Expressions, Utterances and Directive Slots

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Abstract

The same linguistic entity can play a directive or a descriptive role, e.g. "cook dinner" can be moved from a column "to do" in a Kanban board to a column "done". We propose to account for such directive roles by enriching a previous framework of slot mereology for informational entities with the notion of directive slot. We differentiate expressions from the utterances they constitute in order to accommodate for the insight from the literature in pragmatics that most (if not all) expressions can constitute directive utterances in the appropriate context. We propose axioms involving constitution, slot-having and slot-filling on utterances, and articulate this theory with former work on directing actions.

Keywords

Information content entity, Imperative, Pragmatics, Role, Slot mereology

1. Introduction

Some linguistic entities (abbreviated "LIN-E") aim at directing an action – a paradigmatic example being imperative sentences (e.g.: "Eat your vegetables!"). Other LINEs describe an action: either a type of action ("eating one's vegetables"), or a particular action that takes place at some moment in time ("Magalie has eaten her vegetables today."). Some LIN-Es, however, are ambiguous in that respect. Consider for example the LIN-E "cook dinner" on a Kanban board. It can instruct me to cook dinner if placed in a "to do" column, or describe my process of having cooked dinner if placed in a "done" column. Actually, the very same LIN-E can have those two different *roles* (directive vs. descriptive) at different times, if moved from one column to another.

Moreover, sometimes we want to compare not two exactly similar LIN-Es that have different roles, but two *different* LIN-Es that have different roles, where one is more specific than the other. Consider the following example [1]: a doctor writes on a prescription "metoprolol 50 mg bid 1 month" (to instruct the pharmacist to give to a patient medication containing 50 mg of the active ingredient metoprolol in enough quantity to take it twice a day for a month), and a pharmacist writes in his records "Apo-Metoprolol 50 mg – 60 pills" (to register that he distributed to the patient 60 pills of the commercial drug preparation Apo-Metoprolol, which contains 50 mg of metoprolol by pill). In such a case, we may want to abstract the directive role from the instruction "metoprolol 50 mg bid 1 month" written by the doctor; indeed, this would enable to describe the fact that the type of action referred to by the pharmacist's utterance (namely the distribution of 60 pills of Apo-Metoprolol 50 mg) is a subtype of the action type referred to by the doctor's utterance (namely the distribution of an amount of medication enabling to take 50 mg of metoprolol twice a day for a month). Thus, it is important to dissociate a directive role from the content that fills this directive role, in order to compare the contents directly.

Some fields such as Natural Language Processing can aim at disambiguating between directive and descriptive linguistic entities in context. Here, we are instead interested in a representational/ontological question, namely: what is the nature of the entities involved in directive

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and descriptive utterances? Such an ontological representation is important for work that derive a database structures from an ontology (see e.g. [2]). Moreover, we want to have systematic representations not only for supporting the recognition (e.g. by NLP) of the directive or descriptive nature of an existing linguistic entity, but also so that the author of an utterance can tag it appropriately, when possible, such as a doctor tagging the statement "metoprolol 50 mg bid 1 month" as directive when writing it.

For that goal, we will build on former work for representing directive informational entities [3]. More specifically, we will introduce the notion of directive slot, inspired by recent work on a slot mereology on informational entities [4]. In the following, we will speak of "imperative sentences" associated with a "directive role", and "indicative sentences" associated with a "descriptive role". We will limit our present investigation to textual informational entities (excluding e.g. pictures, which can also have directive roles [5]). We will not develop here an ontology of language in the sense defined by Moltman ("the ontology that a speaker accepts when using a language" [6]), but rather an ontology describing linguistic entities. Indeed, linguistic entities are, like mental entities, legitimate denizens of the world, and a fully developed ontology of the world should be able to describe them. Thus, we do not use here language as a prism to consider the world, but as an object of the world that ontology should represent.

We present in Section 2 some former work from various disciplines about informational entities, linguistic entities and imperative sentences. In Section 3, we provide a linguistic and philosophical analysis of the entities that are relevant for the issue at hand. Section 4 proposes a few formal axioms relating them. A discussion and a conclusion follow.

2. State of the Art

2.1. The Ontology of Informational Entities

Ontologically, directive LIN-Es can be analyzed as informational entities. The Information Artifact Ontology (IAO) [7] introduces "Information content entities" (abbreviated "ICE"): an ICE can appear at several places in the physical world, as captured by the relation of *concretization* between an ICE and another entity – e.g. a quality such as the shape of an ink pattern or a hard drive configuration, or a process such as a Morse code signal (for a broader overview of informational entities in ontology, see [8]). Being part of the OBO Foundry [9], IAO is especially relevant for applications to biomedicine, such as deriving a database structure from an ontology in order to deal with cases like the metoprolol example mentioned above. Thus, the ontology we will present here will be largely built as a possible extension of IAO, but it would certainly be adaptable to other mainstream upper ontologies.

Informational entities are strongly related to the mental states that created them. A specificity of mental states is that they can carry an "intentionality" or "aboutness", where this term is taken as "the power of minds and mental states to be about, to represent, or to stand for, things, properties and states of affairs." [10] (in this sense, this refers to a mental attitude different from the "intention to act" that appears in e.g. belief-desire-intention theories). Informational entities are generally considered as also carrying an intentionality. IAO endorses Chisholm's view of "primacy of intentional" [11] according to which ICEs (and in particular some LIN-Es, for which "intentionality" is often called "reference" in the semantics field) inherit their intentionality from the intentionality of the ICE's creator's mind (see also the view defended by Haugeland, Searle and Fodor according to which a sentence's intentionality is derivative and dependent [10]). Biccheri et al. [12] propose a double view of aboutness as having a *content* (that can be expressed by intensional statements, with an "s") and as being about some *intentional object*; those are the respective counterparts of Frege's sense and reference.

An axiomatic system for a mereology of informational entities inspired by Bennett's [13] slot mereology has been proposed [4][14][2]. It rests on a distinction between information fillers (**IF**) and informational slots (**IS**): an IF is a proper part of another IF if and only if it fills (relation **F**) an IS that is a slot of (relation **S**) this IF. This enables the same IF to be part several times of another IF, by filling

[2] The main differences between this system and Bennett's is that the former does not accept the notion of improper slot, but allows slots to have slots, and to be unfilled (to account e.g. for templates).

several slots. For example, consider the string 'aa' that has the same letter 'a' twice over: in this framework, this string has two slots, that are both filled by the same information filler 'a'.

In particular, this theory accepts the following axiom (that will be re-used later):

(AX9) **Slot of a filler is filled** **IF**(x) & **S**(s,x) → ∃y **F**(y,s)

Former work suggests that slots might not only represent parthood relations, but could also carry intentionality [14]. This idea will be here explored in the case of directivity, by introducing the notion of directive slots that will stand for directive roles.

2.2. Speech-Acts, Propositions and Attitudinal Objects

As explained by Moltmann [6], in the standard view in philosophy and natural language semantics, propositional attitudes and illocutionary acts can be associated with two kinds of entities. The first kind encompasses mental acts and speech-acts, which we can classify as subkinds of processes. The second one encompasses propositions, that are the contents towards which propositional attitudes or illocutionary acts are directed, and whose ontological nature is more complex than the processual nature of mental acts and speech-acts.

Moltmann argues that we need another kind of entity to account for truth conditions and satisfaction conditions, which she calls "attitudinal object". Contrarily to propositions, attitudinal objects' representational power can be attributed to the intentionality of the mind itself; they have a limited temporal life span and they are concrete in the sense that they are localized in space-time (even if they are not material entities). This is a very large category, as it encompasses, among others, judgments, claims, beliefs, decisions, desires and intentions.

According to Moltmann, attitudinal objects, rather than propositions, are the primary truthbearers (and propositions would play that role at most derivatively). In this paper, we will not take any stance on the reality of propositions, but will eschew the category of proposition, and instead introduce a kind of linguistic entities that share many characteristics with attitudinal objects, namely "utterance", which are historically dependent on an author. Before that, we will give a quick overview of the analysis of imperative sentences and directive linguistic entities in linguistics, philosophy, logic and ontology.

2.3. Imperative Sentences and Directive Linguistic Entities

Various works in ontology have considered the question of directivity by analyzing the directed processes themselves (e.g. PSL or BPMN – see [3] for a short review). However, it is important to also integrate in the ontological picture the informational entities directing such processes and their characteristics (e.g. their author, time of creation, parts, etc.) This is especially important for ontologies studying documents, e.g. clinical documents [1,15]. A first step in that direction has been proposed [3], which introduces directive ICEs (DICEs) and the relation "attempting to direct" (a-direct) between a DICE and an action, defined as: "1) the cognitive system of the agent representing in some way this DICE […]; 2) this representation leading to an intention to perform an action as described; 3) and this intention leading to a subsequent action". This is completed by additional relations such as "successfully directs". However, DICEs are intrinsically directive, and thus this previous work does not account for the fact that the same LIN-E can aim at either describing an aspect of the world or at directing actions, depending on its context, as illustrated by the above Kanban board and drug prescription examples. Since the imperative nature of a LIN-E can depend on the context, it might be considered as a role; indeed, dependence to context is arguably a defining feature of roles [16,17]. Although there is a rich literature on roles in ontology (e.g. [16–18]), the topic of roles of informational entities has not been much investigated to our knowledge in applied ontology.

In linguistics and philosophy, two relevant fields of investigation can be distinguished: the study of imperative sentences, that is, sentences in the imperative mood; and the study of linguistic entities which have a directive illocutionary force (which can be sentences – but do not need to).

Concerning the first field, several investigations [19–21] have analyzed the logic of how imperative sentences can be combined to perform inferences. Jørgensen [19] identifies two factors of an imperative sentence: the imperative factor, "indicating that something is commanded or wished" and the indicative factor, "describing what it is that is commanded or wished." He associates to an

imperative sentence (e.g. "Shut the front door.") a corresponding indicative sentence (e.g. "The front door is shut."). Although we will not analyze here the logic of inferences involving imperatives, it will be important in our analysis to connect imperative LIN-Es with their indicative counterparts.

There is a rich literature in linguistics analyzing imperative sentences. Katz & Postal [22] introduce an "imperative morpheme" that can distinguish a sentence in the imperative mood from a sentence in the indicative mood (see also [23,24]). Downes [25] provides further pragmatic analyses of imperatives.

Works in philosophy of language have been interested in the meaning of imperative sentences [26], with a tradition linking imperatives and modals (e.g. [27]). An important subclass of imperatives expresses an obligation, e.g. "Eat your vegetables!". However, some may express other deontic attitudes, such as permission ("Go ahead, take the day off") or recommendation ("If you feel bad, take aspirin"). Moreover, some imperative LIN-Es do not express deontics. Some can be bouletic, e.g. expressing what needs to be done conditionally on a desire of the addressee ("Have a piece of fruit!") or teleological, e.g. expressing what needs to be done conditionally on a goal of the addressee ("To get to Union square, take Broadway"). Other can express a well-wish ("Get well soon!" [26]) or a threat ("Go on, throw it. Just you dare." [28]) (see [26] for a more exhaustive list). Although the last two uses might lie outside our present scope of interest, it is important to keep in mind that the connection between imperative sentences and deontics is neither straightforward nor systematic. While deontics are related to the object of our work, they are not essential to structure the proposed approach; therefore, we will not analyze them further in this paper, but will briefly return to this question in the conclusion.

As explained above, LIN-Es that can have a directive illocutionary force are not limited to imperative sentences – and not even to sentences. Searle's [29] taxonomy of illocutionary acts includes directive acts in which "[t]he speaker tries to get the hearer to act in such a way as to fulfill what is represented by the propositional content" [30]. Stainton [31] explains how a speech-act can consist not only in uttering a sentence, but also in uttering merely a word or phrase, and how this can carry an illocutionary force, such as a directive force. The way directive utterances fit in a discourse is analyzed in Segmented Discourse Relation Theory (SDRT) [32].

Note that many of the LIN-E classically analyzed in linguistics pertain to spoken discourse or immutable text, which cannot be moved from one context to another. Thus, although a LIN-E can be directive or non-directive, in such cases it cannot "lose" or "gain" its directive or non-directive status. On the contrary, electronic documents offer the possibility to move or duplicate text, and thus to change the context of a LIN-E. Therefore, we need a theory that can represent the different directive or non-directive roles that can take a same LIN-E. This is essential to build a database in which a complex document workflow can be accurately handled, such as a hospital database.

3. Linguistic and Philosophical Analysis

We will look here for an ontological representation of the various informational entities that are involved in scenarios involving both directive and descriptive LIN-Es, in order to support the construction of non-ambiguous databases. Consider for example the following clinical scenario, called "NITRO". Dr. House writes "nitro" on an electronic drug administration order for a patient Mr. Almásy, with the aim of instructing a nurse to administer him nitroglycerine. Later, Nurse Ratched copies this LIN-E "nitro" to a drug administration report, in order to register that she has administered nitro to Mr. Almásy. How can we capture, in scenario NITRO, what is common and what is different between the (directive) instruction "Nitro" written by Dr. House and the (descriptive) informational entity "Nitro" copied by Nurse Ratched in a drug administration report? To account for such a scenario, we will first distinguish expressions from utterances, then distinguish directive utterances from action utterances and finally introduce directive slots that will stand for directive roles.

3.1. Expressions and Utterances

We will use here the term "utterance" to refer to enduring entities that are the informational outputs of some speech-act or mental act[3]: whereas a speech-act is an occurrent/perdurant, an utterance is here understood as being a continuant/endurant. Utterances are thus somewhat similar to Kaplan's [36] "occurrences" or "sentences-in-context"; however, following IAO, they are not considered as abstract objects (e.g. propositions), but as informational entities that are created at a given time and are concretized in the physical world (typically by physical marks or sounds).

Utterances have many commonalities with Moltmann's category of attitudinal object: their ability to represent can be attributed to the intentionality of the mind itself, they have a limited temporal life span and they are concrete (in the sense that as informational entities, they are concretized by some material features of the world, and cannot exist without such a concretization – although they are different from those concretizations, and are not themselves material entities). Attitudinal object is a larger category than our category of utterance though, as it also includes non-linguistic entities.

Apart from utterances, we can introduce another LIN-E named "expressions". Expressions are sequences of words (and punctuation signs) on which a syntactic and semantic analysis can be performed, be they full sentences or smaller linguistic entities (syntagms) like a verb or noun phrase. An utterance is *constituted* by an expression (following a suggestion by [37]): intuitively, the expression constituting an utterance is what remains of this utterance when stripped from all its contextual features provided by the speech-act that created it. Consider for example three occurrences of the word "nitro": one created by Dr. House for Mr. Almásy, another one created by Dr. Zhivago for another patient, and the last one in a medical dictionary. Those are three different utterances as they have different authors, have been created at different times, and have different illocutionary forces (the two former aim at directing actions, although for different patients, whereas the third utterance merely aims at describing a type of medication); however, they are all constituted by the same expression "nitro".

Thus, an utterance may have an intentionality beyond or different from the intentionality of the expression that constitutes it (see Section 5.2 for more considerations on aboutness), and influenced by the context of utterance (where a context might be analyzed, following Kaplan [36], as composed by one or several agents, a location, a time and a world, and extended, following SDRT [38], with the discourse context of the previous utterances). Thus, their study exceeds semantics and involves the field of pragmatics. On the other hand, an expression constituting an utterance typically pre-exists to this utterance, as it pre-exists to the speech-act that gave rise to it (and can also constitute other utterances, uttered by other agents at other times).

We can start introducing the following entities to account for the scenario NITRO. First, let's call sa_1 the speech-act in which Dr. House prescribed nitro to be administered to Mr. Almásy, which creates the utterance ut_1 (note that sa_1 is a *bona fide* speech-act even if it only consists in the utterance of one word, as explained by Stainton [31]). We can introduce the word w_0 = 'nitro' (that is present on this prescription, but also on many other clinical documents), which is an expression, and could be analyzed as referring to the type of *drug* that contain nitro. ut_1 is constituted by w_0, but it aims to direct a nurse to administer nitro to Mr. Almásy; that is, ut_1 is synonymous[4] with 'Administer nitro!', whereas w_0 is synonymous with 'drug type nitro'.

3.2. Action Utterance

We need now to explain what happens when Nurse Ratched copies the instruction "Nitro" to a drug administration report, creating a new utterance ut_2. Something from the original utterance ut_1 is retained while doing so: indeed, both ut_1 (created by Dr. House) and ut_2 (created by Nurse Ratched) have

[3] Note that there are several possible definitions of a speech-act. Some are restrictive (e.g. : "As a first approximation, speech acts are those acts that can (though need not) be performed by saying that one is doing so." [33]) and identify speech acts with illocutionary acts [34]. Some are broader, and encompass all four of the utterance acts, the locutionary acts, the illocutionary acts and the perlocutionary acts [35]. The definition we endorse here is of the latter type. Note also that sometimes, the term "utterance" is used as a synonym of what we call here a "speech-act"; but here, "utterance" will strictly refer to an informational entity, never to a process. We will also not enter into the question of whether all utterances are created by a speech-act, or if some can be created by a mental act that just precedes the speech-act; for simplicity, we will consider for now that they are the output of a speech-act, and come back to this question in Section 3.5.

[4] The notion of synonymy will only be used here at the pre-formal level, to provide an intuitive grasp of the different relevant entities. For more thoughts on synonymy of directive instructions, see [3].

something in common, namely being about the action type of taking nitro (and not merely referring to the drug nitro, like the expression "nitro" does). This referential feature of ut_1, which is expressed by the pragmatics of communication, is retained by ut_2.

To account for this, we can identify another LIN-E named "ut_0" that is an intermediate between w_0 and ut_1. ut_0 also reads "nitro", and thus is also constituted by w_0; however, it refers to the action type of administering nitro, without any intrinsic directive intention. Note that ut_0 has a meaning that exceeds the meaning of the expression it is constituted by (as w_0 does not refer to the action type of administering nitro, but merely to the drug type nitro). Since ut_0 has this meaning because of contextual factors, it belongs to the level of utterances, rather than to the level of expression: ut_0 reads "nitro", but is synonymous with "administering nitro". We will call ut_0 an "action utterance", namely an utterance that refers to a type of action.

3.3. Directive Utterances and Directive Slots

When Dr. House writes "nitro" in scenario NITRO, he thus creates two utterances ut_0 and ut_1. What is the connection between ut_0 and ut_1? ut_0 plays a directive role because of external factors, and it is not intrinsically directive. In a sense, ut_1 can be considered as ut_0-qua-directive (see [34] for the notion of qua-objects). To account for such a role, we introduce the notion of "directive slot". More precisely, we postulate that ut_0 fills a directive slot s_1 of ut_1. We adopt thus a two-tier representation of directive utterances (which will be systematized in Section 4) with the "action-utterances" at one level (ut_0) that are intrinsically merely *about* a type of action, and the "directive utterances" at another level (ut_1) that aim to *direct* an action (that is, they have a directive illocutionary force). Both ut_0 and ut_1 have been created by the same speech-act sa_1, and they are both constituted by the same word w_0.

However, as explained above, ut_0 and ut_1 can be dissociated from each other. Indeed, consider the speech-act sa_2 in which nurse Ratched copies what Dr. House wrote in a database to indicate that nitro has been administered to Mr. Almásy. sa_2 created the utterance ut_2, where ut_2 is synonymous to "nitro has been administered", and is constituted, like ut_0 and ut_1, by w_0. The speech-act sa_2 has copied ut_0, but not ut_1, since ut_2 has no directive intention; instead, ut_0 has been incorporated into a new layer of meaning to form a new utterance ut_2. This new layer of meaning will also be represented by a slot, which we will call s_2. Contrarily to s_1, s_2 does not provide a directive role, but an assertive role; thus, we will call it a "non-directive slot" (see 5.2.2 for more discussion of the various sub-kinds of non-directive slots). This explains why it is important to represent this intermediate utterance level ut_0, whose reference is influenced by contextual features (like ut_2), but that can be copied or moved from a directive context to a non-directive one.

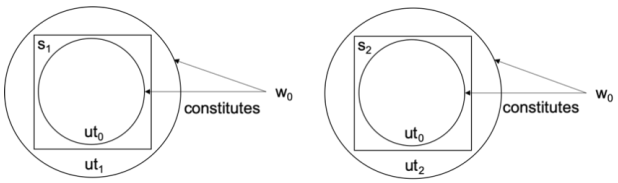

Figure 1: Expression, utterances and directive-slot

Let's come back to the example of the two directive utterances of the word "nitro" created respectively by Dr. House and by Dr. Zhivago. They each have one action-utterance (the former created by Dr. House, the latter by Dr. Zhivago). And all those four utterances are constituted by the same expression "nitro" (which does not have any illocutionary directive force, and does not refer to a class of actions, but merely refers to the class of nitro drug). Thus, not only action-utterances, but also expressions are important to capture important aspects of what several directive utterances can have in common.

3.4. Taxonomy of Relevant Entities

We will use in this paper the taxonomy as pictured on Figure 2.

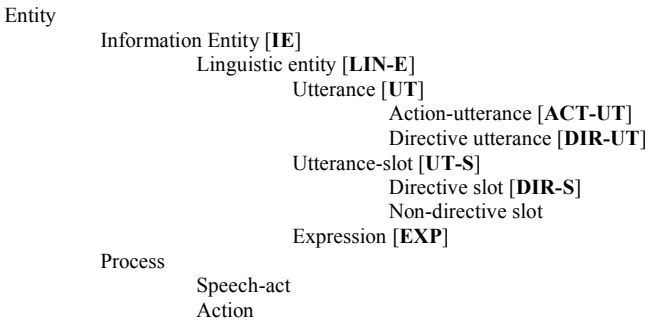

Figure 2: Taxonomy of entities and associated unary predicates

In this paper, we will work in FOL (and assume all free variables are universally quantified when writing axioms and theorems). All the axioms reflecting the taxonomic structure in Figure 2 will be accepted, that is, if A is a subclass of B, we accept $\mathbf{A}(x) \rightarrow \mathbf{B}(x)$. Moreover, we postulate that **UT**, **EXP** and **UT-S** are all disjoint from each other (so we have e.g. $\neg(\mathbf{UT}(x) \wedge \mathbf{EXP}(x))$), and Non-directive slot is defined as the complement of Directive slot in Utterance-slot.

We introduce the following Aristotelian [39] definitions[5]:

- **Expression**: A linguistic entity that is composed by a sequence of words and/or punctuation signs admissible in a given language (a single word is also an expression).
- **Utterance**: A linguistic entity that is created by one or several agents in a given context and constituted by an expression.
- **Directive utterance**: An utterance that has a directive illocutionary force.
- **Action-utterance**: An utterance that is about one or several types[6] of actions and has no directive illocutionary force.
- **Utterance-slot**: A linguistic entity that can only be filled by an utterance.
- **Directive slot**: An utterance-slot that provides a directive role to the utterance that fills it.

Note that some expressions, similarly to action-utterances, may also denote a type of action, e.g. the word "eat" (however, no expression is an action-utterance, since **EXP** and **UT** are disjoint; expressions can only *constitute* utterances, including action-utterances). However, the directive slots that are defined in this paper appear strictly at the level of utterances, and thus cannot be filled by mere expressions. Note also that some action-utterances can describe an action by specifying the agent who is supposed to perform it, the mean used, or other aspects. For example, the action-utterance "meal preparation by John", in the right context, is about the type of meal's preparation by a specific agent, namely John. Let us now clarify what directive slots stand for.

3.5. Directive Slots Stand for Directive Intentions

We can distinguish two questions concerning the directive (or non-directive) role of an utterance like ut_0 above: first, what *provides* to an utterance a directive (or non-directive) role; second, how this role is *expressed* – that is, the syntactic, semantic or pragmatic features that ensure that the directive (or non-directive) role of an utterance can be recognized as such by another agent.

[5] See Section 4 for more details on the connection between directive utterances and directive slots, and see Section 5.1 for a discussion of the nature of utterances.

[6] This type could be a universal, or maybe a concept, following Biccheri et al.'s [12] suggestion that this would better account for the intensional character of aboutness. See Section 5.2 for more discussion.

In the spirit of Chisholm's primacy of intentionality and IAO's stance (cf. 2.1), we consider that the directive role of utterances derives from the intentionality of the mind of the agent who uttered them – which belongs to the context of the speech-act (contrarily to expressions, whose intentionality does not depend on the agent using them). Thus, the directive nature of directive slot ultimately stands for such intentions[7]. However, an utterance that is directive (because of the intention of its creator) but could not be recognized as such by anyone else would be linguistically inefficient. Therefore, this directive role can be publicly expressed in various ways. It could be manifested by syntactic or semantic features of this utterance, e.g. an imperative mood tense combined with the exclamation mark in 'Eat your vegetables!'. It could also be expressed by syntactic or semantic features of *other* utterances that form the discourse context of this utterance, e.g. the header "to do" of a column in a Kanban board, or previous discourse. Finally, it can be expressed by features of the speech-act creating this utterance. Analyses in pragmatics have indeed shown famous examples of utterances that look superficially descriptive but can be used with directive purposes – e.g. "This meal is not salted enough." uttered to request someone to pass the salt. Note however that the speech-act creating an utterance in an electronic document is often not perceptible to a reader of this document, which, among other complexities of pragmatic phenomena, may create significant difficulties for NLP analyses of such documents, and motivates a system of tagging of the directive or non-directive nature of utterances by their authors.

Epistemically, the extrinsic features have precedence over the intrinsic ones to recognize the directive nature of an utterance. Indeed, Downes [25] notices that "Practically any sentence can be said to have the illocutionary potential of commanding in some context." This means that intrinsic syntactic or semantic features can at best *suggest* a directive reading of this utterance, but this (defeasible) inference can be defeated when considering pragmatic features (Stainton [31] relatedly distinguishes between the force of an expression and the force of an action, where the latter has precedence). Here, we are not interested in *analyzing* which syntactic, semantic or pragmatic features can enable to recognize the directive nature of an utterance. Instead, we are interested in *representing ontologically* the directive nature of utterances. As explained earlier, we identify such directive roles with directive slots. That is, directive slots encapsulate directive intentions of the creator of the information, and those intentions might be made visible by syntactic, semantic and/or pragmatic features of the utterance and its context. Said differently, the directive slot is the reification of the directive illocutionary force provided by the intention of the author and that can be linguistically expressed by various means.

The informational slot-mereology we build upon ([4,14]) considers that slots can exist even if unfilled, and this holds in particular for directive slots: consider for example a calendar on which a manager can write what an employee is expected to do at each hour (but can leave some hour-slots unfilled); this calendar has several directive slots, which exist independently on whether they are filled or not – and are actually all unfilled initially.

Now that we have clarified the pre-formal intuitions behind the core notions involved in this paper, we can propose some elements of a formal theory.

4. Formal Analysis

This section will introduce the binary relations summarized in Table 1, where **R** has domain **X** and range **Y** means that we accept the axiom $\mathbf{R}(x,y) \rightarrow \mathbf{X}(x) \wedge \mathbf{Y}(y)$.

Table 1
Binary relations

Binary relation	*Predicate*	*Domain*	*Range*
utterance-slot-of	$\mathbf{S_{UT}}$	**UT-S**	**UT** ∨ **UT-S**
utterance-fills	$\mathbf{F_{UT}}$	**UT**	**UT-S**
constitutes	**CONST**	**EXP**	**UT**

[7] Another possibility, that will not be discussed here, would be that the aboutness derives from the *public commitment* of the utterance.

4.1. Constitution

Let's start by axiomatizing the relation of constitution between an expression and an utterance. We postulate that every utterance is constituted by exactly one expression:

($AX1_{DS}$) $\mathbf{UT}(x) \rightarrow \exists!e\ (\mathbf{EXP}(e) \wedge \mathbf{CONST}(e,x))$

We can trivially deduce from $AX1_{DS}$ that **CONST** is inverse functional:

($TH1_{DS}$) $\mathbf{CONST}(e,x) \wedge \mathbf{CONST}(f,x) \rightarrow e=f$

In our framework, the same expression can constitute several utterances that are uttered by different agents and in different contexts. For example, the same word w_0 = 'nitro' can constitute an utterance ut_1 by Dr. House prescribing Mr. Almásy to take this medication, as well as another utterance ut_3 by the pharmacist Mr. White stating that he distributed this drug to Mr. Almásy. Thus, **CONST** is *not* assumed to be functional: we can have $\mathbf{CONST}(w_0,ut_1)$ and $\mathbf{CONST}(w_0,ut_3)$ with $ut_1 \neq ut_3$.

4.2. Mereology and Slots

We accept a mereology on utterances based on former works ([4][14]). More precisely, the unary predicates **IF** (information filler) and **IS** (information slot) as well as the binary predicates **F** (fills) and **S** (slot-of) from [4] are here respectively transformed as predicates **UT**, **UT-S**, $\mathbf{F_{UT}}$ and $\mathbf{S_{UT}}$. In particular, axiom AX9 reminded in Section 2.1 can be translated here as:

($AX9_{UT}$) $\mathbf{UT}(x) \wedge \mathbf{S_{UT}}(s,x) \rightarrow \exists y\ \mathbf{F_{UT}}(y,s)$

We postulate the additional axiom that a directive slot can only be filled by an action-utterance:

($AX2_{DS}$) $\mathbf{F_{UT}}(x,s) \wedge \mathbf{DIR\text{-}S}(s) \rightarrow \mathbf{ACT\text{-}UT}(x)$

We could want to impose an axiom stating that the mereological sum of several utterances is constituted by the mereological sum of the expressions constituting those utterances; but this would require a theory of mereological sum on informational entities, something that has yet to be developed (see [4] for some pointers).

4.3. Directing Actions, Revisited

The directive ICEs (DICEs) from [3] correspond to what we called here "directive utterances", and we take **DIR-UT** as a primitive. We then impose that a directive utterance must have a directive-slot:

($AX3_{DS}$) $\mathbf{DIR\text{-}UT}(x) \rightarrow \exists s\ \mathbf{DIR\text{-}S}(s) \wedge \mathbf{S_{UT}}(s,x)$

We refrain however from the converse assumption. For example, the utterance "John said 'Eat your vegetables!'" has a directive slot, but it is not a directive utterance (it is rather a descriptive utterance about John having uttered a directive utterance).

We deduce from the former axioms the following theorem stating that every directive utterance has a directive slot filled by an action-utterance:

($TH2_{DS}$) $\mathbf{DIR\text{-}UT}(x) \rightarrow \exists s,y\ \mathbf{DIR\text{-}S}(s) \wedge \mathbf{S_{UT}}(s,x) \wedge \mathbf{F_{UT}}(y,s) \wedge \mathbf{ACT\text{-}UT}(y)$

Proof: Suppose that $\mathbf{DIR\text{-}UT}(x)$. By $AX3_{DS}$, there is an s such that $\mathbf{DIR\text{-}S}(s)$ and $\mathbf{S_{UT}}(s,x)$. By $AX9_{UT}$, there is a y such that $\mathbf{F_{UT}}(y,s)$. By $AX2_{DS}$, we have $\mathbf{ACT\text{-}UT}(y)$. QED.

In scenario NITRO, the directive utterance ut_1 has a directive slot filled by ut_0, which is an action utterance. On top of this, both ut_1 and ut_0 are constituted by the same expression. However, the latter feature does not need to be the case. For example, the directive utterance 'Eat vegetables!' has a directive slot filled by the action-utterance 'Eat vegetables', that does not encompass the exclamation mark; both utterances are thus not constituted by the same expression (the expression constituting the action-utterance is a part of the expression constituting the directive utterance though, see Section 5.1 below).

Then, the relation a-directs from [3] (as reminded in Section 2.3) will be redefined between a **DIR-UT** and an action. Further work should address how to characterize formally this relation in terms of more basic relations. In particular, step 3) in its definition (cf. Section 2.3) could be represented using

an ontological analysis of intentions as dispositions [40]: an intention leading to a subsequent action is nothing else than the intention being realized (in the dispositional sense) by this action.

Coming back to scenario NITRO as represented on Figure 1, we have the following facts: **DIR-UT**(u_1), **UT**(u_2), **ACT-UT**(ut_0), $\mathbf{S_{UT}}(s_1,u_1)$, $\mathbf{S_{UT}}(s_2,u_2)$, $\mathbf{F_{UT}}(u_0,s_1)$, $\mathbf{F_{UT}}(u_0,s_2)$, **DIR-S**(s_1), **EXP**(w_0), **CONST**(w_0,ut_0), **CONST**(w_0,ut_1), **CONST**(w_0,ut_2). This provides trivially a model of the theory presented here, proving thus its consistency.

5. Discussion

Our framework raised three main theoretical challenges: first, representing directive informational entities, including directive utterances, their directive slots and their action-utterances; second, representing the relation between an action-utterance and what it is about; third, representing the relation between a directive informational entity and an action that it directs. Here, we have addressed the first of those challenges and adapted former work [3] to partially address the third one. As we will see now, some open issues remain concerning each of those three challenges, namely respectively 1) the structure of expressions and utterances, 2) aboutness and 3) directing not only actions but also objectives.

5.1. The Structure of Expressions and Utterances

We could build a mereology of expressions on the same basis (namely [3]) as the one we presented above to build a mereology of utterances. We could then cross-constrain both mereologies. For example, if an utterance is part of another utterance, then the expression constituting the former is a part of the expression constituting the latter. But the converse is not true: if Mrs. A utters ut_7 = 'eat' to express (in simplified English) that she has eaten today and Mr. B utters ut_8 = 'eat your vegetables!' to direct his son to eat his vegetables, then the word w_7 = 'eat' constitutes ut_7, the expression w_8 = 'eat your vegetables!' constitutes ut_8, w_7 is a part of w_8, but ut_7 is not a part of ut_8.

We may want stronger constraints. Indeed, if an utterance x constituted by e contains *twice* the utterance y constituted by f (e.g. in scenario NITRO, ut_0 filling two different slots of a document gathering ut_1 and ut_2), we may want e to have f *twice* as part. A slot-mereology inspired by Bennett [4,13] may help in this regard, although it should be amended to enable to count parts adequately [41].

Relations between slots would also need to be added, such as relations of sequential order (slot s is before or after slot t, to account for the fact that in a text, an utterance is before or after another). The intended meaning of such relations (e.g. causality, explanation, temporal succession, etc.) might then be analyzed by a discourse theory, e.g. SDRT [38]. Here, we chose an expressivity level that makes the theory computationally usable (to structure databases according to this ontology), therefore SDRT cannot be directly expressed here; however, directive slots might be mapped to SDRT's "speech-act labels" (π_i) that are linked by rhetorical relations to constitute discourse structure.

We would also need a definition of utterances involving necessary and sufficient conditions (the definition in 3.1 provided only necessary conditions), in order to account for the fact that in the utterance 'Eat your meal', there is no utterance formed by the word 'your'. This question is related to the debate about elementary discourse units and fragments in discourse theories [31,42] and would require a more thorough ontological analysis of speech-acts and their outputs.

5.2. Aboutness

Various questions concerning aboutness are left open in the current work, including specification of an addressee of an utterance, of the time at which the action specified by a directive utterance needs to be done, etc. Here, our goal was not to reflect ontologically or logically the internal discursive structure of statements, a question that we keep for future works. Let us say however a few words about both the intensionality of directive utterances and the aboutness and illocutionary force of non-directive slots.

5.2.1. The Intensionality of Directive Utterances

Directiveness and aboutness are open to similar challenges. For example, from the fact that the expressions "evening star" and "morning star" have different intensions despite being co-extensional in our actual world, the directive utterances "Look at the evening star!" and "Look at the morning star!" can direct actions differently. This is one of the motivations for distinguishing a directive utterance from its action-utterance (e.g. in scenario NITRO, distinguishing the directive utterance ut_1 from the action-utterance ut_0), where the aboutness of the action utterance might be represented following the lines of the dual treatment of aboutness proposed by Biccheri et al. [12], and explain how the two corresponding directive utterances might direct differently. We might thus be able to account for the intensional (with an "s") character of a directive utterance as a consequence of the intensional character of its action-utterance. Since action-utterances are not about a particular action, but about a *type* of action, representing their aboutness may give rise to some formal challenges, such as reifying action subtypes.

5.2.2. The Aboutness and Illocutionary Force of Non-directive Slots

As explained earlier, 'cook dinner' is about the type of action of cooking dinner, but it also has the role of referring to a particular dinner cooking action when written in the column "done" of a Kanban board. That is, although an action-utterance is about a *type* of action or state of affair, it can have the role of being about a *particular* action or state of affair. This (non-directive, assertive) role can then be represented by a (non-directive) slot. For example, in scenario NITRO, s_2 represents a non-directive role of ut_0 to refer to an administration of nitro to Mr. Almásy (and leading to the apparition of utterance ut_2). This slot acts to some extent similarly to an indefinite article (e.g. "a" in English).

We could imagine a large variety of non-directive slots that would add a semantic layer to the action utterance that fills them (note however that not all slots need to be about something: some might merely represent a mereological structure). For example, an action-utterance could have the role of referring to a *failed attempt* to perform an action of the kind described by the action-utterance if placed in the column "failed" of a Kanban board. More generally, it could have the role of referring to the fact that an instruction has been cancelled; that an instruction is permitted, obligatory or recommended; that the action has been performed by a specific agent, or under a specific mode; etc. We could also imagine that some slots add *both* a directive component and an added layer of semantics at the same time. However, as explained above with the examples of the Kanban board and the clinical scenario NITRO, keeping those two layers separated enables to represent how an action-utterance (e.g. ut_0) can be copied in another context while the whole directive utterance (e.g. ut_1) is not, even if both are constituted by the same expression. Finally, note that non-directive slots would also include a variety of slots with non-directive illocutionary force (assertive, commissive, expressive, declarative, etc.).

5.3. Objectives vs. Actions

The Ontology for Biomedical Investigations (OBI) [43] identifies two different kinds of directive informational entities: objective specifications and action specifications. Note however that the distinction between both kinds is not always easy to establish. Consider the instruction 'STOP' on a road sign: is it an objective specification that states that one needs to reach a state of being stopped, or an action specification that states that one needs to perform the action of stopping?[8] Similarly, consider a medical instruction on a drug prescription that reads 'Amoxicilin 500 mg'; does it specify an objective of 500 mg Amoxicilin ending up in the body of the patient, or an action of the patient taking 500 mg of Amoxicilin? Thus, the category "action-utterance" might have to be replaced by the category "objective- or action-utterance". This would require however to clarify the ontology of actions and the ontology of objectives, and how they relate [44].

[8] We are indebted to Alan Ruttenberg for exposing this problem to one of us in a private discussion.

6. Conclusion

We have differentiated expressions from the utterances they constitute, and represented the directive roles that can take some utterances as directive slots, where this role is provided by the intention of the creator and can be expressed by syntactic, semantic or pragmatic features of the utterance or its context. Directive utterances (which can direct actions) are analyzed as having a directive slot filled by an action-utterance. We can add that this action utterance corresponds roughly to what is commonly described as being the *content* of this directive utterance (but contrarily to the orthodox view, this content is itself an utterance, since its aboutness is determined by pragmatic features), whereas the directive slot describes its *illocutionary directive force*. Note that we took the example of an action-utterance constituted by one word ("Nitro"), but this could be generalized to any information from which an action description might be generated in the context of discourse.

This action utterance can be moved to other contexts, including non-directive contexts. Thus, this ontological framework can account for electronic documents (e.g. clinical documents) in which linguistic entities can be moved around or copied and take either directive or non-directive roles.

Further work should address additional issues concerning the connection between the mereology on expressions and the mereology on utterances, the distinction between utterances that have an illocutionary force and those (like action-utterances) that do not, the different kinds of relations that can hold between slots of utterances, the aboutness of both directive utterances and non-directive slots, and how the fulfillment of an objective can be directed.

Other possible extensions include analyzing how ambiguous utterances could be misinterpreted, e.g. misinterpreting utterances that are non-directive as being directive, and vice-versa. For example, an utterance "nitro" that is intended to instruct to administrate nitro to a patient can be misunderstood as an utterance stating that nitro has already been administered to this patient. Representing such misinterpretations is especially important for supporting error-checking and audit process. Note that structuring unambiguously an information system using the entities introduced here could prevent subsequent misinterpretations.

A variety of subtypes of directive slots could also be introduced. One could for example adapt Portner's work [27] to slots by introducing notions such as deontic slots (particularly important for documents such as drug prescriptions, cf. Section 4.2 in [45]), bouletic slots and teleological slots, and providing a modal analysis of those entities. Finally, the current ontology could be integrated into a more general ontological investigation of attitudinal objects, that could shed some lights on the ontology of beliefs, desires and intentions [40].

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