

# Dialogue Acts and Updates for Semantic Coordination

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## Abstract

This paper outlines an account of semantic coordination, focusing on word meaning negotiation, formalised in Type Theory with Records (TTR). The account combines parts of two dialogue act taxonomies related to semantic coordination, and relate these to meaning updates both on an abstract level and at a more detailed level.

## 1 Introduction

Semantic coordination is the process of interactively agreeing on the meanings of words and expressions, and (simultaneously) agreeing on which words are appropriate in a given context. Shared meanings are achieved by agents interactively coordinating their respective takes on those meanings (Larsson, 2008).

Semantic coordination can happen tacitly as a side-effect of dialogue interaction, as a result of dialogue participants quietly accommodating observed differences in their takes on meanings and those of their conversational partners (Larsson, 2010). However, semantic coordination can also happen through more or less explicit discussion and negotiation of meanings of words and expressions. It is the latter type of semantic coordination that we will focus on here.

In this paper, we will sketch a general account of dialogue acts for semantic coordination in dialogue by (1) sketching a synthesis of two existing taxonomies of dialogue acts relating to semantic coordination and (2) relating these dialogue acts to different kinds of updates to (agents takes on) meanings.

## 2 Dialogue acts for Semantic Coordination

In this section, we will begin to synthesize two taxonomies for dialogue acts related to semantic coordination. While these taxonomies are designed for different settings (first language acquisition and online discussion forums), they nevertheless overlap in interesting ways. By combining and relating them, we hope to eventually provide a more comprehensive overview of the dialogue acts used in semantic coordination independently of setting and domain.

### 2.1 Dialogue acts for word meaning negotiation

In Myrendal (2015) and Myrendal (submitted), a taxonomy for dialogue acts involved in Word Meaning Negotiations (WMNs) in online discussion forum communication is presented. We here show only parts of the taxonomy. All examples are taken from Myrendal (2015).

Frequently, the question under discussion (QUD) in a WMN concerns whether a certain *trigger expression*  $T$  correctly describes a situation  $S$  under discussion (what may be called a *SUD* in analogy with QUD). However, in some cases there is no particular SUD, but meanings are negotiated more abstractly.

Two kinds of WMNs are identified: those initiated due to problems with understanding a specific word or expression (NONs) and those indicating disagreement with a choice of words (DINs). NONs typically display a regular TIR(RR) structure: Trigger (a use of the target word  $T$ ), Initiator (indicating a problem understanding  $T$ ), Response (usually repairing the problem) and an optional Reaction to the response (acknowledging the repair). By contrast, DINs are much less structured. While the relative frequency of the various dia-

logue acts differ between NONs and DINs, there is a large overlap in the range of available acts. Hence, the taxonomy of dialogue acts includes all acts involved in NONs or DINs.

**Explicification<sup>1</sup>:** Provides an explicit (partial or complete) definition of *T*. Myrendal (2015) distinguishes between two types of explicifications. **Generic explicifications** foreground the meaning potential of *T*; a complete or partial definition *D* of *T* is provided, but *D* is not clearly derived from *S*<sup>2</sup>. For example, Myrendal (2015) shows an example where a DP (Dialogue Participant) is asked to clarify the meaning of *sexism*, in response to a clarification request "What do you mean by 'sexism'?", and in response offers a definition: "That people are treated differently because of their gender."

By contrast, **specific explicifications** foreground conversational context; particular aspects of the SUD *S* are made explicit and presented as a (typically partial) definition of *T*<sup>3</sup>. One example is taken from a discussion about whether or not piercing the ears of young children is morally acceptable, or if it constitutes (*child*) *abuse*: "Clearly ABUSE to pierce the ears of young children! [...] - you inflict pain upon the child and a physical change which the child herself has not chosen and which cannot be made undone."

Specific explicifications can also be negative. In one discussion the trigger word *boozing* (Sw. *super*). This discussion is about a woman who is denied alcohol in a restaurant. The bartender refuses to serve the woman a second glass of wine when he notices that she is breastfeeding her baby at the table. The thread starter in this discussion describes the woman's behaviour as "boozing" which receives the following response: "2 glasses of wine is not boozing and it is not dangerous to drink while breastfeeding."

**Exemplification:** Providing examples of what the trigger word can mean, or usually means. In a discussion about dietary habits, many DPs state that they prefer to include full fat products in their diet. One DP requests clarification about the meaning of the trigger word ("What counts as full

fat?"). Another DP then exemplifies the meaning of the trigger word: "When it comes to dairy products ordinary full cream milk, the fattest cheese and regular double cream (...)".

Similar to (specific) explicifications, exemplification can be negative. In a discussion about fast food, a DP protests against another DP's claim that (all) food from McDonald's is *unhealthy* (*T*): "Hamburgers with lettuce and water is not especially unhealthy."

**Contrast:** A third way of contributing to a WMN sequence is to contrast *T* against another word *C*, thus indicating a difference in meaning as well as updating the meanings of both *T* and *C* with respect to some example situation or entity. In WMNs, acts of contrasting can serve a delimitation function, when the two contrasted words are closely related and share aspects of meaning potential. According to Clark (1993), participants in conversation generally assume that a difference in form marks a difference in meaning (the principle of contrast). Contrasting two related words thus indicates a difference in their meanings. It may also result in updating both meanings with respect to the SUD.

In a discussion about whether or not it is acceptable to flirt with a married person, after a while it becomes clear that the participant asking this question has a specific situation in mind. The person doing the alleged flirting has expressed strong feelings towards the married person, sending her many text messages and e-mails per week and also sending flowers to her workplace. At this point, one participant objects to the trigger word being used to describe the SUD, and contrasts the trigger word with other words taken to be more suitable descriptions of the situation: "This is pure and utter courtship/picking someone up/declaration of infatuation! This is not how you flirt... at least not how I flirt. This is clearly way beyond flirting in my world." Here, the focus of the contrast is on the "upper boundary" of the meaning potential of the negotiated word. The behavior is claimed to go beyond "flirting" and to be more accurately described as "courtship", "picking someone up" or "declaration of infatuation".

## 2.2 Dialogue acts for first language acquisition

Clark and Wong (2002) provide a taxonomy of dialogue acts involved in first language acquisition.

<sup>1</sup>The term explicification is borrowed from Ludlow (2014), but is adapted and elaborated in Myrendal (2015).

<sup>2</sup>Complete generic definitions are sometimes taken from dictionaries.

<sup>3</sup>The definitional component is typically more specific than one would expect from e.g. a dictionary definition.

tion. We will here describe a subset of this taxonomy. (Note that we will be using some terminology from Myrendal (2015) when describing these acts, even if this is not exactly how they are described in Clark and Wong (2002).)

**Direct offers** are utterances where speakers offer conventional terms or expressions, and nothing else; the primary function of the utterance is as an offer. Direct offers tend to be made using only a limited set of frames for presenting the term being offered. For example, "That's a pen", "That's called a dentist", "What is this? Chair.", "What's that called? Dancing".

There are also *indirect offers*, where speakers (adults) use their next utterance, whatever it is, to include the term that is simultaneously being offered as a correct form of a term in the addressee's (child's) utterance. We will here concern ourselves with one kind of indirect offer, namely *explicit* ones. In cases of **explicit replace**, a term or expression *C* is proposed as a replacement for *T*. An example from Clark and Wong (2002) is the following:

Naomi: Birdie birdie.

Mother: Not a birdie, a seal.

Here, "seal" (*C*) is offered as a replacement for "birdie" (*T*).

### 2.3 Towards a synthesis

A basic difference between WMN in online discussion forums (henceforth ODF) as described in (Myrendal, 2015) and first language acquisition (1LA) is that the latter setting typically requires a shared perceptually available situation, whereas ODF pretty much exclude this possibility. Deictic phrases (e.g. "that") in 1LA typically refer to aspects of the shared perceptual situation, whereas in ODF they typically refer to aspects of the situation under discussion, which is only available to DPs through verbal descriptions.

Also, in ODF speakers are assumed to be competent, so attempts at unprovoked teaching of words (which is frequent in 1LA) are not motivated. Furthermore, ODF interaction is written whereas adult-child dialogues are spoken and arguably more interactive. Despite these differences, we believe it may be interesting to also briefly note some similarities between the respective dialogue act taxonomies for ODF and 1LA.

Firstly, Clark and Wong's **explicit replace** ("that's not an X, that's a Y") is very similar to Myrendal's **contrast**, but where the example is provided by the jointly perceived situation rather than by a verbal description. Secondly, Clark and Wong's **direct offer** is similar to Myrendal's (positive) **exemplification**, but again the example is provided by the jointly perceived situation.

For our current purposes, we will simply assume that direct offers can be treated as exemplifications and that explicit replace can be treated (more or less) as contrast. Importantly, doing so requires allowing for jointly observable situations (potentially including subsymbolic information derived from the sensory apparatuses of agents) to serve as the basis for the updates involved in both exemplification and contrast.

### 3 Meaning representations and updates

A full account of semantic updates involved in WMNs would require capturing the sequential updates at various stages of the negotiation process. Our goals here are more modest, in that we will not consider sequential updates or rejected proposals, but only try to capture isolated updates for *accepted* dialogue acts.

The exact way in which meaning updates are formalised will depend on how meanings are represented. Marconi (1997) distinguishes between inferential meanings of words, which enables to draw inferences from uses of the word, and referential meaning, allowing speakers to identify the objects and situations referred to by the word. Firstly, We will regard inferential meaning as high-level (symbolic) rules governing inference, e.g. meaning postulates in modal logic or record types (and associated functions) in TTR (Larsson and Cooper, 2009). Secondly, referential meaning may be represented at least in part as low-level (sub-symbolic) statistical or neural classifiers of perceptual data (Harnad, 1990; Steels and Belpaeme, 2005; Larsson, 2013; Kennington and Schlangen, 2015). A key insight here is that the step from perception to language can be conceptualised and implemented as the application of a classifier to perceptual data, yielding linguistically relevant classification results as output.

Correspondingly, we may distinguish kinds of meaning updates. High-level structures can be modified e.g. by adding and retracting meaning postulates or "possible languages" (Barker,

2002), or by adding and removing fields in record types representing inferential meanings (Larsson and Cooper, 2009). Low-level aspects of meanings, modeled as classifiers, can be modified by retraining the classifier with new (positive or negative) data.

However, there are also intermediate cases. For example, as shown in the account of vagueness involving comparison classes (Fernández and Larsson, 2014), meanings may involve both high-level (e.g. comparison class for vague terms) and low-level information (e.g. perceived height). Similarly, meaning updates may concern both high-level and low-level information (e.g. perceived height).

We will adopt a fairly abstract formalism for conceptual updates, where we assume that either a full or partial (verbal and hence symbolic/high-level) definition  $D$  of the trigger word  $T$  has been provided, or alternatively an example situation or entity<sup>4</sup>  $E$  (represented using high or low level information, or a combination thereof).  $D$  or  $E$  is then used for updating the meaning in question.

- $\delta^+(T, D)$ :  $T$  updated with  $D$  as a partial definition of  $T$
- $\delta^-(T, D)$ :  $T$  updated with  $D$  as a negative partial definition of  $T$
- $\epsilon^+(T, E)$ :  $T$  updated with  $E$  as a positive example of a situation described by  $T$
- $\epsilon^-(T, E)$ :  $T$  updated with  $E$  as a negative example of a situation described by  $T$

These abstract update operations can then be further specified depending on the semantic formalism used. The abstract meaning update functions thus serve as a sort of API between dialogue acts and their consequent meaning updates.

Although it is not explicit in the formalism used here, semantic updates always concern a particular agent’s take on the meaning of the word in question. Meanings become shared by being interactively coordinated. Also, the viability of a semantic update may be limited to a specific dialogue, or it may eventually spread over a community and become part of “the language” as it is represented in dictionaries, or it may become part of a more limited domain-specific sub-language (Larsson, 2008).

<sup>4</sup>Insofar as entities can be reified as situations involving them, we need only to talk about example situations.

When a particular agent  $A$  updates her take on a trigger word  $T$ ,  $S$  will be  $A$ ’s take on the jointly perceivable situation. In fact, semantic updates are always agent-relative. Group-level semantic updates could be construed in terms of individual-level updates.

#### 4 Meaning updates for dialogue acts

In this section, we present an initial characterisation of explicification, exemplification (including direct offers) and contrast (including explicit replace) in terms of the meaning updates described in the previous section.

Note that we are here formalising the update effect of successful (i.e. accepted) meaning updates. In general, proposed updates may not be accepted immediately but can lead to negotiation that may end up with coordinating on proposed update, no update or modified update. Formalising such exchanges is left for future work.

We will sidestep the problem of interpreting verbal definitions by simply using  $\llbracket$ double square brackets $\rrbracket$  to indicate meanings of linguistic expressions. Updated meanings are indicated by a prime ( $'$ ).

**Explicification:** By definition, explicifications provide a (full or partial) definition  $D$  of  $T$ , and the update is thus symbolic (linguistic) in nature which means that only the  $\delta$  function is needed here.

As mentioned above, in the case of specific explicifications, the definition  $D$  is derived by abstraction over the (verbally described) SUD  $S$ .

- Generic explicification
  - Update:  $T' = D$  (full) or  $T' = \delta^+(T, D)$  (partial)
  - Example:  $\llbracket$ sexism $\rrbracket' = \llbracket$ that people are treated differently because of their gender $\rrbracket$
- Specific explicification
  - Positive update:  $T' = \delta^+(T, D)$
  - Example:  $\llbracket$ child abuse $\rrbracket' = \delta^+(\llbracket$ child abuse $\rrbracket, \llbracket$ to inflict pain upon the child and a physical change which the child herself has not chosen and which cannot be made undone $\rrbracket)$
  - Negative update:  $T' = \delta^-(T, D)$
  - Example:  $\llbracket$ boozing $\rrbracket' = \delta^-(\llbracket$ boozing $\rrbracket, \llbracket$ (drinking) 2 glasses of wine (or less) $\rrbracket)$

**Exemplifying** Proposes an example  $E$  of a situation or entity appropriately (or not, in the case of negative exemplification) described by  $T$ . The example can either be given verbally or it can be relevant aspects of the jointly perceived situation (often indicated by a deictic reference (“that”)).

- Update:  $T' = \epsilon^+(T, E)$  or  $T' = \epsilon^-(T, E)$
- Example:  $\llbracket \text{full fat} \rrbracket' = \epsilon^+(\llbracket \text{full fat} \rrbracket, \llbracket \text{full cream milk} \rrbracket)$
- Example:  $\llbracket \text{pen} \rrbracket' = \epsilon^+(\llbracket \text{pen} \rrbracket, S)$  where  $S$  is a jointly perceivable situation.
- Example:  $\llbracket \text{unhealthy} \rrbracket' = \epsilon^-(\llbracket \text{unhealthy} \rrbracket, \llbracket \text{hamburgers with lettuce and water} \rrbracket)$

The last example above shows that the meanings negotiated may sometimes be specific to a domain (here, fast food).

**Contrast:** Proposes contrasting word  $C$  as an appropriate description of an example entity or situation  $E$  (as in positive exemplification), and trigger word  $T$  as inappropriate (as in negative exemplification)<sup>5</sup>.

- Updates:  $T' = \epsilon^-(T, E)$ ,  $C' = \epsilon^+(C, E)$
- Example:  
 $\llbracket \text{flirting} \rrbracket' = \epsilon^-(\llbracket \text{flirting} \rrbracket, E)$   
 $\llbracket \text{courtship} \rrbracket' = \epsilon^+(\llbracket \text{courtship} \rrbracket, E)$ ,  
 where  $E = \llbracket \text{involves expressing strong feelings, sending many texts and emails, and sending flowers to the workplace} \rrbracket$ .
- Example:  
 $\llbracket \text{birdie} \rrbracket' = \epsilon^-(\llbracket \text{birdie} \rrbracket, E)$ ,  
 $\llbracket \text{seal} \rrbracket' = \epsilon^+(\llbracket \text{seal} \rrbracket, E)$ ,  
 where  $E$  is the jointly perceived (by Naomi and Mother) SUD in the example in Section 2.2.

## 5 Meaning updates in TTR

In this section, we propose a very tentative formalisation of meaning updates in Type Theory with Records (TTR, Cooper (2012)). Given the definitions in the previous section, this means we need

<sup>5</sup>Note that we here assume that contrast is always fleshed out in terms of exemplification rather than explicification. The reason is that in all cases of contrast we have seen, there is a particular situation (typically, the SUD) which is judged to be correctly described by one expression but not by another. One could imagine cases where a more abstract definition (explicification) was used as the basis for contrast, but we have not seen this in our data so far.

to define the four operators used in the definitions of the dialogue acts for meaning updates.

For current purposes, we assume meanings of words and phrases are represented as a meet type (corresponding to conjunction) of a record type  $T_{def}$  encoding a definition<sup>6</sup>, and a join type (corresponding to a disjunction)  $T_{exa}$  of  $n > 0$  record types<sup>7</sup> encoding examples<sup>8</sup>. The intuition is that something is of this type if it is of the definition type, or if it is of one of the example types<sup>9</sup>. This can then be supplemented with methods for updating the definition type by generalising over the example types. For 1LA situations, where there is a jointly perceivable situation and an agent’s take on that situation can be encoded as low-level information (e.g. a picture encoded as a real-valued matrix), generalisation from examples will most likely involve training classifiers. We leave this for future work, but see (Larsson, 2013) for an example of learning meanings (modeled as classifiers) from interaction.

The  $\delta^+$  function can be implemented in TTR using the *asymmetric merge* operator  $\boxed{\wedge}$ . This operator takes two record types  $T_1$  and  $T_2$  and produces a single record type equivalent to the meet type  $T_1 \wedge T_2$ , except that if a label  $\ell$  occurs in both  $T_1$  and  $T_2$ , the value of  $\ell$  in  $T_1 \boxed{\wedge} T_2$  will be  $T_2.\ell$ . We use it here to extend the definition record type  $T_{def}$  with another (possibly overlapping) record type representing the (full or partial) definition  $D$ .

$$\delta^+((T_{def} \vee T_{exa}), D) = (T_{def} \boxed{\wedge} D) \vee T_{exa}$$

Figure 1 shows an example of an update resulting from positive explicification and using the  $\delta^+$  operator.

<sup>6</sup>Elsewhere, we have assumed this to be a function  $f = \lambda r : T_{bg}.T_{fg}(r)$  from a record (representing a situation) of a “background type”  $T_{bg}$  to a “foreground type”  $T_{fg}(r)$  (representing the added information about the situation). The simplified representation used here can be thought of as the fixpoint type  $\mathcal{F}(f)$  (Larsson, 2013). This means that the meaning updates presented here need further specification in terms of how they update  $T_{bg}$  and  $T_{fg}$ . We leave this for future work.

<sup>7</sup>To avoid that  $n = 0$  we assume for the moment that either a definition or an example is available for any word, and whenever a new word is added and no example is available, the definition also serves as an example.

<sup>8</sup>We assume that examples are encoded as record types. In cases where the examples are instead records, we convert them to the corresponding singleton types (see Cooper (2012)).

<sup>9</sup>A consequence of this definition is that the definition is no less important than any example (which may or may not be what one wants). The difference between the definitions lies instead in how they are updated.

$$\llbracket \text{child-abuse} \rrbracket = \left[ \begin{array}{l} x \quad : \quad \text{Ind} \\ y \quad : \quad \text{Ind} \\ e_{abuse} \quad : \quad \text{abuse}(x,y) \\ c_{ip} \quad : \quad \text{inflict-pain}(x,y) \\ c_c \quad : \quad \text{child}(y) \end{array} \right] \vee T_{exa}^{c-a}$$

D =  $\llbracket$ to inflict pain upon the child and a physical change which the child herself has not chosen and which cannot be made undone $\rrbracket =$

$$\left[ \begin{array}{l} x \quad : \quad \text{Ind} \\ y \quad : \quad \text{Ind} \\ e_{abuse} \quad : \quad \text{abuse}(x,y) \\ c_{ip} \quad : \quad \text{inflict-pain}(x,y) \\ c_{phys} \quad : \quad \text{physical-change}(e_{abuse}) \\ c_{nc} \quad : \quad \neg \text{chosen}(y, c_{phys}) \\ c_{undo} \quad : \quad \neg \diamond \text{undo}(y, c_{phys}) \end{array} \right]$$

$$\llbracket \text{child-abuse} \rrbracket' = \delta^+ (\llbracket \text{child-abuse} \rrbracket, D) = (T_{def}^{c-a} \sqcap D) \vee T_{exa}^{c-a} =$$

$$\left[ \begin{array}{l} x \quad : \quad \text{Ind} \\ y \quad : \quad \text{Ind} \\ e_{abuse} \quad : \quad \text{abuse}(x,y) \\ c_{ip} \quad : \quad \text{inflict-pain}(x,y) \\ c_c \quad : \quad \text{child}(y) \\ c_{phys} \quad : \quad \text{physical-change}(e_{abuse}) \\ c_{nc} \quad : \quad \neg \text{chosen}(y, c_{phys}) \\ c_{undo} \quad : \quad \neg \diamond \text{undo}(y, c_{phys}) \end{array} \right] \vee T_{exa}^{c-a}$$

Figure 1: TTR example of meaning update resulting from positive explicitification

$$\llbracket \text{full fat} \rrbracket = T_{def}^{ff} \vee T_{exa}^{ff}$$

$$\llbracket \text{full cream milk} \rrbracket = \left[ \begin{array}{l} x \quad : \quad \text{Ind} \\ c_{milk} \quad : \quad \text{milk}(x) \\ c_{fc} \quad : \quad \text{full-cream}(x) \end{array} \right]$$

$$\llbracket \text{full fat} \rrbracket' = \epsilon^+ (\llbracket \text{full fat} \rrbracket, \llbracket \text{full cream milk} \rrbracket) = T_{def}^{ff} \vee T_{exa}^{ff} \vee \left[ \begin{array}{l} x \quad : \quad \text{Ind} \\ c_{milk} \quad : \quad \text{milk}(x) \\ c_{fc} \quad : \quad \text{full-cream}(x) \end{array} \right]$$

Figure 2: TTR example of meaning update resulting from positive exemplification

The  $\epsilon^+$  operator can be modeled as adding the example (represented as a record type) to  $T_{exa}$  using the  $\vee$  operator.

$$\epsilon^+((T_{def} \vee T_{exa}), E) = T_{def} \vee (T_{exa} \vee E)$$

An example of positive exemplification is shown in Figure 2.

We leave the definitions of the negative operators  $\delta^-$  and  $\epsilon^-$  for future work<sup>10</sup>.

Incidentally, TTR also enables formalising the intuition that for specific explicifications, the definition  $D$  is an abstraction over the SUD  $S$ . This can be done using the subtype relation to say that  $S$  is a subtype of  $D$ ; formally,  $S \sqsubseteq D$ .

## 6 Conclusion

We have sketched a formal account of semantic coordination, combining parts of two dialogue act taxonomies and relating these to meaning updates on an abstract level as well as on a more detailed level (but incompletely) using TTR. We hope the present account can work as a first attempt, to form the basis for future work towards a formal and implementable account of how dialogue agents can coordinate on meanings through interaction in natural language.

In near-future work, we plan to increase the coverage of the taxonomy, verify and if necessary extend the range of meaning update functions, and provide further details about how the meaning update functions can be specified in TTR. Specific issues that need to be dealt with include:

- extending our taxonomy to cover all the categories in both Myrendal’s and Clarks’ taxonomy
- working out how meaning updates work when meanings of sentences are functions rather than record types (fixpoint types)
- situating the whole account in a compositional semantics for (a fragment of) a natural language
- defining the negative operators  $\delta^-$  and  $\epsilon^-$  in TTR

<sup>10</sup>A complication here is that we do not want to require, for a situation  $s$  to be judged as being of a type  $[e]$  for some expression  $e$ , that a situation is of type  $\neg D$ , where  $D$  is an definition provided in a negative specific explicification. Nor do we want to allow that situations of type  $\neg E$ , where  $E$  is a situation type provided in a negative exemplification, count as being of type  $[e]$ .

- formalise more complicated sequences of meaning negotiation acts (not just the end result of successful, i.e. accepted, dialogue acts)

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