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# 7<sup>th</sup> INTERNATIONAL CONFERENCE ON MEANING AND KNOWLEDGE REPRESENTATION (4, 5 and 6 July, 2018)

Session 8 – 6th July 2018

## How can one evaluate a conversational software agent framework?

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# Overview

- Context – conversational agent space
- Linguistic approach
- Building blocks of a Linguistic CSA
- Drivers of LING-CSA
- Conceptual framework LING-CSA
- Implementation of LING-CSA
- How to evaluate LING-CSA?
- Evaluations and findings
- Evaluation – conclusions & recommendation

# 1 Conversational agents space

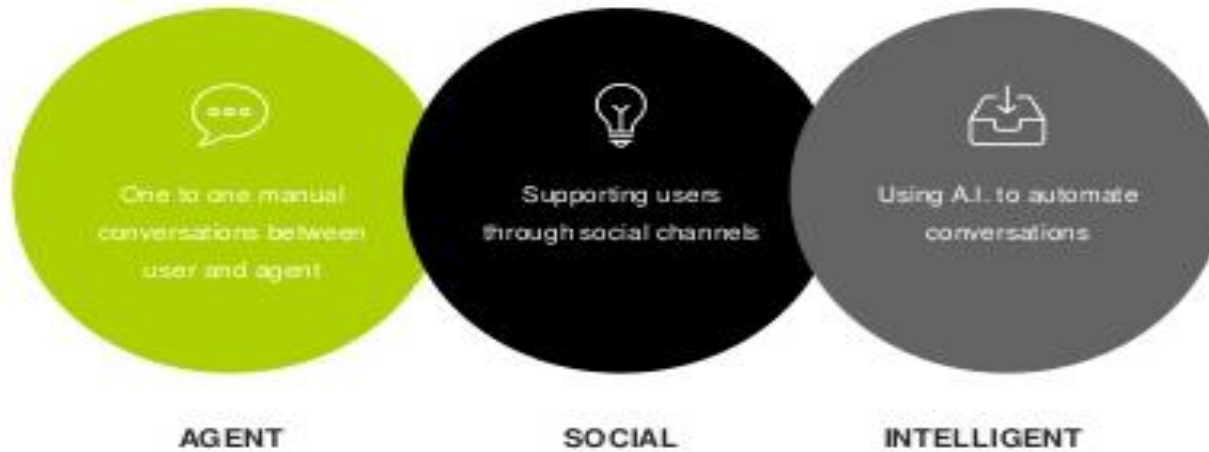


Figure 1 - Types of conversation  
Source: FactionXYZ

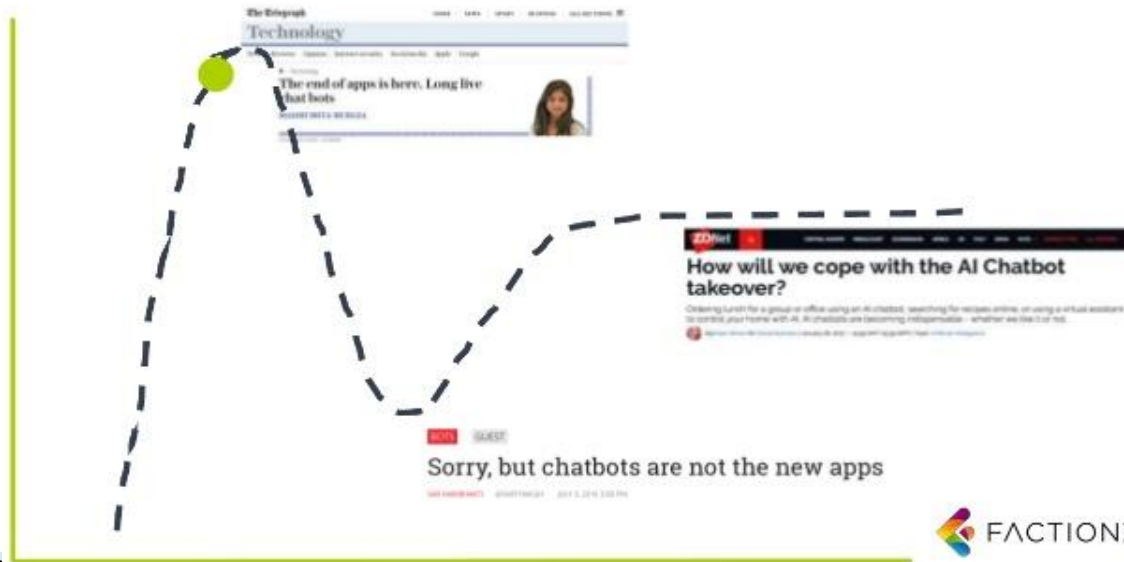


Figure 2 - Hype cycle and myths  
Source: FactionXYZ

# 2. Linguistic Approach

## Conversational Software Agents (CSA)

- **Challenges of NLU and meaning**
- NL -> functional system
- Periñán-Pascual (2013): eligibility
- Communication-cognition
- **Approach** - unique framework, model/theory interaction, communicative
- Language levels, interface between syntax, semantic, and pragmatics
- Language Model: **RRG and the clause**
- Simple sentences -> Linguistic act (**Speech Act**) - SA
- Understand the utterance
- Agent attributes
- (Utterance) **Message** from USER → AGENT
- Agent's belief - Knowledge representation (KR)
- Plan-based dialogue (response) **Message** AGENT → USER

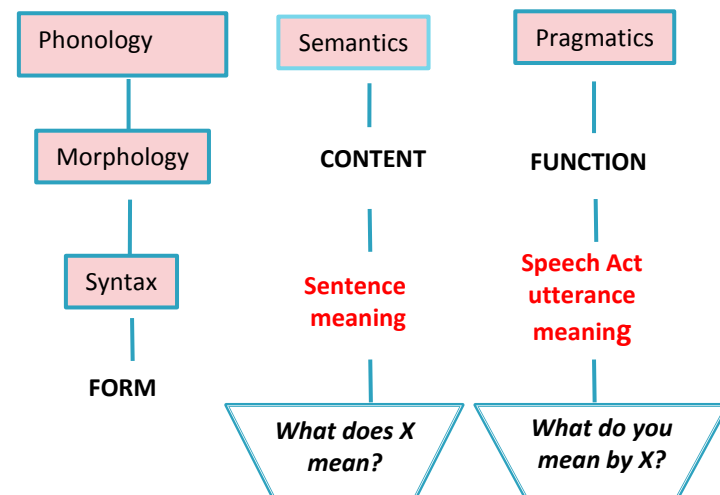


Figure 1: Language interfaces

# 3. Building blocks of a CSA

**AGENT + INTELLIGENT DIMENSION (S) = INTELLIGENT AGENT**

**INTELLIGENT TAXONOMY** Behavioural, Social, Ambient, Collective, Genetic, and **COGNITION**

**COGNITION = BDI + Rational Interaction**

**CA = Interpretation + Dialogue Mgt + Response Generator**

**CSA = CA + RRG + SA + COGNITIVE + KB (Panesar, 2017)**

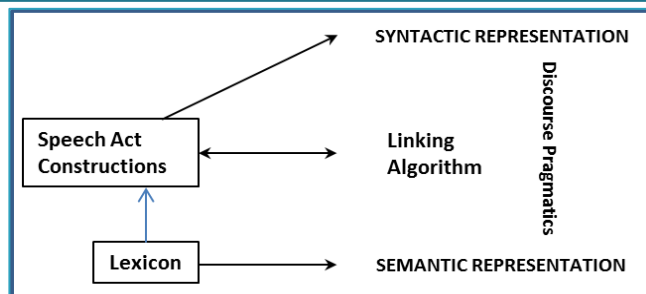


Figure 3-  
Reorganisation of RRG

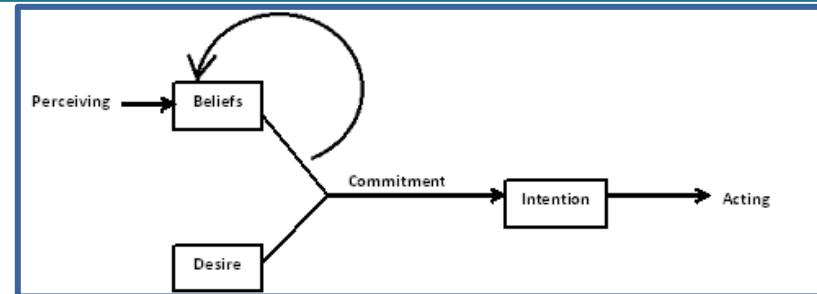


Figure 4- A BDI model of an intelligent agent  
(Allen, 1995)

# 4. Drivers of LING-CSA

- ▶ Investigate the *integration, intersection and interface* of the language, knowledge, and speech act constructions (SAC) based on a grammatical object (Nolan, 2014), and the sub-model of belief, desires and intention (BDI) (Rao and Georgeff, 1995) and dialogue management (DM) for natural language processing (NLP).
- ▶ A long-standing issue within NLP CSA systems is *refining the accuracy of the interpretation of meaning* to provide a realistic dialogue to support the human-to-computer communication.

# 5. Conceptual Framework: LING-CSA

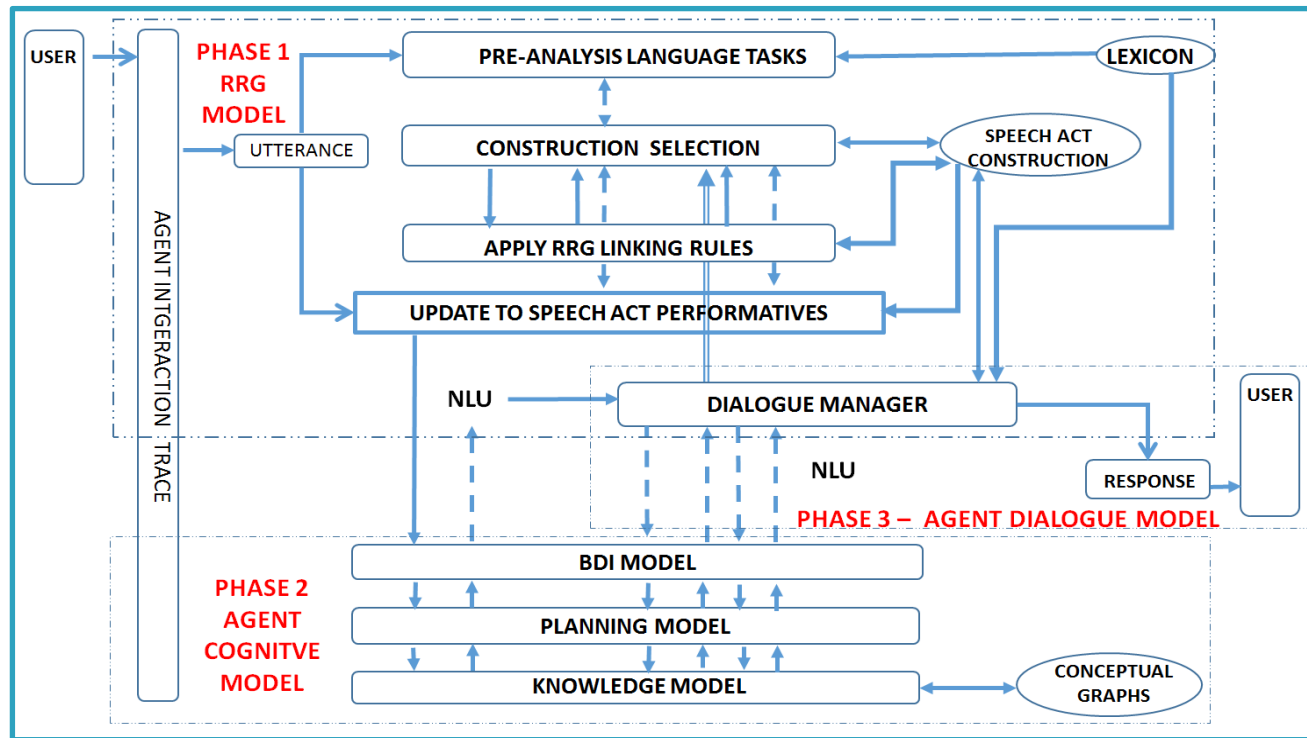


Figure 5- Conceptual framework of the Conversational Software Agent (Panesar, 2017)

PHASE 1 - Role and Reference Grammar (RRG) Language Model

PHASE 2 - Agent Cognitive Model interfaces with:

BDI Model, Planning Model, Knowledge Model

PHASE 3 - Agent Dialogue Model (Dialogue Mgmt > RRG Model)

# 6. Phase 2 – Agent Cognitive Model Design Framework

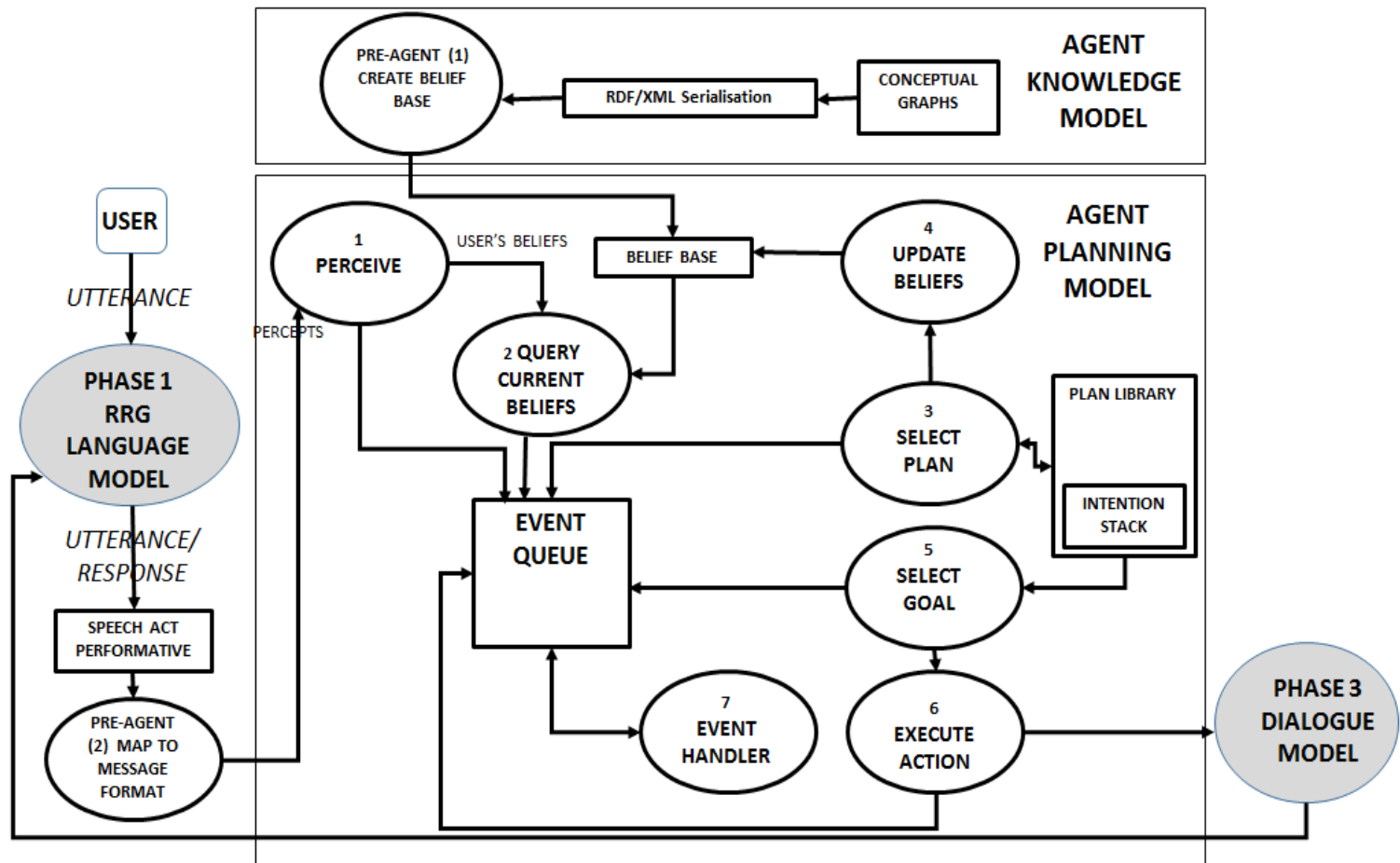


Figure 6 – The Agent Cognitive Model – Design Framework (Panesar, 2017)

# 7. How to evaluate LING-CSA?

- ▶ ISO 9241 concept of usability?
- ▶ Turing test?
- ▶ Define goals
  - Phase model based
  - Interfacing, intersection and integration
- ▶ Customised multi-approach assessment
- ▶ Testing strategy
  - Grammatical testing and NLP tasks
  - Software engineering
  - Knowledge representation
  - Agent practice and environment
  - RRG specific tests and goals of linguistic theory
- ▶ Evaluation criteria (goal-driven)

# 8. Evaluation criteria

## Phase 1 – RRG Language Model

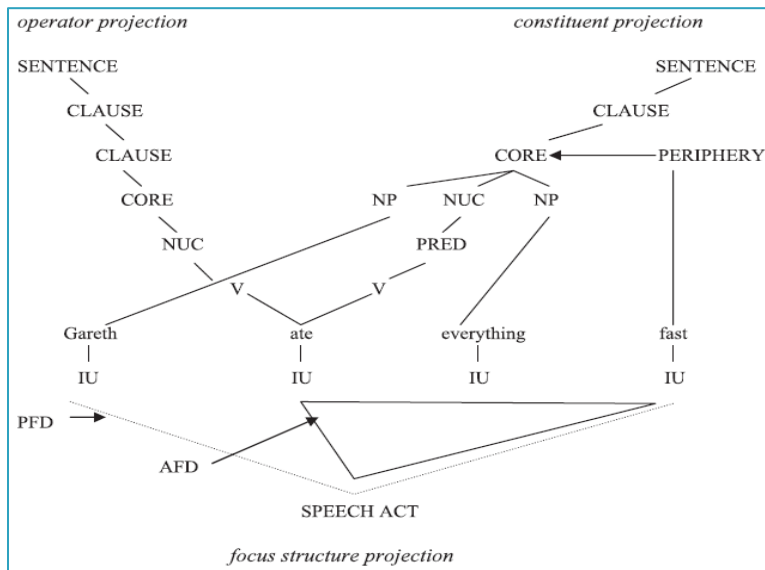
- Criteria 1 – Could the system present a mapping of the syntactic representation to a semantic representation, for the utterance taking the form of a simple sentence?
- Criteria 2 – Could the system present an adequate explanation of the NLU of the utterance?
- Criteria 3 – Could the system demonstrate the SAC use in the manipulation of the utterance?
- Criteria 4 – Can the dialogue manager interface the language model?

## Phase 2 and 3 – Agent Cognitive Model and Agent Dialogue Model

- Criteria 5 – Could the system demonstrate the agent BDI and knowledge representation?
- Criteria 6 – Could the system represent the user's BDI states?
- Criteria 7 – Could the system query the knowledge base for a fact (from the speech act performative)
- Criteria 8 – Could the system devise an appropriate plan based on the BDI states?
- Criteria 9 – Could the system generate a grammatically correct response in RRG based on the agent's knowledge?

# 9. Evaluation Phase 1 – RRG :LSC and LS

- RRG is a **functional** model. It views language as a communicative social action.
- Layered structure of the clause (**LSC**) = **PREDICATE + ARGUMENT + NON-ARGUMENTS**.
- Logical Structure (LS) – **semantic meaning of the sentence**.
- **Lexicon** - mental dictionary - lexical entries contain semantic features and constraints.
- It maps the **syntax(structure): LSC** ⇔ **semantic (meaning): LS** the actual form of the sentence using two different **LINKING ALGORITHMS**.
- RRG parser (algorithm) checks the grammar (rules) of English. **Specialised parser (CSA)**
- **RRG facilitates syntactic, semantic and information structure (FOCUS & TOPIC)**



**Figure 7 - An English sentence with three representations**

## RRG steps (Panesar, 2017)

### Worked example

## Gareth ate everything fast

(BNC ADY 1079) (Butler et al, 2009) -> Figure 5

### SYNTACTIC:

**SENTENCE ( CLAUSE ( <CORE> <NP> gareth ( <NUC> ( <PRED> <V> ate ) ) ( <NP> (everything) ) ) (PERIPHERY fast)**

### SEMANTIC:

**[<IF> ASS <TNS> PST, do'(ACT:Gareth, (eat'(Gareth <NOM>, pizza <ACC>)))] & INGR consumed' (UND:pizza)]**

# 10. Evaluation Phase 1 – RRG : Data sources – Lexicon, SA, & SAC

LEXICAL ENTRY	POS-TYPE	VERB TENSE/ ASPECT	DEF	P TYPE	NO	GR	CASE	ANIM	HUM	LOGICAL STRUCTURE (LS)
ate	VERB	PST	DEF+/-	3	SG	M/F	DNA	ANIM	HUM	<tns:pst <do'(x, [eat'(x, y)]) & BECOME consumed'(y) >>
eat	VERB	PRS/ FUT	DEF+/-	3	SG	M/F	DNA	ANIM	HUM	<tns:prs <do'(x, [eat'(x,y)]) & BECOME consumed'(y) >> <tns:fut <do'(x, [eat'(x,y)]) & BECOME consumed'(y) >>
eating	VN	PROG	DEF+/-	3	SG	M/F	DNA	ANIM	HUM	<tns:prs <asp:prog <do'(x, [eat'(x, y)]) & BECOME consumed'(y) >>>
is	VBE	DNA	DEF+	DNA	DNA	DNA	DNA	DNA	DNA	be'(x,[pred'])
hungry	ADJ	DNA	DNA	DNA	DNA	M/F	DNA	ANIM	HUM	DNA
restaurant	N	DNA	DEF+/-	DNA	SG/PL	DNA	DNA	DNA	DNA	DNA

Table 1 – Snapshot of the Lexicon (Panesar, 2017)

Speech (linguistic) Act (SA) Theory (Searle, 1969) – message types as in Figure 6

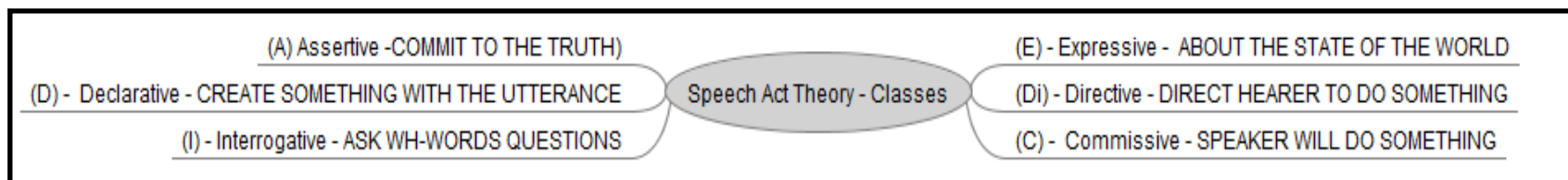


Figure 8– Speech Act message types

3 actions associated with an utterance include:

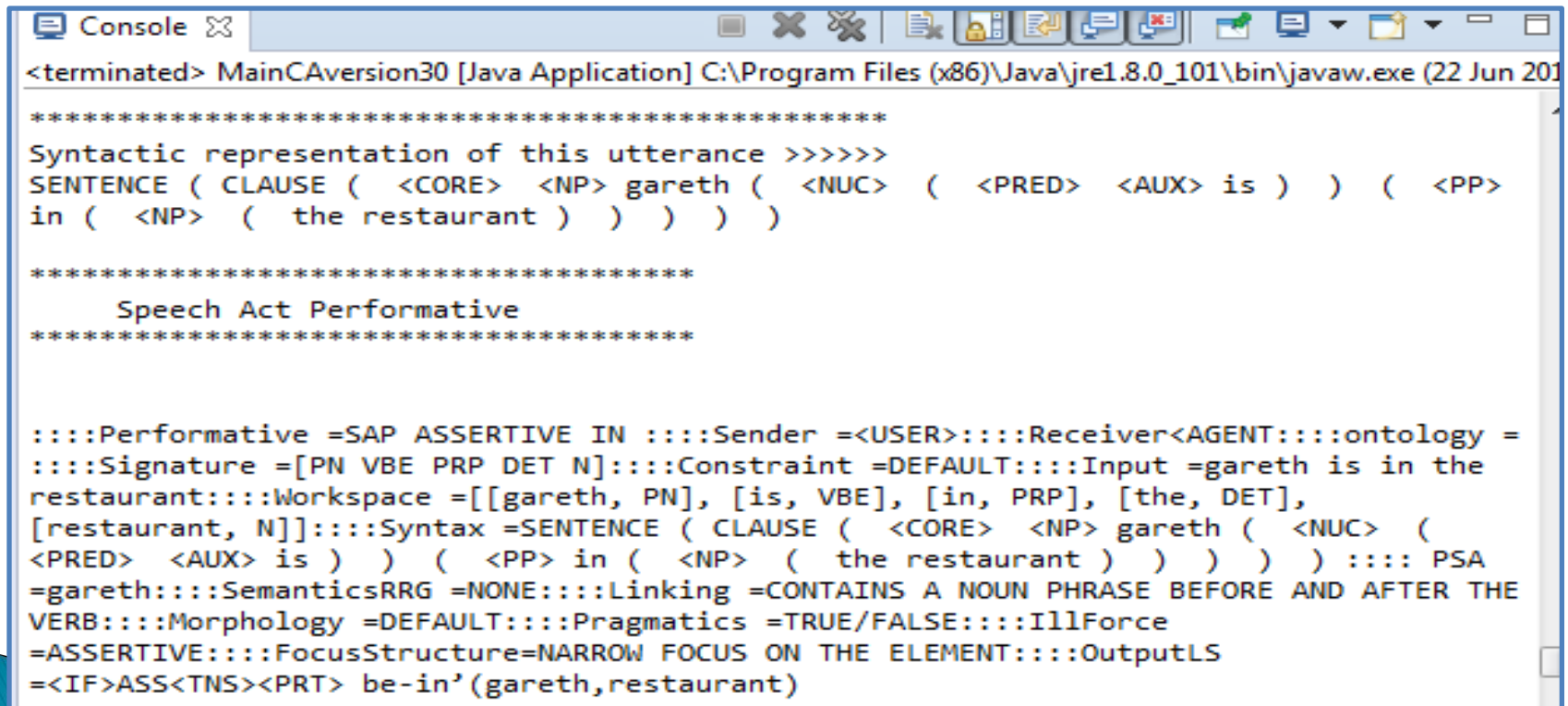
- Locution:
- **Illocution: illocutionary act (speaker's intention) [SI]** for A, Di and I message types
- Perlocution:

Figure 9 – Empty SAC  
(Speech Act Construction)  
(Panesar, 2017)

ASSERTIVE:ATE RRG [NP VERB NP], [PN VERB], [ADV PN VERB DET N], [PN VERB N ADJ], [PRP DET N PN VERB DET N], [PN VBE VERB N], [PN PRP DET N PRP DET N], [PRO VERB DET N], [PN VERB NP], [PN VERB DET N], [NP VERB QNT N], [DET N VERB DET N], [DET N VERB QNT N], [NP VERB (DET) (ADJ) N (ADJ)], [PN VERB DET N ADJ], [PN VERB (DET) ADV N ADJ], [PN VERB DET N PRP DET N], [PN, VERB, N, PRP, DET, N], [PN VERB N PRP DET N] RRG NONE RRG UTTINPUT RRG WKSPACE RRG DEFAULT ASSUMPTION (1ST NP = 'ACTOR') RRG NO PARTICULAR SPEC RRG NONE RRG CONTAINS A NOUN PHRASE BEFORE AND AFTER THE VERB RRG DEFAULT RRG TRUE/FALSE RRG ASSERTIVE RRG NARROW FOCUS ON THE ELEMENT RRG LOG STRUCTURE TO ADD

# 11. Evaluations (Phase 1 – RRG Model)

- **Aim**– assessment of Criteria 1 –4
- Each specific construal (either an utterance or response) –two steps.
  1. Find the matching SA construction of that specific predicating element. In Figure 2: *'is'* and **selected SAC of assertive.**
  2. Select the matching signature pattern → **[PN, VBE, PRP, DET, N]**
- Updates > SAC first and extended SAP (Panesar, 2017)



```
<terminated> MainCAversion30 [Java Application] C:\Program Files (x86)\Java\jre1.8.0_101\bin\javaw.exe (22 Jun 2017)

*****
Syntactic representation of this utterance >>>>>
SENTENCE ( CLAUSE ( <CORE> <NP> gareth ( <NUC> ( <PRED> <AUX> is ) ) ) ( <PP>
in ( <NP> ( the restaurant ) ) ) ) )

*****

Speech Act Performative
*****

::::Performative =SAP ASSERTIVE IN ::::Sender =<USER>::::Receiver<AGENT::::ontology =
::::Signature =[PN VBE PRP DET N]::::Constraint =DEFAULT::::Input =gareth is in the
restaurant::::Workspace =[[gareth, PN], [is, VBE], [in, PRP], [the, DET],
[restaurant, N]]::::Syntax =SENTENCE ( CLAUSE ( <CORE> <NP> gareth ( <NUC> (
<PRED> <AUX> is ) ) ) ( <PP> in ( <NP> ( the restaurant ) ) ) ) ):::: PSA
=gareth::::SemanticsRRG =NONE::::Linking =CONTAINS A NOUN PHRASE BEFORE AND AFTER THE
VERB::::Morphology =DEFAULT::::Pragmatics =TRUE/FALSE::::IllForce
=ASSERTIVE::::FocusStructure=NARROW FOCUS ON THE ELEMENT::::OutputLS
=<IF>ASS<TNS><PRT> be-in'(gareth,restaurant)
```

Figure 10 – Snapshot output of LING-CSA (Panesar, 2017)

# 12. Phase 1 – RRG & Speech Act Performative

Based on the SAC with four additional attributes. Input to Phase 2–ACM

PERFORMATIVE: <ASSERTIVE:ATE>

:SENDER <USER>

:RECEIVER <AGENT-1>

:ONTOLOGY <FoodAndCookKB>

:CONTENT <do'(Gareth, (eat'(Gareth, pizza)))] & INGR consumed' (pizza)] everything>

SIGNATURE: [PN V NP ADJ]

CONSTRAINT: Default

INPUT: Gareth ate everything fast

WORKSPACE: (Gareth, PN), (ate, VERB), (everything N), (fast, ADJ)

SEMANTICS: Contains a noun phrase before and after the verb

CONSTRUCTION BODY

SYNTAX: SENTENCE ( CLAUSE ( <CORE> <NP> gareth ( <NUC> ( <PRED> <V> ate ) )  
( <NP> (everything ) ) ) (PERIPHERY fast)

PSA: gareth

SEMANTICS

Linking:

MORPHOLOGY:Default

PRAGMATICS

Illocutionary force: ASSERTIVE

Focus structure: narrow focus on the element

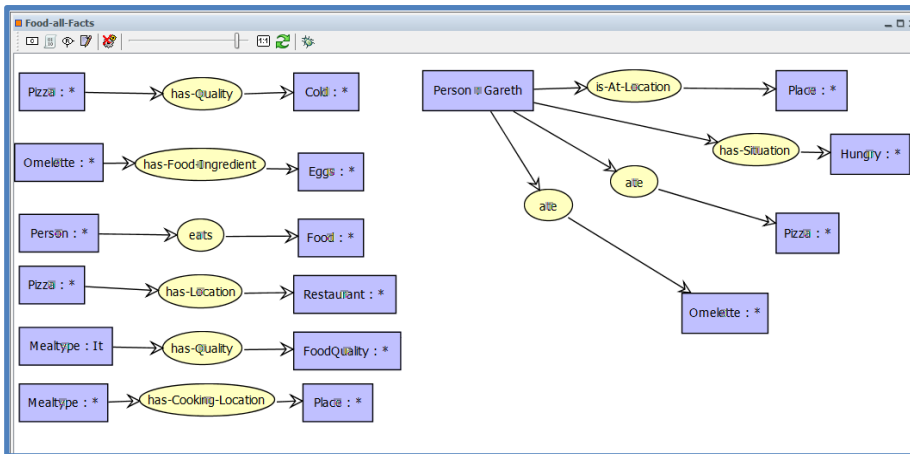
OUTPUT [LS]: [<IF> ASS <TNS> PST, do'(ACT:Gareth, (eat'(Gareth <NOM>, pizza  
<ACC>)))] & INGR consumed' (UND:pizza)]

Table 2–Speech Act Construction Performative “ate” used as a message to the Agent Environment (Panesar, 2017)

# 13. Phase 2 – Agent Cognitive Model & Knowledge Model (Panesar, 2017)



**SHARED** and **INDIVIDUAL BELIEFS** cognitively → mental knowledge.



- Conceptual graphs (CGs) (Sowa, 1986), Vocabulary, **First order logic (FOL)** created in COGUI as in Figure 7 and 8
- Serialised into **RDF/XML (W3C SW)**, mapped to **RDF Triple Stores** – forms the agent’s belief base – 446 lines (Table 3)
- KB ready for querying to check truth of the agent’s beliefs
- Key Performance Indicators – representational and inferential adequacy

Figure 11 & 12– COGUI– Original KB of facts – graphically

Table 3 – Extract of a RDF triple Stores KB

No	Subject	Predicate	Object
1	<a href="http://www.lirmm.fr/cogui#t_ad452f18-e654-4ae6-b3a1-b7320616283b">http://www.lirmm.fr/cogui#t_ad452f18-e654-4ae6-b3a1-b7320616283b</a>	<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">http://www.w3.org/1999/02/22-rdf-syntax-ns#type</a>	<a href="http://www.w3.org/2000/01/rdf-schema#Class">http://www.w3.org/2000/01/rdf-schema#Class</a>
2	<a href="http://www.lirmm.fr/cogui#t_fdc6d7d0-1314-4fb7-8428-51e122953250">http://www.lirmm.fr/cogui#t_fdc6d7d0-1314-4fb7-8428-51e122953250</a>	<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">http://www.w3.org/1999/02/22-rdf-syntax-ns#type</a>	<a href="http://www.w3.org/2000/01/rdf-schema#Class">http://www.w3.org/2000/01/rdf-schema#Class</a>

# 14. Lexical Bridging Solution (Panesar,2017)

Reduce this semantic gap, by “building a lexical bridge (LB)” between the NL semantic and ontology semantics, with an aim to capture more of the meaning, by attempting to ‘lexicalize the ontology’.

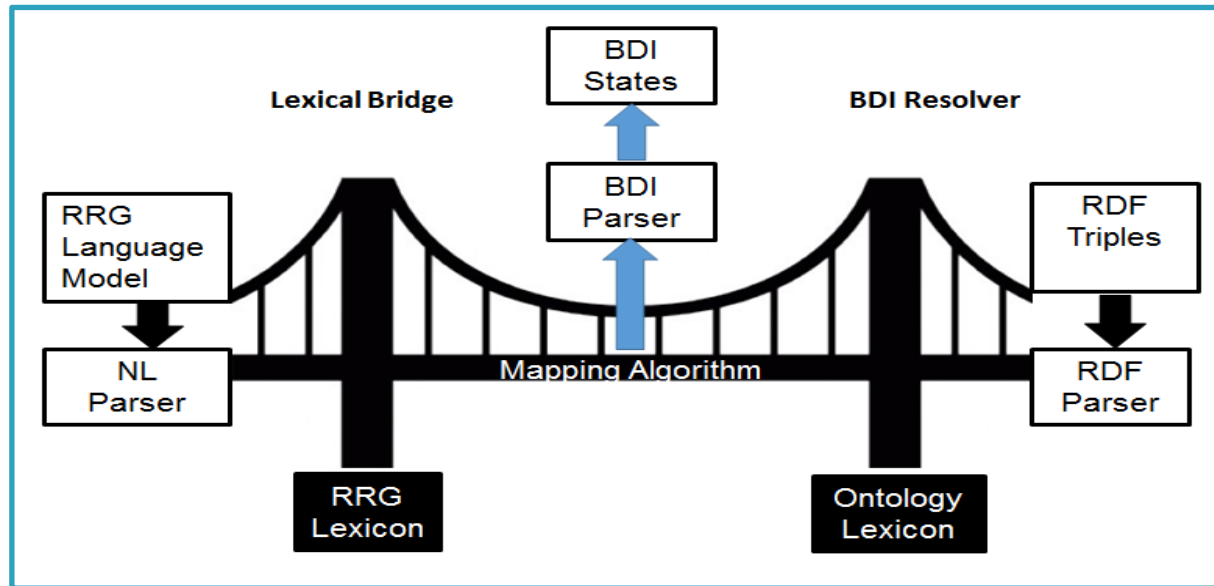


Figure 13 - Lexical Bridge for the CSA's belief base + BDI Parser to resolve the agent's BDI states

# 15. Evaluations, Findings, and Recommendations

## Implementation outcomes :

- Proof-of-concept achieved;
- Dialogue Manager is common to Phase 1 and Phase 3

## Findings

- RRG is fit for purpose -> linguistic engine for the CSA;
- RRG explains, describes linguistic phenomena; facilitates language processing and knowledge of language -> computationally adequate (Panesar, 2017)

## Phase 1 - RRG Model Improvements:

1. All pronoun resolutions (E.g. 'Your', 'she', 'it' etc.)
2. Application of the propositional stranding rules
3. Complex sentences (extension of the RRG linking system)
4. Multi-lingual (additional lexicons) such as Spanish
5. Other SA classes such as emotive and commissives E.g analyse tweets
6. Include superlative adjectives/adverbs in the RRG Lexicon (E.g. 'spicier')
7. Invoke WordNet API for synonymous entries to the RRG Lexicon - ↑value

**Phase 2 Agent Cognitive Model** working - 70% achieved Dialogue mgnt

**Technical Challenge** - Querying a natural language (NL) text against a knowledge representation (KR) of RDF triples poses a significant semantic gap

**Conceptual solution** (lexical bridge, BDI parser and RDF parser) (Panesar, 2017)

**Single agent to multi-agent environment** - an extended design framework

**Content creation** - via machine learning algorithms

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Thank you for listening!