Computational Pragmatics

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Abstract

In data-driven agent-based Database Semantics (DBS), propositions are contents.[1] A content type is built (i) from the semantic kinds *concept, indexical*, and *name*. They are connected (ii) by the semantic relations of structure[2] *functor-argument* and *coordination*, which are (iii) coded by *address*.

Computational pragmatics[3] connects content types to the agents' on-board orientation system (OBOS), resulting in content tokens. A content type with a language-dependent surface is a *literal meaning*$_1$. A content token used for inter-agent language communication is an *utterance meaning*$_2$.

There is literal and nonliteral pragmatics. Literal pragmatics is obligatory for proper understanding, may require different speaker and hearer inferences, and includes adjustments of perspective, e.g. the hearer's you see/saw me for the speaker's I see/saw you (Sect. 3). Nonliteral pragmatics is optional, applies the same inference deductively in the speak mode (input matching antecedent) and abductively in the hear mode (input matching consequent), and includes syntactic mood adaptations, e.g. Could you pass the salt? for Pass the salt!, and metaphor, e.g. melt for disappear (Sect. 4).

keywords: language vs. nonlanguage content, content types vs. content tokens, on-board orientation system, STAR, pragmatics of literal vs. nonliteral use

1 Four Kinds of Content in DBS

In DBS, a content is defined as a set (order-free) of proplets. As the computational data structure, proplets are defined as non-recursive feature structures with ordered attributes and connected by (i) semantic relations of structure coded by address and (ii) a shared prn value.

There are four kinds of content in DBS, characterized by the binary values ±surface and ±STAR. Nonlanguage contents are −surface and language contents +surface. Content types are −STAR and content tokens +STAR.[4].

[1] Instead of "denoting truth values," as in substitution-driven sign-based semantics.

[2] Subject/predicate, object\predicate, adnominal|noun, adverbial|verb, and conjunct−conjunct at the elementary, phrasal, and clausal level of grammatical complexity.

[3] Overviews of noncomputational pragmatics are Kempson (2001) and Horn&Ward eds. (2004).

[4] The STAR in agent-based DBS may be seen as a development of the sign-based "parameter ap-

1.1 NONLANGUAGE CONTENT TYPE: [–surface, –STAR]

sur:	sur:	sur:
noun: dog	verb: find	noun: bone
cat: snp	cat: #n′ #a′ decl	cat: snp
sem: def sg	sem: past ind	sem: indef sg
fnc: find	arg: dog bone	fnc: find
mdr:	mdr:	mdr:
nc:	nc:	nc:
pc:	pc:	pc:
prn: K	prn: K	prn: K

This proposition is a content type because there is no STAR and the prn value is a variable, here K, and it is a nonlanguage content because the sur slots are empty.

The next example is a corresponding nonlanguage token:

1.2 NONLANGUAGE CONTENT TOKEN: [–surface, +STAR]

sur:	sur:	sur:	S: yard
noun: dog	verb: find	noun: bone	T: friday
cat: snp	cat: #n′ #a′ decl	cat: snp	A: sylvester
sem: def sg	sem: past ind	sem: indef sg	R:
fnc: find	arg: dog bone	fnc: find	3rd:
mdr:	mdr:	mdr:	prn: 12
nc:	nc:	nc:	
pc:	pc:	pc:	
prn: 12	prn: 12	prn: 12	

According to the STAR values, the token resulted as an observation by the agent Sylvester on Friday in the yard.

The following example is the language content type corresponding to 1.1. It illustrates the independence of language-dependent sur values, here German, from the relatively language-independent placeholders (English base forms for convenience):

1.3 LANGUAGE CONTENT TYPE (MEANING$_1$): [+surface, –STAR]

sur: der_Hund	sur: fand	sur: einen_Knochen
noun: dog	verb: find	noun: bone
cat: snp	cat: #n′ #a′ decl	cat: snp
sem: def sg	sem: past ind	sem: indef sg
fnc: find	arg: dog bone	fnc: find
mdr:	mdr:	mdr:
nc:	nc:	nc:
pc:	pc:	pc:
prn: K	prn: K	prn: K

A language content type is called a literal meaning$_1$. It is an abstraction insofar as an actual time-linear surface-compositional DBS hear mode derivation, e.g.

proach," which uses parameters such as I (possible worlds), J (possible times), S (possible speakers), H (possible hearers), etc., such as the index @, I, J, g superscripted to logical formulas in Montague (1973). Cresswell (1972, p.4) wonders tongue in cheek about adding a next drink parameter.

CC 2.1.3, results in a content token. However, a content type may always be obtained from a content token by removing the STAR and replacing the prn constants with suitable variables.

The fourth kind of content is a language token which matches the type 1.3, called an *utterance meaning*$_2$. It is produced by the speaker Sylvester in German towards the intended hearer Tweety and corresponds to the nonlanguage content token 1.2 except for the R value:

1.4 LANGUAGE CONTENT TOKEN (MEANING$_2$): [+surface, +STAR]:

sur: der_Hund	sur: fand	sur: einen_Knochen	S: yard
noun: dog	verb: find	noun: bone	T: friday
cat: snp	cat: #n′ #a′ decl	cat: snp	A: sylvester
sem: def sg	sem: past ind	sem: indef sg	R: tweety
fnc: find	arg: dog bone	fnc: find	3rd:
mdr:	mdr:	mdr:	prn: 12
nc:	nc:	nc:	
pc:	pc:	pc:	
prn: 12	prn: 12	prn: 12	

According to the STAR, the transfer of content occurred on Friday in the yard. The content types 1.1 and 1.3 match not only the tokens 1.2 and 1.4, but an open-ended number of corresponding tokens with different prn values.

An utterance meaning$_2$ exists in the cognition of the speaker, and – if transfer is successful – of the hearer. The raw data serving as the vehicle of transfer in communication, in contrast, have absolutely no meaning or grammatical properties whatsoever at all (no reification in DBS), but may be measured by Natural Science.

2 Coactivation Resulting in Resonating Content

The basis of literal and nonliteral pragmatic interpretation is the automatic coactivation of *resonating content* in the agent's on-board database. Resonating content is the computational counterpart of association in psychology and relies on (a) the database schema of the agent's A-memory and (b) the data structure of proplets.

2.1 TWO-DIMENSIONAL DATABASE SCHEMA OF A-MEMORY IN DBS

- *horizontal*
  Proplets with the same core value are stored in the same token line in the time-linear order of their arrival.
- *vertical*
  Token lines are in the alphabetical order induced by their core value letter sequence.

The time-linear arrival order of proplets is reflected by the position in their token line and by their prn value. The sequence of member proplets is followed by a free slot as part of the column called the *now front*, and the *owner*.[5]

[5]The terminology of member proplets and owner values is reminiscent of the member and owner

2.2 SCHEMATIC EXAMPLE OF TOKEN LINE WITH CLEARED NOW FRONT

(i) member proplets			*(ii) now front*	*(iii) owner*
noun: bone … fnc: bury … prn: 2	noun: bone … fnc: eat … prn: 5	noun: bone … fnc: find … prn: 12		bone

Consider the content 1.2 as stored at the now front before clearance:

2.3 STORAGE OF A PROPOSITION AT THE NOW FRONT

	member proplets		*now front*	*owners*
…	sur: noun: bone cat: snp sem: indef sg fnc: fetch … prn: 2	sur: noun: bone cat: snp sem: def sg fnc: hide … prn: 5	… sur: noun: bone cat: snp sem: indef sg fnc: find … prn: 12	bone
…	sur: noun: dog cat: snp sem: indef sg fnc: bury … prn: 3	sur: noun: dog cat: pnp sem: def pl fnc: eat … prn: 7	… sur: noun: dog cat: snp sem: def sg fnc: find … prn: 12	dog
…	sur: verb: find cat: #n′ #a′ decl sem: pres prog arg: (person x) square … prn: 5	sur: verb: find cat: #n′ #a′ decl sem: past ind arg: cat mouse … prn: 8	… sur: verb: find cat: #n′ #a′ decl sem: past ind arg: dog bone … prn: 12	find
…	S: living room T: monday A: sylvester R: tweety 3rd: Speedy prn: 2	… S: garden T: thursday A: sylvester R: hector 3rd: prn: 10	… S: yard T: friday A: sylvester R: 3rd: prn: 12	sylvester

The storage of a proplet at the now front uses the letter sequence of the core value for accessing the correct token line via the owner. Retrieval searches the token line using the prn value. Content is automatically activated by computing successor proplets based on continuation addresses.

When the proplets at the current now front have ceased to be candidates for additional intrapropositional concatenations, the now front is cleared by moving it and

records in a classic network database (Elmasri and Navathe (1989[1]/2017[7]), which inspired the database schema of the DBS A-memory (formerly called word bank).

the owners one step to the right into fresh memory territory (loom-like clearance). By leaving the proplets of the completed proposition with the prn value 12 behind, their location becomes permanent storage as member proplets, like sediment, never to be changed. The only way to correct is adding content, like a diary entry.

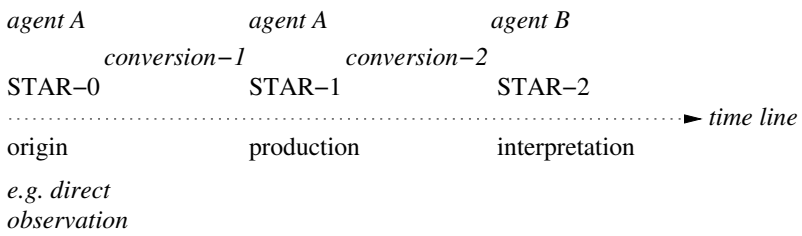
The A-memory illustrated in 2.3 is content-addressable for the following reasons. First, it does not use a separate index (catalog), unlike a coordinate-addressable database, e.g. an RDBMS. Second, the key for a proplet's storage in and retrieval from the agent's memory is the letter sequence of the proplet's core value (which enables computational string search in combination with a trie structure).

3 Literal Pragmatics of Adjusting Perspective

In automatic monitoring, the STAR codes the state of the agent's current moment. However, because a current content of origin recedes inevitably into the past, there are two STARs, the STAR of origin attached to the old content, called the STAR-0, and the current STAR of the agent's looking back at the old content in memory, called the STAR-1. For example, if the STAR-0 content I see you is retrieved from memory it must be changed to the STAR-1 content I saw you. Also, the values Paris and Thursday of the STAR-0, for example, may change to London and Sunday of the STAR-1, and similarly for the R and the 3rd value.

In language communication, the speaker uses the STAR-1 to encode the past STAR-0 content into a language surface. The hearer's interpretation of the speaker's STAR-1 surface, however, necessitates a third STAR, called the STAR-2. For example, the STAR-1 content I saw you must be changed to the STAR-2 content You say me. The (i) origin, (ii) production, and (iii) interpretation of a content used in language communication are in an obligatory temporal order (empirical backbone):

3.1 Time line of origin, production, and interpretation



The agent's STAR-0 values Paris and Friday, for example, may change into the speak mode's STAR-1 values London and Sunday, which in turn may change to New York and Wednesday of the hearer's STAR-2, and similarly for the R and the 3rd value.

To illustrate the changes from a STAR-0 content of origin to a STAR-1 content of production, let us begin with the following example:

3.2 STAR-0 CONTENT OF ORIGIN: I see you.

STAR-0 proplet of origin

sur:	sur:	sur:	S: yard
noun: pro1	verb: see	noun: pro2	T: thursday[6]
cat: s1	cat: #n-s3′ #a′ decl	cat: sp2	A: sylvester
sem: sg	sem: pres ind	sem:	R: hector
fnc: see	arg: pro1 pro2	fnc: see	3rd:
mdr:	mdr:	mdr:	prn: 12
nc:	nc:	nc:	
pc:	pc:	pc:	
prn: 12	prn: 12	prn: 12	

By definition, a STAR-0 content is (i) without language (quasi language-independent) and (ii) the verb's sem value is pres ind. The pro1 and the pro2 indexicals in the content point at the A value sylvester and the R value hector, respectively, of the STAR-0 proplet.

In the speak mode, the agent's STAR-0 content I see you (3.2) may be mapped automatically into one of the following STAR-1 variants. They differ semantically, but are pragmatically equivalent (CC Chap. 7):

3.3 PRAGMATICALLY EQUIVALENT STAR-1 CONTENTS

STAR-1 a: Sylvester remembers the content 3.2 without speaking.
STAR-1 b: Sylvester tells Hector that he saw him.
STAR-1 c: Sylvester tells Speedy that he saw "him," referring to Hector.
STAR-1 d: Sylvester tells Speedy that he saw Hector.
STAR-1 e: Sylvester tells Speedy that he saw Hector in the yard.
STAR-1 f: Sylvester tells Speedy that he saw Hector on Thursday in the yard.

In variants a-d, the semantic differences in the contents are compensated pragmatically by varying STAR-1 values. In e and f, past STAR-0 values which were overwritten by the current ones are preserved by writing them into the content.[7]

In the hear mode, each STAR-1 variant in 3.3 must be mapped into an equivalent STAR-2 content (CC Chap. 8):

3.4 PRAGMATICALLY EQUIVALENT STAR-2 CONTENTS

STAR-2 a: <For nonlanguage content, a hear mode counterpart does not exist>
STAR-2 b: Hector understands that Sylvester saw him.
STAR-2 c: Speedy understands that Sylvester saw "him," i.e. Hector.
STAR-2 d: Speedy understands that Sylvester saw Hector.
STAR-2 e: Speedy understands that Sylvester saw Hector on Thursday.
STAR-2 f: Speedy understands that Sylvester saw Hector on T. in the yard.

The speaker's STAR-0 STAR-1 conversion-1 and the hearer's STAR-1 STAR-2 conversion-2 use different inferences for the interpretation of pronominal indexi-

cals. The reason is that the interpretation of pronominals in the speaker's conversion-1 is unchanged, but inverted in the hearer's conversion-2.

The pragmatic equivalence of the semantically different contents 3.2, 3.3, and 3.4 is based (i) on the choice between coding certain values either in the content as concepts or names or as STAR values, and (ii) variations of the S, T, R, and 3rd values which are not part of the semantic content type. Furthermore, there is a choice between leaving the S and T of the STAR-0 implicit, as in variants a-d in 3.3 and b-d in 3.4, or writing them explicitly into the content, as in the variants e and f.

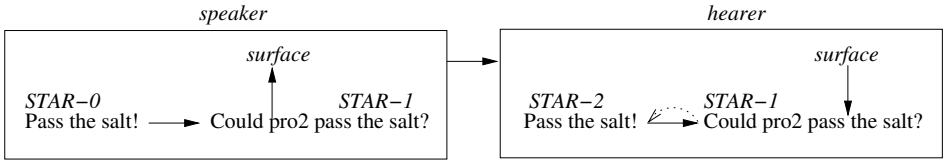
4 Nonliteral Pragmatics of Syntactic Mood Adaptation

The literal pragmatic inferences described in the previous section are obligatory insofar as the STAR-0, STAR-1, and STAR-2 contents must be pragmatically equivalent in order for communication to succeed. Thereby the STAR-0 STAR-1 transitions (speak mode) and the STAR-1 STAR-2 transitions (hear mode) each require their own inference.

We turn now to two kinds of nonliteral pragmatics, called syntactic mood adaptation and figurative use. In contradistinction to literal pragmatics, they are optional and their STAR-0 STAR-1 (speak mode) and STAR-1 STAR-2 (hear mode) transitions use the same inference, but inductively in the speak mode and abductively in the hear mode. In order for communication to succeed, the hearer must revert the speaker's nonliteral content back into the speaker's original content modulo the obligatory hear mode adjustments of a STAR-2 content.

Consider the following example from J.L. Austin ([1955]1962) of a syntactic mood adaptation:

4.1 SYNTACTIC MOOD ADAPTATION IMP-INT



The speaker's communicative purpose of the STAR-1 STAR-2 conversion is softening a command (imperative[8]) into a polite request (yes-no interrogative). If the hearer were to take the speaker's STAR-1 content literally by answering yes or no, communication would fail. For communication to succeed, the hearer must use the same inference as the speaker, but abductively (⟵).

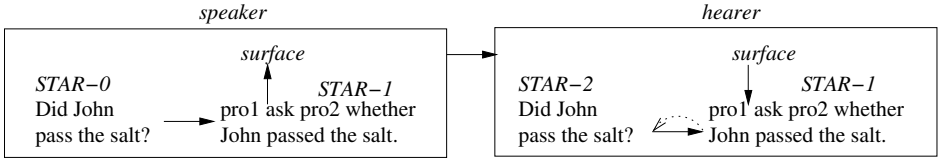
[6]Using weekdays as T values may be crude as compared to nano- or pico-seconds, but is sufficient for current purpose.

[7]For formal details see CC, Sect. 7.1.

[8]The subject of imperatives in English and many other languages is implicit: it is automatically assumed to be pro2 in the speak mode and pro1 in the hear mode, without any surface manifestation. Consequently, the hearer's standard STAR-2 reversal from pro2 to pro1 is implicit as well.

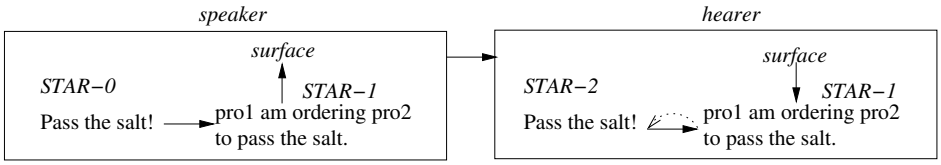
Syntactic mood adaptions are common in the European languages, but not universal.[9] The following two examples are based on the inferences INT-DECL and IMP-DECL, respectively.

4.2 SYNTACTIC MOOD ADAPTATION INT-DECL



For the explicit definition of INT-DECL see CC 7.4.2.

4.3 SYNTACTIC MOOD ADAPTATION IMP-DECL



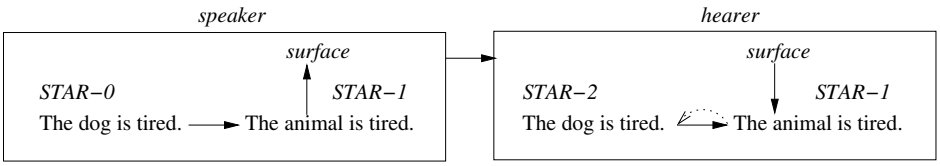
For the explicit definition of IMP-DECL see CC 7.5.2. There are more syntactic-mood adaptations, such as the interrogative-imperative adaptation from Did you pass the salt? to Tell me if you passed the salt![10]

5 Nonliteral Pragmatics of Figurative Use

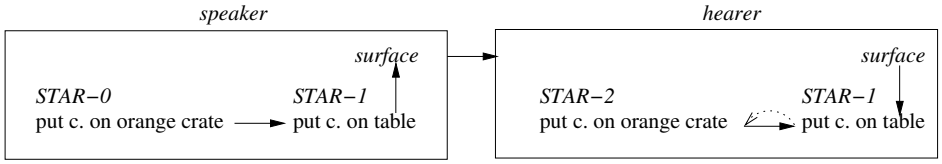
While the inferences of syntactic mood adaptation use complete propositions as input and output, the inferences of figurative use only a part, elementary or phrasal, of a proposition. Figurative use is subject to the invariance constraint (CC 6.4.1), according to which the figurative replacement must be of the same syntactic category and the same semantic field as the literal original. The condition that successful communication requires the hearer to reconstruct the speaker's original content applies equally to syntactic mood adaptation and figurative use.

In figurative use, lexical relations such as hyponymy, metonymy, property sharing, abbreviation, and membership in the same semantic field serve as the basis of inferencing (CC Chap. 9). Consider the following examples:

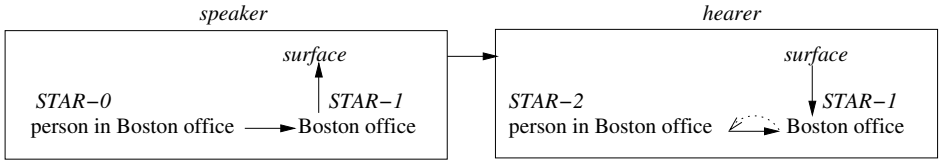
5.1 FIGURATIVE USE BASED ON HYPONYMY RELATION



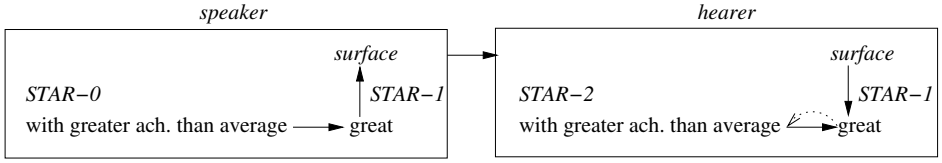
5.2 FIGURATIVE USE BASED ON SHARED PROPERTY INFERENCE



5.3 SPEAK AND HEAR MODE OF AN ABBREVIATING ADVERBIAL USE



5.4 SPEAK AND HEAR MODE OF AN ABBREVIATING ADNOMINAL USE



As in all abductive use, there is no certainty regarding the output of the inference (i.e. of the antecedent). For example, if the orange crate in 5.1 were accompanied by a footstool, a sideboard, and a low bookshelf, it would be impossible for the hearer to decide what the speaker meant with "table" (too many candidates with flat horizontal surfaces in the current context of interpretation, embarrassment of riches). In such a case, the speaker would have to specify more precisely what is meant in order for communication to succeed.

Conclusion

In agent-based data-driven DBS, the semantic/pragmatic distinction is based on the type/token distinction from philosophy. The semantics of a content is a type which is independent of the utterance situation, while the pragmatics is a token which connects a type to the agent's on-board orientation system (OBOS).

There are two kinds of pragmatics in DBS. The *obligatory literal* kind adapts a semantic content to the alternative perspectives of speaker and hearer. This requires different inferences for the speak and the hear mode (Sect. 3).

[9]The alternative in Korean, for example, is the use of two morphological systems, one for honor and one for mood, which are agglutinated to the verbal stem. Thanks to Prof. Kiyong Lee for his help in this matter.

[10]The dependence of nonliteral use pragmatics on specific pronouns, concepts, tense, mood, etc. is reminiscent of Construction Grammar (Fillmore 1988).

The other kind is *optional nonliteral* pragmatics. It provides informative views such as metaphor on literal content. In successful communication, the hearer must reconstruct the speaker's literal content from which the nonliteral view was derived. For this, speaker and hearer use the same inference, though deductive in the speak mode and abductive in the hear mode (Sect. 4).

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