action	*you have beer*, *you have no beer*
Person, Citizenship	Action	*you are German*
Person, Place	Action	*you are in the bar*
Person, Sentence	Action	*you know that I am in the bar*
Person, Person	Action	*you know my wife*
Person, Question	Action	*you know how far the bar is*
Person, Number	Action	*I am seventy years old*
Person, Number	Action	*I have six children*
Person, Name	Action	*my name is Bond*
Person	Action	*I am hungry*
Person, Item	Action	*I like this pizza*
Person, Country	Action	*I live in Sweden*
Person, Language	Action	*I speak Polish*
Person, Currency	Action	*I have Swedish crowns*
Person, Object	Action	*I want two apples*
Person, Place	Action	*I want to go to the hospital*

Person	Question	*how old are you*
Item	Question	*how much does the pizza cost*
Item, Price	Proposition	*the pizza costs five euros*
Place	Proposition	*the museum is open*
Place, Date	Proposition	*the museum is open today*
Place, Day	Proposition	*the museum is open on Mondays*
Place, Date	Greeting	*see you in the bar on Monday*
Person	Person	*my wife, your husband*
Number, Currency	Proposition	*five euros*
Place	Question	*how far is the zoo*
Place, Place	Question	*how far is the centre from the hotel*
Transport, Place	Question	*which bus goes to the hotel*

How far can we get?


MOLTO
precision
Google
100
1,000
10,000
100,000
coverage

Improving precision by recognizing the ”language game”

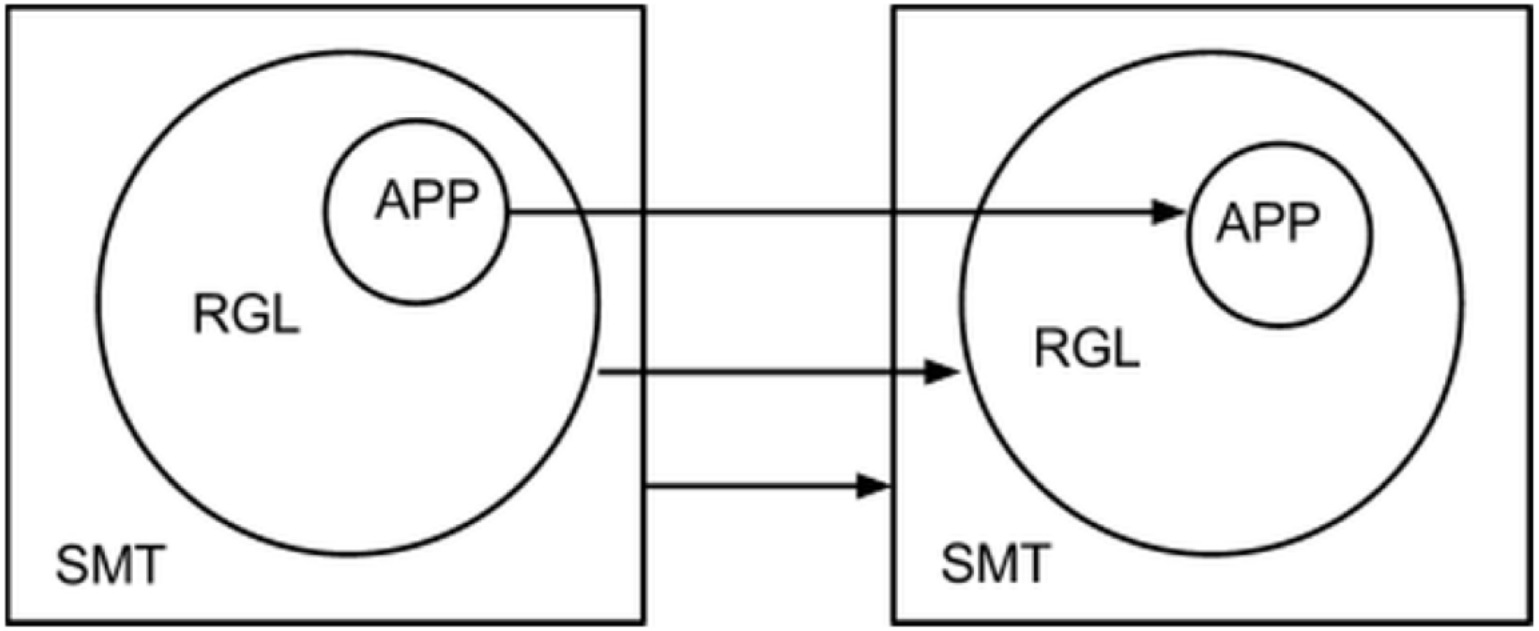
s’il vous plaît

- *if he pleases you*, direct syntactic translation
- *please*, language game translation

he is fifty

- *il est cinquante*, direct syntactic translation
- *il a cinquante ans*, language game translation

Ultimate back-up: statistical translation



Conclusion

Language games are good for language technology!

- They reduce ambiguity.
- They can be shared between languages.
- They connect language with action.
- They permit formal grammars.
- They permit simple, abstract semantics.

Question: how much of language can we cover by formalizing more and more language games?