The pragmatics and semantics of feedback in dialogue

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Feedback

Communicative feedback *("feedback")* is the activity of providing or eliciting information about the outcome of previous communicative actions , in particular about their processing.

Feedback: motivation

- **Ubiquity of feedback in human communication**

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  Feedback is the mortar of conversation. Throughout a dialogue, the participants continuously give and elicit information about their attention, perception, understanding, and reactions to what is said by others.

  They do so explicitly through (combinations of) words, gestures, and facial expressions, as well as implicitly.

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- **Non-ubiquity of feedback in human-computer communication is a major source of problems in communicating with machines.**

  Has the machine understood me? What does the machine expect me to do?

  How can I get back to were we were before?

Feedback in HCC (or the lack of it)

Existing (spoken) dialogue systems are notoriously poor in:

-recognising feedback behaviour on the part of a user;

- producing adequate feedback behaviour

Non-ubiquity of feedback in HCC

Example:

A: What is RSI?

S: RSI stands for Repetitive Stress Injury.

(IMIX dialogue system)

Non-ubiquity of feedback in HCC

Example:

A: What is RSI?

S: RSI stands for Repetitive Stress Injury.

A: Yes, but what is it?

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  Has the machine understood me? What does the machine expect me to do?

  How can I get back to were we were before?

- **Importance of feedback: Essential for the creation of Common Ground.**

  Communication without common ground is impossible.

The Grounding problem

Once upon a time there were

two generals A and B on either side of enemy C...

The Grounding problem

Message from general A to general B:

I will attack tomorrow at dawn if you do the same!!

The Grounding problem

Message from general B to general A:

OK !!

The Grounding problem

Message from general B to general A:

OK !!

Intelligent fellow: We must send feedback!

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Message from general B to general A:

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Intelligent fellow: We must send feedback!
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and so on, and so on…

The Grounding Problem

Once upon a time there were

two generals A and B on either side of enemy C...

To allow A and B to take action,

*A and B should **mutually believe** that they will attack*

i.e.

A believes that …

B believes that …

A believes that B believes that …

B believes that A believes that …

A believes that B believes that A believes that …

B believes that A believes that B believes that …

and so on…

The Grounding Problem

Each feedback message adds one level of nesting to beliefs about each other's beliefs,

but mutual belief requires indefinitely deeply nested beliefs about each other's beliefs.

How can participants in a dialogue establish a mutual belief in a dialogue of finite length?

Common Ground

The set of mutual beliefs of participants in a conversation: their
"Common Ground"

Grounding a belief = adding it to the Common Ground

The problem:

How do beliefs get grounded in a finite dialogue?

in particular
if communication is the only source of information

The problem of Common Ground

Common idea (e.g. Herbert Clark): Common Ground as mutual beliefs is "infinite", is computationally intractable.

Wrong!

Mutual belief can be given its own finite, recursive axiomatization:

μBel(A,B,p) --> Bel(A, p)
--> Bel(B, p)

μBel(A,B,p) --> Bel(A, μBel(A,B,p))
--> Bel(B, μBel(A,B,p))

Common Ground revisited

Common idea: (iterative) Common Ground is “infinite”, is computationally intractable

Wrong! Axiomatization:

μBel(A,B,p) --> A bel p
--> B bel p
μBel(A,B,p) --> A bel μBel(A,B,p)
--> B bel μBel(A,B,p)

hence:

μBel(A,B,p) --> A bel μBel(A,B,p)
μBel(A,B,p) --> A bel B bel μBel(A,B,p)
μBel(A,B,p) --> A bel B bel A bel p

... and so on: all iterations of belief about belief can be inferred.

Outline

- Introduction and motivation
- Forms and functions of feedback in human communication
  - Forms of feedback
  - Semantic and pragmatic analysis of feedback
  - implicit feedback: Entailments and implicatures
- Feedback and grounding, a computational model
  - Analysis frameworks: DIT and ISO 24617-2
  - Feedback acts as context-changing actions
  - Feedback, understanding, and grounding
  - An implementation of the model
- Concluding remarks

feedback in human communication

Participants in a dialogue constantly give and elicit information about their attention, perception, understanding, and reactions to what is said

To do so, they must maintain a model of whether and how well utterances (and nonverbal and multimodal activities) are:

- Noticed
- Perceived
- Understood
- Evaluated
- Responded to

feedback

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Feedback updates this information in a participant's model of the interactive situation, his *'context model'.*

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➔ ➔ **Semantics of feedback behaviour: as *context model updates*.**

Properties and forms of feedback

- Polarity
  - positive
  - negative
  - neutral ?
  - partly positive, partly negative
- Specificity
  - level-specific
  - level-unspecific
- Articulation (of semantic scope)
  - articulate
  - inarticulate

Properties and forms of feedback

- Explicitness
  - Explicit
  - Implicit (Implied)
    - entailed
    - Implicated
- Direction (about one's own or an addressee's processing)
  - auto- vs.
  - allo-feedback

Forms of Feedback

Example:

1. A: Can you tell me from which platform the train to Rotterdam leaves?
2. B: Rotterdam that's platform 6.
3. A: Thank you.

Forms of Feedback

Example:

1. A: Can you tell me from which platform the train to Rotterdam leaves?
2. B: 6.
3. A: Thank you.

Forms of Feedback

Example:

1. A: Can you tell me from which platform the train to Rotterdam leaves?
2. B: That's platform 126.
3. A: ??

Forms of Feedback

Example:

1. A: Can you tell me from which platform the train to Rotterdam leaves?
2. B: That's platform 126.
3. A: ??

"Thank you" would implicate acceptance of B's answer, and hence would form implicit positive feedback.

polarity and articulation of feedback

Articulate feedback: specification of processing outcome typically requires repeating or paraphrasing something, thereby indicating the feedback scope.

Partially articulate feedback: repetition/paraphrase of part of what was said.

Positive:

C: Can you tell me what time is the first train to the airport on Sunday?

S: On Sunday the first train is at… 5.54

Implied scope: C's entire utterance

Negative:

A: Avon to Bath is four hours.

B: Four?

Implicature: positive feedback about rest of utterance

articulate and inarticulate feedback

Inarticulate feedback: no indication of 'scope' (what the feedback is about)

- "OK"; "Yes; "M-hm"; nodding – *positive auto-feedback*
- "Excuse me?"; "Huh?"; "What?"; frowning, raising eyebrows – *negative auto-feedback*
- "OK?"; "All right?"; raising eyebrows – *feedback elicitation (allo-feedback)*
- "Quite"; "Yes"; nodding – *positive allo-feedback*

Articulate feedback: indication of 'scope' (what the feedback is about)

- C: "Which flights do you have on Thursday?"

  S: "On Thursday 20 the first flight I have is at 7.15" – *positive auto-feedback*
- "Tuesday you said?" – *negative auto-feedback*
- "Yes Tuesday." – *positive allo-feedback*
- "No Thursday." – *negative allo-feedback*

Feedback direction: Auto- and Allo-feedback

Auto-feedback is most common (and is ubiquitous, at least implicitly).

Allo-feedback:

A: I don't have a good connection on Thursday.

B: *I said Tuesday.*

A: Friday the 13th?

B: *That's what I mean.*

A: The 13th, *did you get that?*

Levels of feedback

Participants in dialogue must have a model of whether and how well utterances (and nonverbal and multimodal communicative activities) are:

- Noticed
- Perceived
- Understood
- Evaluated
- Adopted

Feedback behaviour can indicate success of processing at the following levels :

- Attention
- Perception
- Understanding
- Evaluation/acceptance
- Execution

Level-specific feedback indicates a level of processing;
level-unspecific feedback does not.

Semantics & Pragmatics of feedback: entailments & implicatures

Positive:

Execution >>
< Evaluation >>
< Interpretation >>
< Perception >>
< Attention

Negative:

Attention >>
< Perception >>
< Interpretation >>
< Evaluation >>
< Execution

>> = entailment
< = implicature

Feedback behaviour in terms of dialogue acts

Description and analysis of feedback behaviour in terms of communicative actions, “dialogue acts”, using Dynamic Interpretation Theory (DIT) and the concepts of ISO standard 246172 for dialogue acct annotation.

Dialogue act semantics in DIT

In Dynamic Interpretation Theory (DIT), dialogue acts describe *utterance meanings* ('interpretations') as dialogue acts, whose semantics is defined as *update operations on* participants' *information states* ('contexts').

These operations depend on:

- the ***semantic content*** of the dialogue act;
- its ***communicative function***;
- semantic dependence relations with other dialogue acts;
- qualifiers.

Details: "A context-change semantics for dialogue acts" in Computing Meaning, vol. 4 (2014).

ISO standard 24617-2 for dialogue act annotation

Features:

- ♥ Domain-independent
- ♥ Concepts defined as data categories (following ISO 12620 standard) and stored in the ISOcat online registry – communicative functions, dimensions, and (rhetorical and other) relations in dialogue
- ♥ Multidimensional (for multifunctionality)
- ♥ Annotation language **DiAML** (Dialogue Act Markup Language) with:
  - abstract and concrete syntax
  - semantics in terms of information-state update operators defined for *abstract* syntax
  - concrete syntax defining XML representations

dimensions

- Task: dialogue acts moving the underlying task forward
- ***Auto-Feedback***: providing information about speaker's processing of previous utterances
- ***Allo-Feedback***: providing or eliciting information about addressee's processing of previous utterances
- Turn Management: allocation of speaker role
- Time Management: managing use of time
- Discourse Structuring: explicitly structuring the dialogue
- Own Communication Management: editing one's own speech
- Partner Communication Man: editing addressee's speech
- Social Obligations Management: dealing with social conventions (greeting, thanking, apologizing,..)

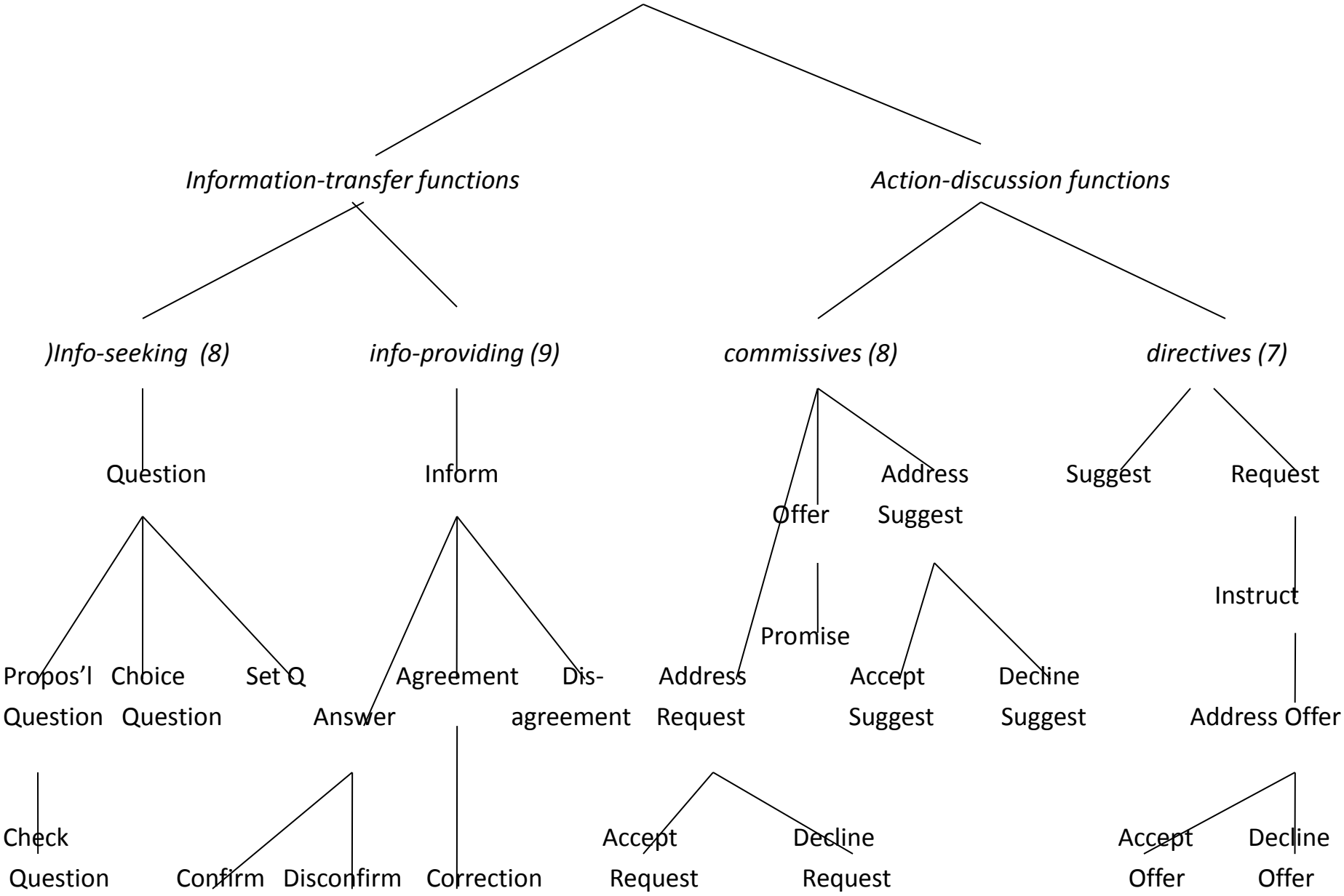
communicative functions in ISO 24617-2 and DIT^{++}

2-part taxonomy:

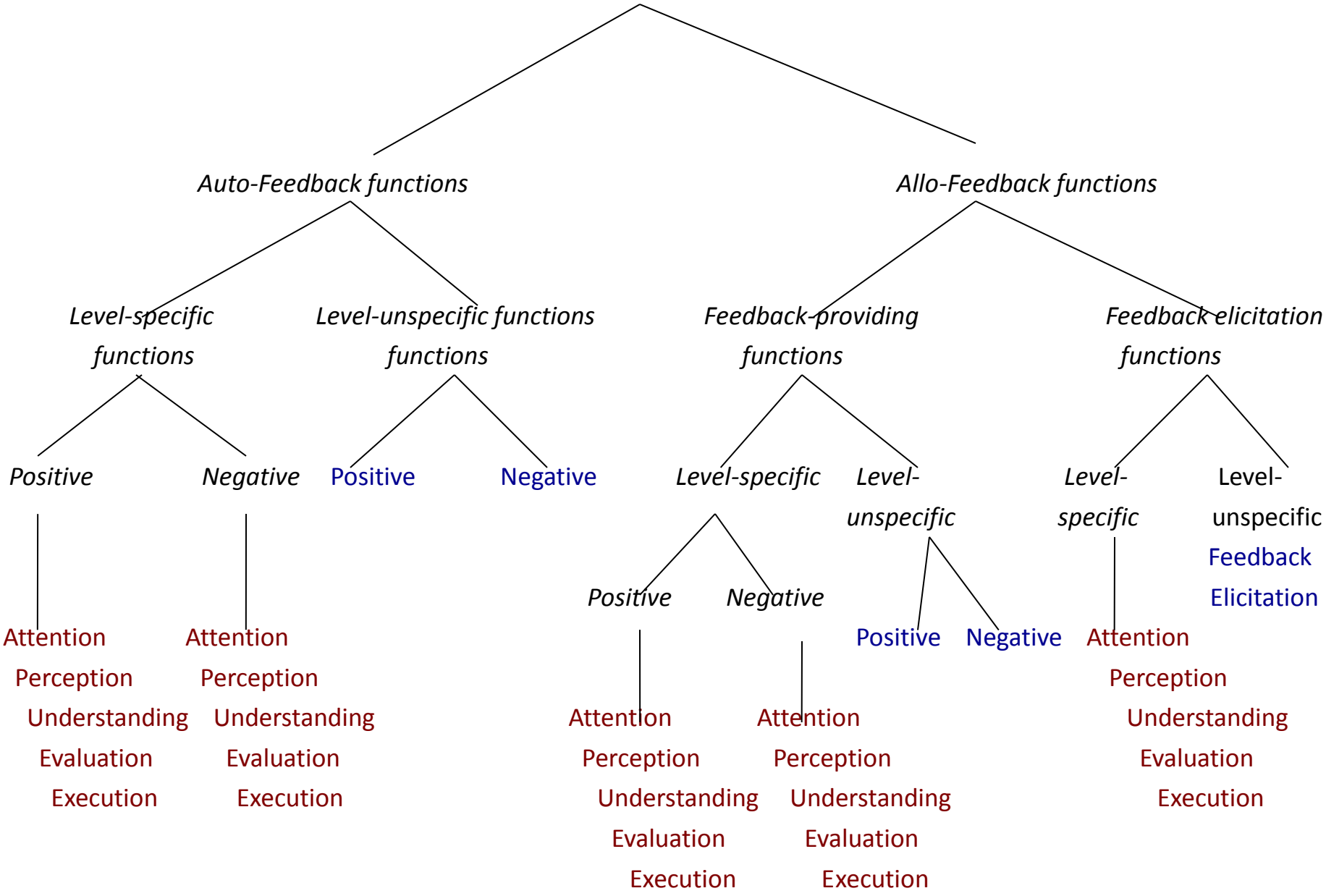
a. **General-purpose functions**, which can be used in every dimension, e.g. Inform, Question, Answer, Request, Offer

b. **Dimension-specific functions**, e.g. Take Turn, Stalling, Apology

ISO 24617-2 and DIT++ General-Purpose Communicative Functions



ISO 24617-2 and DIT++ Feedback-Specific Communicative Functions



feedback as dialogue acts

Feedback acts:

A. Inarticulate (not specifying scope or processing outcome, just indicating success of processing):
Dialogue acts with ***Feedback-specific communicative function***: positive or negative, level-specific (in DIT^{++}) or level-unspecific (in ISO 24617-2).

B. Articulate (specifying scope and/or processing outcome):
Dialogue acts with a ***General-purpose communicative function*** and a ***semantic content*** concerning the processing of previous utterances (level-specific or level-unspecific).

Focus: **Semantics of type-A feedback acts**.

Dialogue act semantics

In Dynamic Interpretation Theory (DIT), dialogue acts describe *utterance meanings* ('interpretations') as dialogue acts, whose semantics is defined as *update operations on* participants' *information states* ('contexts').

General idea:

- The ***communicative function*** of a dialogue act is a recipe for specifying how to update an addressee's information state with the information that forms its ***semantic content*** when the addressee understands the dialogue act.

semantics of level-specific feedback acts

B: From Evon to Dowth is 4 hours.

A: I see -

inarticulate positive auto-feedback act at the level of understanding

semantics of level-specific feedback acts

B: From Evon to Dowth is 4 hours.

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inarticulate positive auto-feedback act at the level of understanding

communicative function: AutoPositive

semantic content: *A has understood that B believes that p4*

p4 =" E-D is 4 hrs"

semantics as context update

Speakers by default assume that they are well understood (Clark), in particular when “normal input/output conditions” (Searle) (NIO) apply.

Understanding communicative behaviour: recognising the dialogue acts performed

semantics as context update

Speakers by default assume that they are well understood (Clark), in particular when "normal input/output conditions" (Searle) (NIO) apply.

Understanding communicative behaviour: recognising the dialouge acts performed i.e. believing that the characteristic conditions of the dialogue acts hold :

(*) *S assumes that A believes that the char.conditions of S's dialogue acts hold*

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(****) and… ➔➔ *mutual belief about (*)*

The expected understanding of communicative behaviour gives rise to believed mutual beliefs of the form:

S and A mutually believe that S assumes that A believes that c

S and A mutually believe that S weakly believes that A believes that c

for every characteristic condition *c*.

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for every characteristic condition *c*.

feedback, understanding, and grounding

Grounding problem reformulated:

How do “weak mutual beliefs” of the form:

*S and A mutually believe that S **weakly believes** that A believes that c*

get strengthened to become firm mutual beliefs:

*S and A mutually believe that S **believes** that A believes that c*

which is equivalent to:

S and A mutually believe that A believes that c

(Positive) Feedback Chaining

Evidence of being understood and believed continues to accumulate as the dialogue continues successfully.

To receive positive feedback on your last utterance is evidence that the speaker thinks you successfully processed his preceding utterance.

Example:

da1 A: What time is it?

da2 S: It's ten fifteen.

da3 A: Thanks.

➔ da3 forms evidence for S that he successfully processed dialogue act da1. ("Apparently I understood the question correctly")

Negative Feedback Chaining

Negative feedback on a previous utterance means that the speaker thinks that his previous utterance was not processed successfully.

Example:

- A: Where do you work?
- S: On the Eiffel tower.
- A: Excuse me?

➔ S should cancel the update effects caused by assumed correct understanding of the first utterance

feedback, understanding, and grounding

A: From Evon to Dowth is 4 hours.

S: I see - *positive auto-feedback at the level of understanding*

Characteristic conditions of S's feedback act (p4 = *E-D is 4hrs)*:

(c1) **Bel**(S, **Bel**(A, p4))

(c2) **Want**(S, **Bel**(A, **Bel**(S, **Bel**(A, p4))))

Effects of expected understanding:

Mbel(A,S, **Wbel**(S, **Bel**(A, c1)))

Mbel(A,S, **Wbel**(S, **Bel**(A, c2)))

The creation of these mutual beliefs is the semantics of the feedback act.

feedback, understanding, and grounding

A: From Evon to Dowth is 4 hours.

S: I see - *positive auto-feedback at the level of understanding*

Effects of expected understanding:

(c1') **Mbel**(A,S, **Wbel**(S, **Bel**(A, **Bel**(S, **Bel**(A, p4)))))

(c2') **Mbel**(A,S, **Wbel**(S, **Bel**(A, **Want**(S, **Bel**(A, **Bel**(S, **Bel**(A, p4))))))))

Additional effect of *full-out successful processing, including the 'adoption' level*:

(d1) **Mbel**(A,S, **Wbel**(S, **Bel**(A, **Bel**(S, **p**4))))

Strengthening (c1') and (d1) would lead to:

(c1'') **Mbel**(A,S, **Bel**(S, **Bel**(A, **Bel**(S, **Bel**(A, p4))))), i.e. to **Mbel**(A,S, **Bel**(A, p4))

(d1') **Mbel**(A,S, **Bel**(S, **Bel**(A, **Bel**(S,p4)))), i.e. to **Mbel**(A,S, **Bel**(S,p4)).

Together, these two are equivalent to **Mbel**(A,S, p4) !

feedback, strengthening, and grounding

A dialogue participant S strengthens a "weak mutual belief" of the form *S believes that it is mutually believed that S* **weakly** *believes that A believes that p* (with precondition *p* of a dialogue act performed by S by means of utterance *u*)

iff:

(1) S believes that [*] u was correctly understood;

(2) S has evidence that A believes that [*];

(3) S has evidence that A has evidence that (1) and (2)

This means that both participants should have received at least one positive feedback message plus one confirmation of understanding that message.

Note: This is a pragmatic principle, which holds only under the conditions of Normal I/O (NIO) and Everyday Risk (ERC).

As such, its implications are defeasible in certain contexts.

strengthening the weakest link

Evidence for understanding and believing what was said is gained from:

- **Explicit feedback** (positive or negative feedback acts)
- **Implicit feedback: *entailed* or *implicated***

  Positive

  - Task-related dialogue acts as continuations that are relevant to the underlying activity;
  - Social dialogue acts like thanking and saying goodbye

  Negative

  - Task-related dialogue acts as continuations that are irrelevant to the underlying activity;

  Neutral/Absent (except at the level of attention)

  - No evidence either way: Time management acts; Turn management acts; Contact management acts

feedback, strengthening, and grounding

1. A: From Evon to Dowth is 4 hours.
2. S: I see.
3. A: OK, shouldn't be any problem I think.
4. S: I don't think so.
5. A: Let's go that way then.

Two times positive feedback, either explicitly or implicitly, licences creation of a firm mutual belief.

After utterance 4, the information *E-D is 4hrs* may be assumed to be grounded; utterance 5 can be seen as the closure of this grounding process.

implementations

- Early implementation: PARADIME Dialogue Manager component of the IMIX multimodal dialogue system
  - Simon Keizer, Harry Bunt, and Volha Petukhova (2011) Multidimensional Dialogue Management. In: A. van den Bosch and G. Bouma (eds.*) Interactive Multimodal Question Answering*. Springer, pp. 57-86.
- Tracking of beliefs and common ground in European Youth Parliament debates
  - Andrei Malchanau, Volha Petukhova,Harry Bunt and Dietrich Klakow (2015) Multidimensional dialogue management for tutoring systems. *Proceedings 7th Language and Technology Conference (LTC 2015)*, Poznan, Poland);
  - Volha Petukhova, Andrei Malchanau and Harry Bunt (2016) Modelling argumentation in parliamentary debates: data collection, analysis, and test case**.** *Springer Lecture Notes in Computer Science* (forthc.)
- Dialogue Manager component in Metalogue system
  - (EU project: http://www.metalogue.eu)

semantics of level-unspecific feedback acts

B: I think the next meeting is on Friday

A: Okay - *positive auto-feedback at the level of understanding*

1. B'_{PC} =+ **Bel**(B, **Want**(A, **Bel**(B, **Understood**(A, *B thinks the next meeting is on Friday*))))

2. B'_{PC} =+ **Bel**(B, **Want**(A, **Understood**(A, *B thinks the next meeting is on Friday*)))

General form of level-specific (negative) auto-feedback:

1. B'_{PC} =+ **Bel**(B, **Want**(A, **Bel**(B, (not) **Success-Proc'd**$_i$(A, *scope*))))

2. B'_{PC} =+ **Bel**(B, **Want**(A, (not) **Success-Proc'd**$_i$(A, *scope*)))

Successfully processed: *processed with sufficient success to not require a clarification, repetition, or correction of the material in the scope*

semantics of level-unspecific feedback

DIT++ dialogue act taxonomy has level-specific and level-unspecific feedback acts;

ISO 24617-2 has only level-unspecific feedback act types.

B: I think this may lead to too many buttons.

C: *(nodding)* M-hm. *positive auto-feedback*

1. B'_{PC} =+ **Bel**(B, **Bel**(A, **Successfully-Processed**(A, … *too many buttons*))))

2. B'_{PC} =+ **Bel**(B, **Want**(A, **Bel**(B, **Successfully-Processed**(A, … *too many buttons*))))

What does **Successfully-Processed** mean?

Successfully processed: *processed with sufficient success to not require a clarification, repetition, or correction of the material in the scope*

interpretations of 'successful processing'

Interpretation levels (in %) of level-unspecific feedback acts in Map Task (= MT) and Dutch OVIS (= OV) dialogues

	Auto-	positive	Auto-	negative	Allo-	Positive	Allo-	negative
	MT	OV	MT	OV	MT	OV	MT	OV
attention	3	0	0	0	0	0	0	0
perception	0	28	0	6	1	3	0	9
understanding	4	20	2	6	2	0	9	14
evaluation	32	0	0	0	8	0	0	6
execution	34	0	1	8	12	0	0	0

Conclusions:

- "never" at the level of attention;
- MT (human-human): positive = at least evaluation; negative: understanding
- OV (human-computer): perception/understanding – interpret cautiously!

Semantics & Pragmatics of feedback: entailments & implicatures

Positive:

Execution >>
< Evaluation >>
< Interpretation >>
< Perception >>
< Attention

Negative:

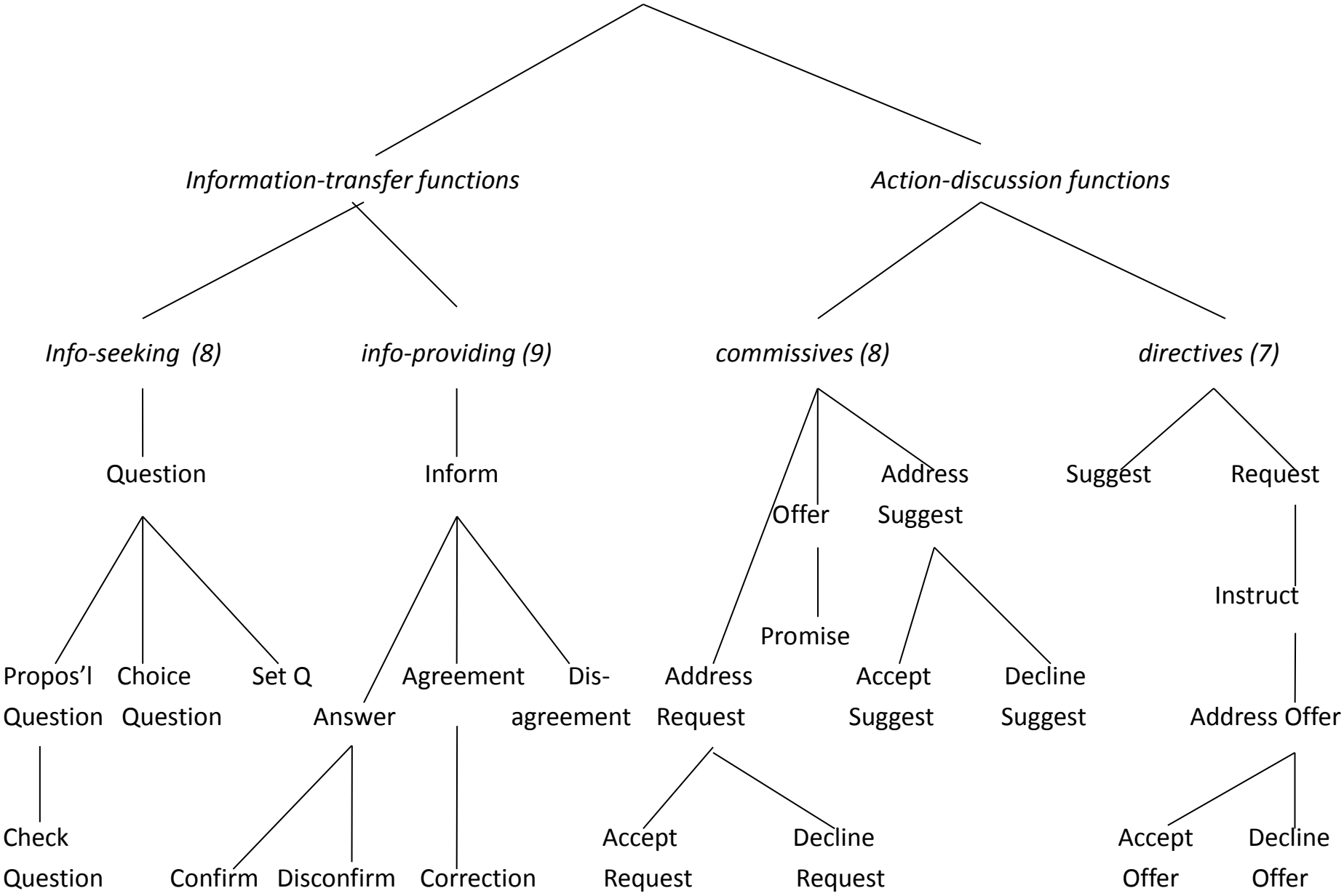
Attention >>
< Perception >>
< Interpretation >>
< Evaluation >>
< Execution

>> = entailment
< = implicature

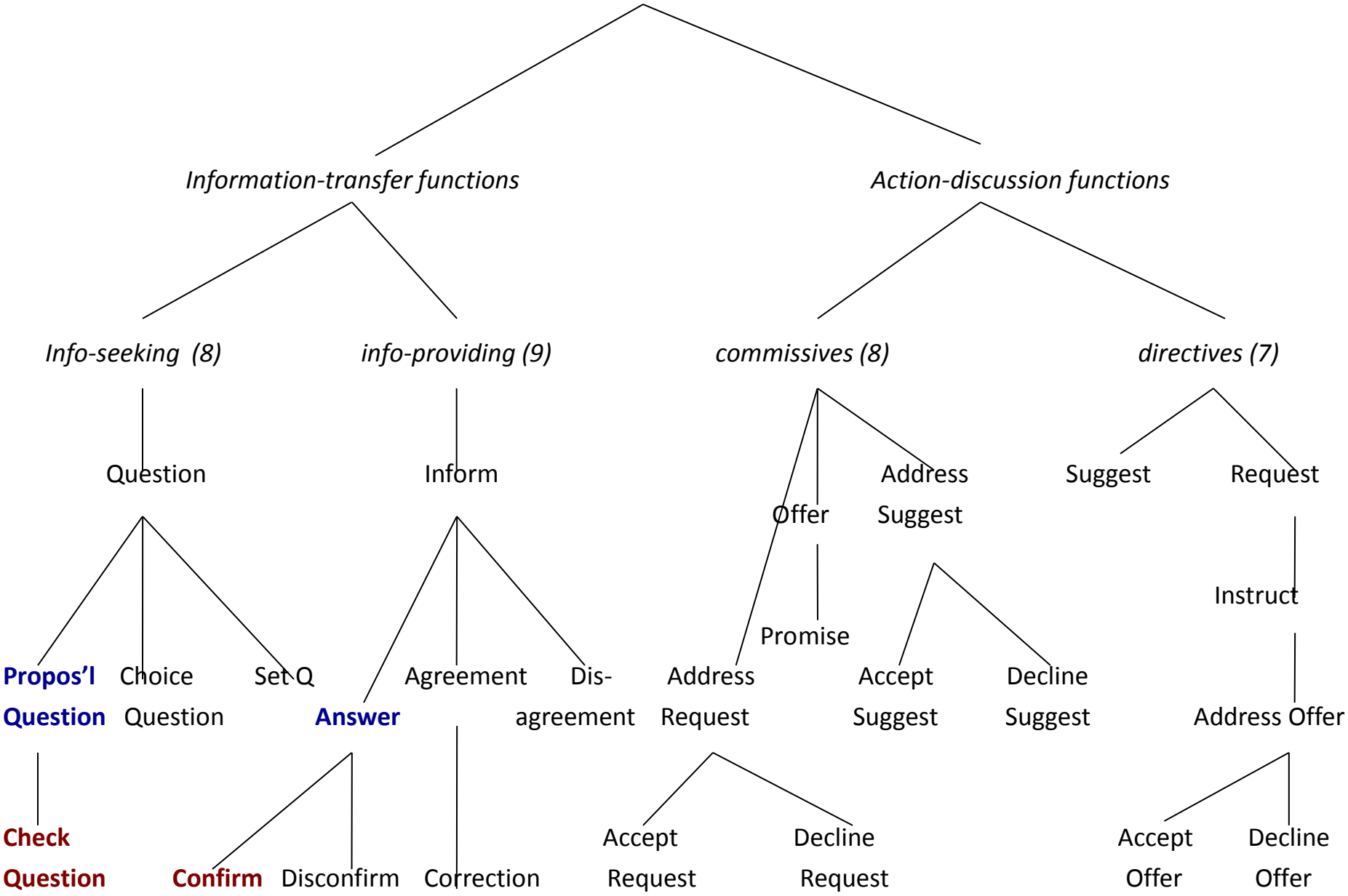
Concluding remarks

- Feedback behaviour can be analysed in terms of dialogue acts, having a context-update semantics dependent on the level of processing that they address.
- Inarticulate, level-unspecific feedback can be interpreted at a level of processing that depends on the interactive situation.
- Level-specific and level-unspecific feedback functions can peacefully coexist. (ISO 24617-2 ought to be revised in this respect…?)
- Establishment of Common Ground can be modelled computationally through the semantic update effects of (explicit or implicit) feedback as "weak mutual beliefs" whose strengthening is described by the pragmatic Strengthening Principle.
- Proof-of-concept implementations of this model of feedback and grounding show interesting results.

ISO 24617-2 and DIT^{++} General-Purpose Communicative Functions



ISO 24617-2 and DIT++ General-Purpose Communicative Functions



outline

outline

outline

Concluding remarks

Level-specific feedback acts have a 'straightforward' context-update semantics, using the semantic primitives relating to processing levels

Inarticulate feedback acts constructed with a feedback-specific communicative function have a similar but slightly different (implicatures!) update semantics at a level of processing that depends on the global dialogue context

Level-specific and level-unspecific feedback functions can peacefully coexist. (ISO 24617-2 ought to be revised in this respect…?)

Partial repetition or paraphrase of an utterance identifies feedback scope:

- positive feedback ➔ positive feedback about the entire utterance;
- negative feedback ➔implicated positive feedback about the rest of the utterance.

dimensions

Participants in a dialogue act in order to

- perform a certain task or activity

and they also

- provide and elicit feedback;
- manage the use of speaking turns and time;
- edit their own and their partner's speech;
- open and close topics and subdialogues;
- deal with social obligations (*greet, thank, apologize...*)

and they often do several of these things simultaneously.

These different kinds of communicative activity, concerned with different information categories, are called **dimensions**.

effects of understanding feedback acts

A: From Evon to Dowth is 4 hours.

S: I see - *inarticulate positive auto-feedback at the level of understanding*

Characteristic conditions of S's feedback act: *(p4 = "E-D is 4hrs")*

(c1) **Bel**(S, **Understood**(S, *A believes that p4*))

(c2) **Want**(S, **Bel**(A, **Understood**(S, *A believes that p4*)))

Effects of performing this dialogue act:

1. **Mbel**(A,S, **Wbel**(S, **Bel**(A,c1))

2. **Mbel**(A,S, **Wbel**(S, **Bel**(A, c2))

effects of understanding feedback acts

A: From Evon to Dowth is 4 hours.

S: I see - *positive auto-feedback at the level of understanding*

Characteristic conditions of S's feedback act:

(c1) **Bel**(S, **Understood**(S, *A thinks E-D is 4hrs*))

(c2) **Want**(S, **Bel**(A, **Understood**(S, *A thinks E-D is 4hrs*)))

Effects of understanding this dialogue act:

1. **Mbel**(A,S, **Wbel**(S, **Bel**(A, c1))

2. **Mbel**(A,S, **Wbel**(S, **Bel**(A, c2))

Effect of acceptance ('believing') what S says:

3. **Mbel**(A,S, **Wbel**(S, **Bel**(A, **Understood**(S, *A thinks E-D is 4hrs*)))

semantics of level-specific feedback acts

B: From Evon to Dowth is 4 hours.

A: I see -

inarticulate positive auto-feedback act at the level of understanding

communicative function: AutoPositive

semantic content: *A has understood that B believes that p4*

p4 =" E-D is 4 hrs"

Update of B's information state:

1. B'_{PC} =+ **Bel**(B, **Bel** (A, *B believes that p4*))
2. B'_{PC} =+ **Bel**(B, **Want**(A, **Bel**(B, **Bel**(A, *B believes that p4*))))

Multifunctionality

A: Henry, could you take us through these slides?

Turn Assign (to Henry); *Request*

H: O..w..k..ay.. just ordering my notes

Turn Accept; Stalling; Positive Feedback; Accept Request; Inform

Level-unspecific feedback

Unlike level-specific feedback, *level-unspecific feedback acts, interpreted at a certain level of processing, have no level-related implicatures*

A: How many buttons did you say?

B: I said five max.

A: Right.

Adding the possibility for annotators to use level-unspecific feedback functions increases inter-annotator agreement from $\kappa = 0.34$ to $\kappa = 0.88$.

➔ Feedback functions can reliably be annotated in a level-specific way, provided that annotators are not forced to choose a level.

feedback, strengthening, and grounding

1. A: From Evon to Dowth is 4 hours.
2. S: I see.
3. A: OK, shouldn't be any problem I think.
4. S: I don't think so.

Characteristic conditions of A's Inform act (p4 = *E-D is 4hrs*):

(c3) **Bel**(A,p4)

(c4) **Want**(A, **Bel**(S,p4))

Effect of expected successful processing of the Inform act:

[MB1a] **Mbel**(A,S, **Wbel**(A, **Bel**(S,c3))) i.e. **Mbel**(A,S, **Wbel**(A, **Bel**(S, **Bel**(A, p4))))

Expected belief adoption: **[MB1b]** **Mbel**(A,S, **Wbel**(A, **Bel**(S, p4)))

feedback, strengthening, and grounding

1. A: From Evon to Dowth is 4 hours.
2. S: I see.
3. A: OK, shouldn't be any problem I think.
4. S: I don't think so.

Effect of expected understanding of the Inform act in 1:
[MB1] **Mbel**(A,S, **Wbel**(A, **Bel**(S, **Bel**(A, p4))))

Feedback Chaining Principle: successful processing of the feedback act in 2 tells A that his Inform in 1 was successful ➔ A strengthens [MB1] to:

[MB1'] **Mbel**(A,S, **Bel**(A, **Bel**(S, **Bel**(A, p4)))), i.e. to **Mbel**(A,S, **Bel**(A, p4))

feedback, strengthening, and grounding

1. A: From Evon to Dowth is 4 hours.
2. S: I see.
3. A: OK, shouldn't be any problem I think.
4. S: I don't think so.

A strengthens [MB1a] and [MB1b] to:

[MB1a'] **Mbel**(A,S, **Bel**(A, **Bel**(S, **Bel**(A, p4)))), i.e. to **Mbel**(A,S, **Bel**(A, p4))

[MB1b'] **Mbel**(A,S, **Bel**(A, **Bel**(S, p4))), i.e. to: **Mbel**(A,S, **Bel**(S, p4)).

So according to A: **Mbel**(A,S, p4): p4 can be grounded!

(i.e. **Bel**(A, **Mbel**(A,S, p4)))

After successful performance of the dialogue act in utterance 3, S believes that his feedback act in utterance 2 was successful, and S can ground p4 as well.