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An Account of Constructions in ASD-STE100: Formalizing Non-propositional Meaning in Aviation Instructional Texts

Construcciones en ASD-STE100: Una formalización del significado no proposicional en los textos instructivos empleados en la aviación

ANA DÍAZ-GALÁN
MARÍA DEL CARMEN FUMERO-PÉREZ
INSTITUTO UNIVERSITARIO DE LINGÜÍSTICA ANDRÉS BELLO. UNIVERSIDAD DE LA LAGUNA

Constructional meaning is essential to understand any piece of natural language; its formalization, however, poses challenges that have to be faced for an adequate processing of natural language. This paper addresses this issue by providing a formalized description of the role that constructional structures play in the controlled natural language ASD-STE100. Based on a corpus of instructional texts written in this language, we will assess the existence in such texts of the four levels of constructional meaning described by the Lexical Constructional Model (Ruiz de Mendoza & Mairal-Usón, 2008; Mairal-Usón & Ruiz de Mendoza, 2009) which, in turn, shape the Constructicons in the FunGramKB knowledge base (Periñán-Pascual, 2013; Periñán-Pascual & Arcas-Túnez, 2014). Our findings show that the technical nature of the controlled language has direct influence on the type of constructions employed, making some of the constructional levels irrelevant. A formalized account of the main types of constructions encountered is also provided.

Keywords: *FunGramKB; ASD-STE100; constructional meaning; LCM; instructional language*

El significado construccional constituye una parte fundamental del lenguaje natural cuya formalización no deja de implicar ciertas dificultades. En este artículo abordamos este tema proponiendo una descripción formal del papel que las estructuras construccionales tienen en el lenguaje natural controlado ASD-STE100. Basándonos en un corpus de textos instructivos escritos en dicho lenguaje, evaluaremos la existencia de los cuatro niveles construccionales postulados por el Modelo Léxico Constructional (Ruiz de Mendoza & Mairal-Usón, 2008; Mairal-Usón & Ruiz de Mendoza, 2009), el cual, a su vez, modela los Constructicones de la base de conocimiento FunGramKB (Periñán-Pascual, 2013; Periñán-Pascual & Arcas-Túnez, 2014). Nuestro análisis demuestra que la naturaleza técnica de este lenguaje influye directamente en el tipo de construcciones empleadas, haciendo, incluso, algunas irrelevantes. Asimismo se ofrece la formalización de los tipos principales de construcciones.

Palabras clave: *FunGramKB; ASD-STE100; significado construccional; LCM; lenguaje instructivo*

1. INTRODUCTION

`Alexa, I'm bored´. Ask Alexa for entertainment on demand. So reads the slogan on the Amazon webpage (Amazon, 2009) which encourages prospective buyers to acquire the "intelligent"

voice assistant. Human-machine interaction via natural language, written or spoken, has developed to the point that they seem to be able to decode human speech in order to carry out not only straightforward tasks expressed as plain imperatives, as in "Alexa, play some music", but also the request implied in "Alexa, I'm bored". This type of dialogue systems, which are increasingly accurate in their response as a result of the development of Natural Language Processing (NLP) and Natural Language Understanding (NLU), rely partly on linguistic knowledge, partly on statistical information. Although there is no denying that it is statistical information that allows them to perform faster and to be increasingly accurate, it is also true that their "understanding" comes at a price: the user not only needs training as to what "Alexa commands" to use so that the device understands what it has been asked to do, but also to be prepared for the inevitable misunderstandings that will arise. On a quick search on the YouTube platform it is easy to find the witty answers Alexa has to the *`Alexa, I'm bored´* command: "*Being bored is boring*" [...] "*Pick one of these items to cure your boredom:* […] *why not clean your bedroom*" (ChadBockius, n.d). These statistically valid answers to the indirect illocutionary act are obviously not a natural language exchange, but an illusion of it that sometimes also comes with delusion, in fact, it is equally easy to find examples of Alexa's failures which end up in frustrated conversations or unexpected, sometimes hilarious, outcomes (BrothervsBrother, n.d). It seems, therefore, that there is still substantial room for improvement in NLP and NLU tasks, which could be provided by linguistic knowledge. Linguistic resources such as ontologies, lexica, morphicons or parsers have effectively contributed to these tasks; however, the non-propositional or constructional dimension of meaning essential to understand any piece of natural language has often been disregarded. Accounting for constructional meaning is vital for NLU and NLP, since, this type of meaning can not only override core verbal semantics, but it can also modify syntax. This paper approaches this issue by providing a formalized description of the role that constructional structures play in the controlled natural language ASD-STE100, a simplified version of English employed mainly in the field of aviation, where communicative failures can lead to dire consequences. The resemblance of controlled languages to natural languages and their simplified nature makes them perfect candidates for testing systems which aim at automated reasoning (Schwitter, 2010). Our study will present a qualitative analysis of a corpus of ASD-STE100 texts to identify the different levels of constructional meaning described by the Lexical Constructional Model (henceforth LCM; Ruiz de Mendoza & Mairal-Usón, 2008; Mairal-Usón & Ruiz de Mendoza, 2009) which shape the grammar component in the FunGramKB knowledge base (Periñán-Pascual, 2013; Periñán-Pascual & Arcas-Túnez, 2014). It is our aim to establish which of these levels are relevant for the description of this simplified language and to provide their formalization to facilitate an unambiguous parsing. With this in mind, we will structure the paper as follows: Section 2 outlines the main components of FunGramKB and gives an overview of the four constructional levels described by the LCM. Section 3 presents the corpus of technical texts analyzed and describes the main characteristics of the controlled natural language ASD-STE100. Section 4 is devoted to the analysis itself and, finally, conclusions are drawn in Section 5.

2. FUNGRAMKB MODULES AND CONSTRUCTIONAL LEVELS

The Functional Grammar Knowledge Base (FunGramKB) has been designed (Periñán-Pascual, 2013; Periñán-Pascual & Arcas-Túnez, 2014) as a repository of semantic, lexical and constructional data to be used in different NLP applications. These three types of knowledge are stored in separate but interrelated components, namely, the conceptual, lexical, and grammatical modules.

The conceptual module aims at providing a machine tractable description of purely semantic meaning as well as of world knowledge. It does so by means of a Cognicon -which stores scripts and frames-, an Onomasticon -which contains encyclopaedic knowledge-, and an Ontology where semantic knowledge is organized as an IS-A hierarchy of conceptual units. In this Ontology the semantic properties of a concept are provided through conceptual schemata; each concept is described by means of a Thematic Frame (TF) and a Meaning Postulate (MP). The following example shows the formalization of the concept +ADVISE_00 in the FunGramKB Ontology (Periñán-Pascual & Mairal-Usón, 2010: 35):

(1) +ADVISE_00
TF: (x1: +HUMAN_00)Theme (x2)Referent (x3: +HUMAN_00)Goal
MP: +(e1: adv +SAY_00 (x1)Theme (x4: (e2: pos +DO_00 (x3)Theme (x2)Referent))Referent (x3)Goal)

As we see, a TF gives information about the number and type of participants implicated in an event, whereas, MPs provide a formalization of the events in which these participants are involved. The common language employed to formalize meaning is COREL (COnceptual Representation Language), which is consistently used in all the FunGramKB components and applications (Periñán-Pascual & Mairal-Usón, 2010). In example (1) the information included in the MP for +ADVISE_00 shows that this concept has the semantic prime +SAY_00 as its superordinate. The three participants (theme, referent and goal) take part in the two predications (e_1 and e_2) which describe the main features of the concept. It differs from +SAY_00 in that the propositional content includes epistemic (pos) and non-epistemic operators (adv). Accordingly, the MP of +ADVISE_00 translates as: "a person says suggestively to another person that he/she can do something" (Periñán-Pascual & Mairal- Usón, 2010: 35).

The other two modules within FunGramKB -the Lexicon and the Grammaticon- are language specific. The first describes lexical units (verbs, nouns, adjectives or adverbs) as realizations of an ontological concept in a given language (to date English, Spanish and Italian). Lexical descriptions are largely based on the functional tenets of Role and Reference Grammar (Van Valin & LaPolla, 1997; Van Valin, 2005) and of the LCM. Thus, verbs are characterized not only in terms of their Core Grammar, which includes the verb's Aktionsart, its lexical template (variables, macroroles and thematic roles), but also according to the possible constructions in which they can participate. Constructional meaning is compiled in the Grammaticon (Periñán 2013; Periñán-Pascual & Arcas, 2014; Mairal-Usón 2012, 2015; Van Valin & Mairal-Usón, 2014; Luzondo & Ruiz de Mendoza, 2015; Jiménez Briones, 2016). This component consists of four Constructicons inspired in the four constructional levels described by the LCM, which allows FungramKB to represent both propositional and non-propositional meaning. The repository of constructions is structured according to the kind of meaning they convey. The first layer is dedicated to propositional meaning, thus encompassing argument structures. Middles, Inchoatives and Locative structures would count among the best known instances of this type of argumental or Level 1 constructions. Level 2 includes implicational constructions which deal with low level situational meaning, as expressed in semi-fixed patterns of the type *Don´t you X me* and *Do I look like I X?* (Mairal-Usón, 2017). Level 3, the illocutionary level, describes high level situational meaning which affects the interpretation of speech acts, as is the case of indirect speech acts such as advising, or apologizing. Finally, Level 4 houses discourse constructions which include cohesive and coherence devices.

The syntactic and semantic information given by L1-constructions is provided in the format of Attribute Value Matrices (AVMs), which are characterized through descriptors and constraints, as shown in Figure 1 for the Instrument Subject Construction (as in *The hammer*

broke the window). A constructional schema presents both syntactic and semantic information: the former is described by means of a Conceptual Logical Structure or CLS, and the latter in a COREL scheme. The CLS in Figure 1 displays information with respect to the Aktionsart of this argumental construction (L1-constructions), here a causative accomplishment (CACC). At the same time, the AVM states that the construction presents two variables *w* and *y*. If relevant, it also provides information about the role of the variables in the construction, which in the case of *w* has the thematic role instrument, the macrorole actor and functions syntactically as an argument. The AVM also depicts that the variable *w* presents a realization restriction, i.e. that it has to be a noun phrase (NP), and it also shows a selection restriction +INSTRUMENT _00. Finally, the AVM provides the COREL scheme of the construction, a formalized conceptual representation through the COREL metalanguage, which summarizes the semantics contributed by the L1-construction. In this case it would read as follows: there is an event (e1) in which an entity (x1) uses an instrument (w) to perform an action (e2) which affects another entity (x3), which, as a result of the action (x3), undergoes a change of state.

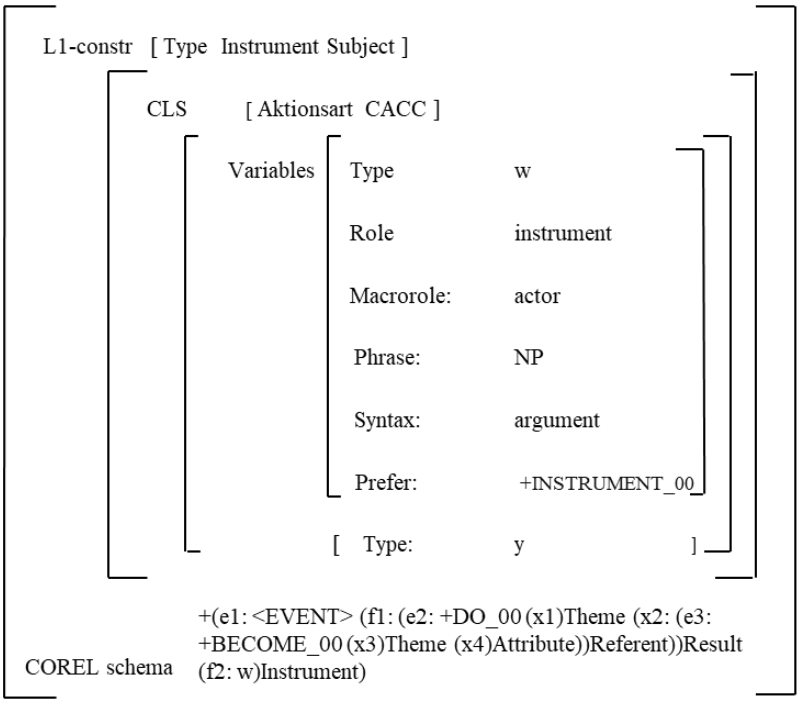

Figure 1: ***AVM for the Instrument Subject Construction***

Different from argumental constructions, implicational, illocutionary and discursive constructions "do not alter the Logical Structure […] but can only extend the corresponding COREL scheme" (Periñán-Pascual, 2013: 217), this is, their contribution is merely semantic and, consequently, in the FunGramKB Constructicon they are just described by means of their possible realizations (those which trigger the construction) and a COREL scheme. Figure 2 shows the information stored in the L3-Constructicon for the illocutionary construction Advising-type-1 (see Subsection 4.3.2):

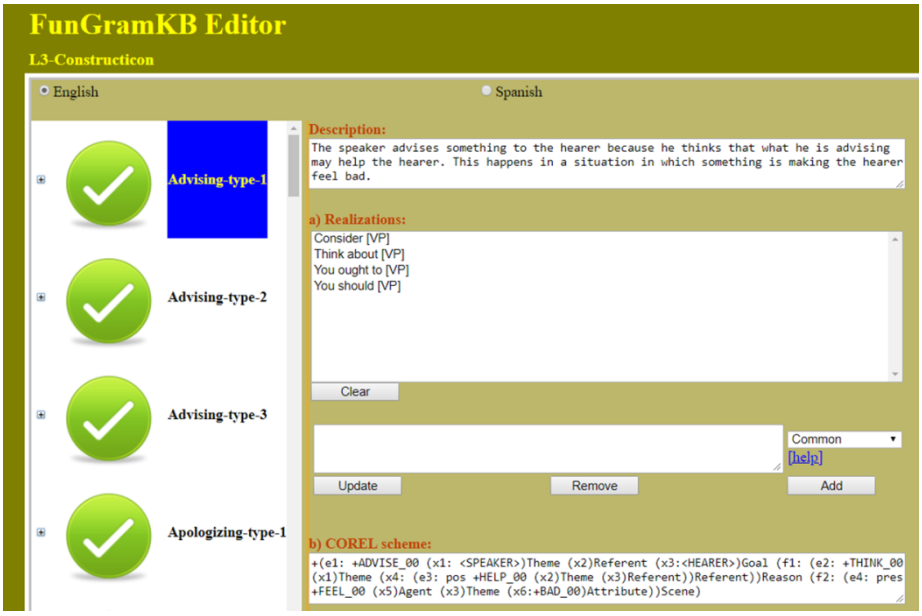

Figure 2: ***The Advising-Type 1 construction within the L3-Constructicon***

3. TECHNICAL DOCUMENTATION IN THE CONTROLLED NATURAL LANGUAGE ASD-STE100: AIRBUS MAINTENANCE INSTRUCTION MANUALS

If it aims at an effective parsing, the formalization of constructional meaning needs to be sensitive to the specific characteristics of the texts to be parsed. In the case of the corpus we are searching -Airbus maintenance instruction manuals written in ASD-STE100-, two factors will shape constructional meaning and, therefore, construction-types: the restrictions imposed by the controlled natural language and the discursive characteristics of these technical texts. [1]

Controlled languages have been designed with the specific purpose of complying with certain linguistic constraints in order to simplify them and make them easier to understand and accessible to a larger audience. One of the best known controlled languages is the Aerospace and Defence Industries Association of Europe (ASD) Simplified Technical English (STE), which, in a specification manual establishes as its purpose (2017: ii) "to give technical writers guidelines on how to write technical texts in a clear simple and unambiguous manner that readers throughout the world will find easy to understand". The importance of understanding maintenance and operation documentation correctly in aviation made it necessary to simplify the English language used in these documents. The basic ASD-STE100 philosophy is to keep texts as simple and readable as possible, avoiding complex sentence structure and the polysemy inherent to natural English. To achieve this, the specification contains two different sections. One of them consists of a dictionary of controlled English which lists the words that are permitted in ASD-STE100 together with its approved and non-approved forms. The other establishes writing rules which impose morphological, lexical and syntactic restrictions on the language and on formal aspects such as punctuation or the number of words allowed per

[1] The examples presented here are part of a corpus of texts from aircraft maintenance instructions, courtesy of Airbus Seville. This repository consists of 2,480 files and 687,345 tokens. For a full description of the corpus we refer the reader to Felices-Lago and Alameda-Hernández (2017: 109).

sentence. In this section we can also find rules which regulate the language to be employed in the writing of three different types of texts:

1. Procedural writing, this is, "sentences for procedures" or "instructions that tell you how to do a task" (2017: 1-5-1).
2. Descriptive writing, which "gives information, not instructions" and which "can be: a description of an item, a system or a component, its function, how it is made and how it operates- a text that gives general information, a note in a procedure" (2017: 1-6-1)
3. Rules for safety instructions, which "tell the readers that procedures or steps in procedures can be dangerous or cause damage" (2017: 1-7-1).

In fact, these three kinds of writing correspond to the main text types in instruction manuals, namely, procedures, descriptions, and safety instructions. Aviation maintenance instruction manuals are an instance of technical writing and, therefore, fall within the realm of technical communication. The ultimate aim of instruction manuals is to (Felices Lago & Fernández Lloret, 2012: 28) "ensure the proper use of a device and to help the reader act in the right way", substituting (2012: 29) "the engineer's verbal instruction with text". They present fairly stable characteristics which have been described within the field of English for Specific Purposes as an instance of instructional genres. As described by Swales (1990), each genre is associated with certain rhetorical functions which aim at a common communicative purpose. In our revision of the Airbus maintenance instruction manuals, the most relevant rhetorical functions associated with the three text types mentioned above are: naming procedures, stating, giving instructions, warning and indicating consequences. The effective parsing of our corpus, therefore, seems to require a linguistically sound system as is FunGramKB which will allow for the formalization of propositional and non-propositional meaning. In what follows we will a) assess the existence in the ASD-STE100 corpus of the four different constructional levels put forward by the LCM, b) offer the formal encoding of some of the constructions which are not included in the FunGramKB Constructicon and c) show how such constructions are highly motivated by the nature of the controlled natural language employed and by the technical characteristics of the texts analysed. We will devote each of the constructional levels - argumental, implicational, illocutionary and discursive- a different section.

4. CONSTRUCTIONS IN ASD-STE100

4.1 *Argumental or L1-constructions in ASD-STE100*

As previously argued (Fumero-Pérez & Díaz-Galán, 2017), a computational approach to the processing of constructions has made it necessary to redefine the conception of argumental constructions within FunGramKB. These are now understood as constructs which necessarily alter the lexical template of the verb (its Core Grammar), either by modifying its argumental structure (subtracting arguments or adding non-optional constituents) and/or by changing aspectual meaning (Aktionsart). Our analysis of L1-constructions in the ASD-STE100 corpus has shown that the controlled nature of the language does not restrict the catalogue of argumental constructions, which seems to be as varied as the catalogue for natural English. The following are only some of the instances of argumental constructions found in the Airbus corpus:

(2) The green light flashes when the kneeling actuator is in the kneeling operation (Inchoative Construction)
(3) Each input lever is connected to the related brake pedal through a system of mechanical linkages. (Caused-motion Construction)
(4) It changes to amber when a minimum of one engine is started. (Resultative Transitive Accomplishment Construction)
(5) A clamp attaches the body of the kneeling manifold to the top part of the shock absorber assembly. (Instrument Subject Construction and Causative Motion Construction)
(6) It changes to amber when a minimum of one engine is started. (Resultative Transitive Accomplishment Construction)
(7) The heat shield radiates the heat from the brake unit. (Substance Source Construction)
(8) The three panels do the same function for the middle and aft main fittings. (For Benefactive Construction).

It is our belief that technical documentation, as an instance of language employed for a specific purpose, will not only present subject specific terminology, but that it is also possible to characterize it by means of some recurring argumental constructions which seem to be closely related with the type of discourse employed. Although further quantitative research is needed, we have found that Caused-motion Constructions and Instrument Subject Constructions are among the most common types. Another instance of constructional pattern present in the corpus which we believe is associated with the technical nature of the language can be illustrated by the following examples:

(9) All the brake units release their wheels.
(10) A hydraulic actuator opens each door.

These sentences signal an event that is partly a Middle Construction and partly an Instrument Subject Construction. They are Middle Constructions in that they denote generic states depicting an attribute of an entity (eg. *brake units* or a *hydraulic actuator*); such an attribute refers to a potential event in which the entity would participate as an actor. At the same time, they present characteristics of an Instrument Subject Construction. A decomposition of examples (9) and (10) would read as follows:

(9) All the brake units release their wheels.
   a. Someone releases the wheels by using the brakes (activity + instrument)
   b. The brakes release the wheels (Instrument Subject)
   c. The brakes have the property of releasing wheels (State)

(10) A hydraulic actuator opens each door.
   a. Someone opens each door with the hydraulic actuator (activity + instrument)
   b. The hydraulic actuator opens each door (Instrument Subject)
   c. The hydraulic actuator has the property of opening doors (State)

To provide a formalization for these structures, we have labelled them Instrument Subject Middle Constructions: in terms of Aktionsart, they are states depicting attributes but, different from Middle Constructions, the entity (the instrument) participates in the potential event as a secondary effector. That is, an unexpressed agent uses an instrument in a chain of events such that the instrument itself brings about the states of affairs encoded in the predicate.

In the FunGramKB L1-Constructicon two types of Middle Constructions are already described, those exemplified by the sentences *The bread cuts easily* (Middle Construction) / *This book doesn't sell* (Middle-type-2 Construction). Instrument Subject Middles are a third type of Middle Constructions to be added to the repository.

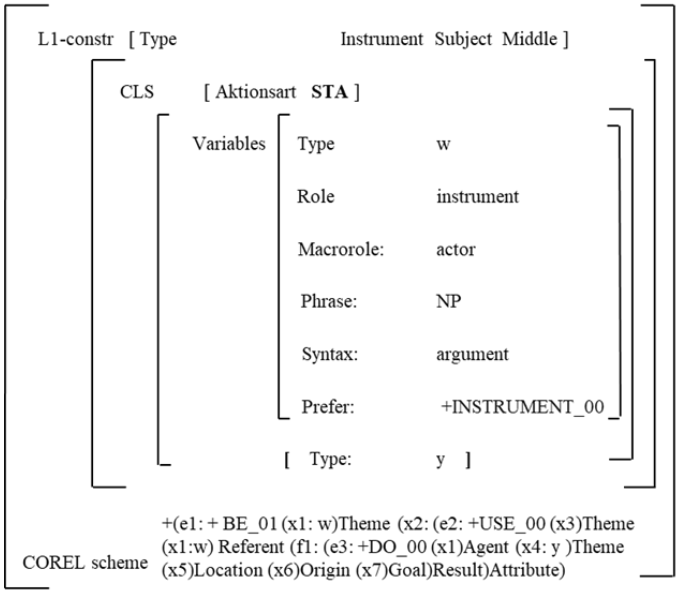

Figure 3: ***AVM for the Instrument Subject Middle Construction***

The AVM in Figure 3 is our proposal to formalize this construction. It describes the Instrument Subject Middle as a similar construction to the Instrument Subject (see Figure 1): in both cases, the CLS presents two variables, *w* and *y*, and in both the macrorole assigned to the instrument (*w*) is actor; the distinguishing feature is in the Aktionsart of the construction, which is now a State, and not a Causative Accomplishment. Semantically, this difference is also shown in a different COREL scheme. As an example, the semantic rendering of (10) as a COREL scheme would be the following:

(11) A hydraulic actuator opens each door
(e1:+BE_01(x1:+HYDRAULIC ACTUATOR_00)Theme (x2:(e2: +USE_00 (x3:+HUMAN_00)Theme (x1: +HYDRAULIC ACTUATOR_00)Referent) (f1: (e3: +OPEN_00 (x1: +HYDRAULIC ACTUATOR_00)Agent (x4: +DOOR_00)Theme (x5)Location (x6)Origin (x7)Goal)Result)Attribute)

4.2 *Implicational or L2-constructions in ASD-STE100*

Ruiz de Mendoza and Galera (2014: 32) state that "Level 2 addresses situation-based implicated meaning, which can sometimes become conventionally associated with a given linguistic form thus giving rise to so-called implicational constructions". Within FunGramKB, the L2-Constructicon is scarcely populated as it contains only a short list of such constructions. Therefore, a thorough description of L2-constructions in natural English, including their conventionalized linguistic forms and their corresponding COREL scheme, should be provided. This, however, does not imply that there has not been research in this field. Thus, Luzondo-Oyón and Ruiz de Mendoza (2017: 40-41) describe and formalize constructions such

as What's X doing Y*?*, Who's been V-ing Y*?*, etc. which belong within the Wh-attitudinal family (2017: 42). However, the very nature of L2-constructions, which (Ruiz de Mendoza & Galera, 2014: 31) "arise from meaning implications that were originally derived through inferential mechanisms from the activation of relevant elements of low-level situational models," makes them incompatible with the type of language inherent to our corpus. If the main purpose of technical texts which employ a simplified controlled language is to avoid ambiguity and potentially subjective readings, it comes as no surprise that implicational constructions are not present in our corpus. It is, then, at this constructional level where the controlled nature of ASD-STE100 becomes more evident.

4.3 *Illocutionary or L3-constructions in ASD-STE100*

Contrary to what was the case with L2-constructions, L3 or illocutionary constructions are not only compatible with the simplified language, but inherent to the characteristics of technical language. The computational treatment of the types of speech acts associated with maintenance manuals calls for an unambiguous representation of the rhetorical functions of the main types of texts: descriptive, procedural and safety instructions. While natural language and syntactic rules can account for descriptions, however, procedures and safety instructions are strongly associated with constructional schema, and should be described in reference to fixed and variable elements, as summarized in the following quote by Del Campo Martínez and Ruiz de Mendoza (2012: 17):

> According to the LCM, the expression of illocution is often based on specific constructional patterns. Illocutionary constructions are considered linguistic mechanisms with fixed and modifiable elements capable of providing relevant points of access to high-level situational cognitive models. The nature of illocutionary constructions ranges from full codification to different degrees of conventionalization.

In accordance with the principles of the LCM, Level 3 of the FunGramKB Constructicon is organized into twelve different types of speech acts: advising, apologizing, boasting, condoling, congratulating, offering, ordering, pardoning, promising, requesting, thanking and threatening. Jiménez-Briones (2016: 55) describes the process for the formalization of the different constructions which realize each of these speech acts. Their description by means of COREL schemes imposes expressive limitations which have been surpassed by establishing constructional domains where different constructions are grouped under the umbrella of a common COREL scheme. Thus, the L3-Constructicon in FunGramKB describes 34 different constructional domains, among them, Advising-type-1, whose description we have already offered in Figure 2. However, none of the domains described in the L3-Constructicon fully coincides with those we consider the most relevant constructions for our text types, namely, giving instructions and warning. In the following subsections we will provide their formalization.

4.3.1 *Giving instructions*

Of the constructional domains included at this level, the most closely related with the rhetorical function *giving instructions* is that of *ordering*. In the repository, three constructional domains describe this type of function (see Figure 3): Ordering-type-1, Ordering-type-2 and Ordering-type-3.

Figure 3: ***L3-Constructicon: Ordering (types 1, 2, and 3)***

There are major differences between these three types of *ordering* and the rhetorical function of giving instructions inherent to instructional texts. The first of these constructional patterns, Ordering-type-1, is, in our opinion, the closest to the function *giving instructions*, since it is described as: "The speaker, who has authority over the hearer, tells the hearer that he has the obligation to act as commanded." In our corpus, it is the writer of the manual who exerts power over the maintenance crew who has to comply with the orders, there is, however, a relevant and distinguishing feature in the case of giving instructions in aviation manuals, this is, that the ultimate purpose of this directive speech act is "to learn how to complete a task." However, none of the realizations described for Ordering-type-1 (*Can you [VP]?, You are going to [VP], You are to [VP]*) would be accepted forms in ASD-STE100, as this controlled language 1) does not allow for interrogative sentences, 2) imposes restrictions on the use of continuous verb forms, and 3) prescribes that commands should be written in the imperative form. As for the second type of commands, Ordering-type-2, these are described in the Constructicon as "The speaker, who has authority over the hearer, appeals to the hearer's willingness to act as commanded" and they are realized by means of these structures*: Can you please [VP]?, Why don't you [VP]?, You have got to [VP], You must [VP]*. Looking at their semantics and their formalization, it is obvious that this type of interpersonal constructions will not be present in aviation maintenance manuals. The same is true of Ordering-type-3 commands, those which are realized by means of *Let's* structures, and described as: "The speaker, who has authority over the hearer, tells the hearer that he has the obligation to act as commanded because it would be beneficial for the hearer." The interpersonal reading of this kind of constructions is highlighted by Del Campo and Ruiz de Mendoza, who describe them as suggestions, rather than as orders (2012: 22): "The plural imperative form *let's* is generally associated with acts of suggesting that involve both the speaker and the addressee. The `order´ reading of this construction is largely based on contextual variables".

It seems, then, that in ASD-STE100 none of the three domains described in the FunGramKB Constructicon for ordering are suitable for the directives used to give instructions in the texts analyzed. We need, therefore, to provide both a semantic and a formal description of the rhetorical function *giving instructions* in the context of aviation maintenance manuals written in this simplified language.

Instructional texts transmit practical knowledge in order to help readers carry out a specific task (Nickl, 2018: 321). Consulting dictionaries, we encounter similar definitions for the word *instruct*. Thus, the *Collins English Dictionary* entry reads: "If you instruct someone to do something, you formally tell them to do it"; "Someone who instructs people in a subject

or skill teaches it to them". The *Oxford English Dictionary* defines *instruct* as: "To teach, train, or educate (a person, the mind, etc.); to provide with knowledge or training"; "To teach (a person) how to do something". In this sense, we understand that instructing in aviation manuals is a special type of *teaching* in which what is learnt is how to complete a task. In order to formulate this meaning into a COREL scheme we have to resort to the FunGramKB Ontology. Checking the ontological concept +TEACH_00 we find that it belongs in the following conceptual route:

(12) #EVENT >> #COMMUNICATION >> #+SAY_00 >> +EXPLAIN_00 >> +TEACH_00

Thus, +TEACH_00 is depicted as a communication verb; its immediate superordinate is +EXPLAIN_00, another speech verb, which, in turn has as a superordinate +SAY_00. Each of these concepts has something in common, the *genus*, and, at least, one differentiating feature or *differentia*. Accordingly, the meaning postulates in (13) and (14) portray +EXPLAIN_00 as "saying something to someone in a clear manner", and +TEACH_00 as explaining, but, in this case, "with the purpose of learning something".

(13) +EXPLAIN_00:
+(e1: +SAY_00 (x1)Theme (x2)Referent (x3)Goal (f1: +CLEAR_00)Manner)

(14) +TEACH_00
+(e1: +EXPLAIN_00 (x1)Theme (x2)Referent (x3)Goal (f1: (e2: +LEARN_00 (x3)Theme (x2)Referent))Purpose)

In order to create a COREL scheme for giving instructions in ASD-STE100 we cannot use the ontological concept +TEACH_00. As we saw in example (14) above, +TEACH_00 is defined as explaining "with the purpose of learning something", therefore, it is not explicit enough to account for the *differentia* inherent to the rhetorical function of giving instructions in ASD-STE100, namely, "teaching with the specific purpose of learning how to complete a maintenance chore". In our opinion, to represent this *differentia*, we could use the superordinate ontological concept +EXPLAIN_00 which, as we said previously, is also a speech verb described as "saying something to someone in a clear manner." In order to account for our *differentia*, we would need to add to the COREL scheme an adverbial of purpose (or purpose satellite, f1). Accordingly, we propose the following scheme for the illocutionary function *giving instructions* in ASD-STE100:

(15) +(e1: +EXPLAIN_00 (x1)Theme (x2)Referent (x3)Goal (f1: (e2: +LEARN_00 (x3)Theme (x2: (e2: +FINISH_00 (x3) Theme (x4: +WORK_03) Referent)Referent))Purpose)

This COREL scheme reads as: "a speaker explains something to a hearer with the purpose that the hearer learns how to complete a task." The formal cues which trigger this L3-construction are the following: 1) imperative sentences in the positive form, 2) declarative sentences + deontic *must*, and 3) imperative *let*. By way of illustration, the following are some corpus instances of *giving instructions*:

(16) Clean the components.
(17) You must do the required conditions of the operational tests on ground.
(18) Let the hydraulic fluid drain from the shock absorber.

4.3.2 *Warning*

Although the main purpose of instructional texts is to indicate how to complete a task, it is often the case that the activity may entail a danger or a risk to the operator or to the objects involved. As a consequence, instruction manuals not only contain instructional information, but also include warnings and cautions. These two very similar speech acts are differentiated in the ASD-STE100 specification as follows (2017: 1-7-1): "a warning tells the reader that there is a risk of injury or death" while "a caution tells the reader that there is a risk of damage to objects". Given the importance of avoiding risks, technical writing usually adheres to warning message design standards, one of the most common being the American National Standard for product safety Information in product manuals, instructions and other collateral materials, the so-called ANSI Z535 standard for hazardous situations. According to this standard, a "warning indicates a hazardous situation which, if not avoided, could result in death or serious injury", while a "caution indicates a hazardous situation which, if not avoided, could result in minor or moderate injury". The difference between the two is, then, only a matter of degree. In fact, in our corpus there seems not to exist any relevant distinction between warnings and cautions, which has led us to codify them as two variants of the same type of constructional meaning.[2] Thus, we have encoded a "Warning-1" type and a "Warning-2" type, both illustrated by this extract:

(19) *Make sure that* you hold the electrical harness along its full length during removal and installation procedures (Warning-type-2). *If you do not obey* this instruction, damage to the harness, cables and electrical connectors can occur (Warning-type-1).

There are, in our opinion, semantic and formal differences between these two types of warnings which justify their treatment as separate constructions. Warning-type-1 Constructions are always realized as negative structures which can take the form of negative imperative sentences or of negative type zero conditionals that express general truths; semantically they "advise the reader not to do something because it is dangerous", as in examples (20) to (23).

(20) If you do not obey these precautions, there is a risk of explosion.
(21) Do not use these materials near a flame, sparks or sources of heat.
(22) Be careful not to cause damage to the aircraft attachment lugs.
(23) Do not apply a liquid or gas fire extinguisher directly on a hot wheel or brake unit. If you do not obey these precautions, there is a risk of explosion.

As can be noticed in the examples above, the danger may or may not be explicitly stated. This does not pose a problem for a human reader who can rely on his/her knowledge of the world to interpret what the likely danger may be; it might, nevertheless, be of great importance for the automatic treatment of the text. We believe, however, that by treating it as a construction and providing the formal cues, the contextual conundrum can be avoided. It is also worth highlighting that Warning-type-1 Constructions realized by imperative sentences can also be considered as instructions; for the purpose of their automatic treatment, we will understand

[2] It must also be noted that in ASD-STE100 there is also a compositional or lexical way of expressing warnings through declarative sentences that contain lexical items such as *risk, damage* or *danger,* where the "warning" meaning is already inherent, as in these examples:

a) Unwanted electrical power can be dangerous.
b) If the leg moves, there is a risk of injury to personnel and/or damage to the aircraft.

negative imperative sentences as warnings, since instructions always appear in the positive form, as in (24) and (25):

(24) Do a visual inspection of the component interface. (Giving instructions)
(25) Do not touch hot parts with your bare hands. (Warning-type-1)

The semantic rendering of Warning-type-2 Constructions would read as "A speaker advises a hearer to do something with the purpose of preventing danger." Formally, these warnings are substantiated through the fixed phrases *Make sure that* and *Be (very) careful when*. As was the case with Warning-type-1 Constructions, the danger can be explicitly stated or not:

(26) Make sure that the wheel chocks are in the correct position. This will prevent unwanted movement of the aircraft, and thus possible damage.
(27) Make sure that the safety devices and the warning notices are in position before you start a task.
(28) Be very careful when you turn the changeover valve nut to prevent internal damage to the valve.
(29) Be careful when the retraction actuator is unlocked.

Similar to what was the case with giving instructions, there is no domain in the L3-Constructicon that coincides completely with warnings in ASD-STE100. Although not totally equivalent, the one that best resembles this rhetorical function is that of advising. In fact, dictionary entries for *warn* describe it as a form of advising, thus, the *Oxford English Dictionary* defines it as "To give (a person) cautionary notice or advice with regard to actions or conduct; to caution against neglect of duty or against wrong or mistaken action or belief."; similarly, the *Collins Cobuild Dictionary* reads "If you warn someone not to do something, you advise them not to do it so that they can avoid possible danger or punishment."

Within the FunGramKB Constructicon, advising is represented by three different constructional domains. The first, Advising-type-1, is defined as "The speaker advises something to the hearer because he thinks that what he is advising may help the hearer. This happens in a situation in which something is making the hearer feel bad" and it is realized by the phrases *Consider [VP], You ought to [VP]* or *you should [VP]*. Advising-type-2 is triggered by the cues *I advise you [VP]; If I were you, I would [VP]; [VP] is a good idea; [VP] is the best option* and it is defined as "The speaker advises something to the hearer because he thinks that what he is advising is good for the hearer. This happens in a situation in which something is making the hearer feel bad". Finally, Advising-type-3 (which presents the forms *How about [VP]?* and *Why not [VP]?*) receives the following semantic description: "The speaker advises something to the hearer because he thinks that what he is advising may be interesting for the hearer. This happens in a situation in which something is making the hearer feel bad."

Reading these descriptions we immediately realize what they all have in common: interpersonal meaning. As Del Campo Martínez (2012: 115) states, the act of advising is characterized by the benefit that it intends for the addressee; in the act of advising there are always interpersonal relations involved (which becomes clear through the presence of personal pronouns). Accordingly, the constructional domain of advising as described in the FunGramKB Constructicon is not suitable for the analysis of instructions manuals written in ASD-STE100. The reasons are twofold: firstly, interpersonal meaning is incompatible with technical language; secondly, the ASD-STE100 specification prescribes against the use of most of the formal cues of the Advising-constructions described in the FunGramKB Constructicon, as it bans 1) the use of epistemic modality, 2) the hypothetical meaning inherent to type-2 conditional clauses and 3) interrogative structures.

To be able to include in the L3-Constructicon the two types of warning which characterize the ASD-STE100 corpus, and which are triggered by the formal cues already indicated, we need to provide their corresponding COREL schemes. For that purpose, and following the dictionary definitions of *warn*, we resorted to the ontological concept +ADVISE_00, which in the FunGramKB Ontology is described as a speech verb (see example (1)). [3]

In the first type of warning, a speaker advises a hearer (in our case, a writer and a reader) not to do something as it might be dangerous. This, which is the ultimate purpose of this kind of warning, is also what differentiates it from the act of advising. Formally, this *differentia* is encoded in the COREL scheme of the construction as an adverbial of reason (satellite f1: Reason):

(30) Warning-type-1. COREL schema:
+((e1: +ADVISE_00 (x1: <SPEAKER>)Theme(x4: (e2: n +DO_00 (x3)Theme (x2)Referent)Referent (x3:<HEARER>)Goal (f1: (e3: +BE_01 (x2)Theme (x5: +DANGEROUS_00)Attribute) Reason)

As for the second type of warning -those in which a writer advises a reader to do something to prevent danger- they are also codified as advising, although, this time, the *differentia* is expressed as a purpose satellite (f1: Purpose):

(31) Warning-type-2. COREL schema:
+((e1: +ADVISE_00 (x1: <SPEAKER>)Theme (x2)Referent (x3:<HEARER>)Goal (f1: (e2: $PREVENT_00 (x2) Theme (x4) Referent) (e3: +BE_01 (x4)Theme (x5: +DANGEROUS_00)Attribute))Purpose)))

4.4. *Discursive or L4-constructions in ASD-STE100*

According to Mairal-Usón and Ruiz de Mendoza (2009), connectedness in a discourse can be achieved implicitly, through inferencing, or explicitly, via linguistic cues, that is, by means of L4 o discursive constructions, those which (2009: 168) "deal with how the speaker creates connectedness in his speech production". The authors, following the semantic classification of complex sentences (2009: 175), divide discoursal constructions into three different semantic realms -elaboration, extension and enhancement-, which are further subdivided into specific semantic relations such as restatement, addition, condition, etc. The FunGramKB Constructicon contains an enhanced version of their description and lists 21 different types of L4-constructions. As was the case with L2 and many of the L3-constructions in the FunGramKB catalogue, none of the L4 constructions described are suitable for the formalization of ASD-STE100 instruction manuals. Again, many of the realizations are not approved forms in ASD-STE100, nor are they pertinent to technical language. Take as an example the L4-constructions Disagreement Contrast, realized by means of phrases such as *I'm sorry but* or *at odds with*, or the Demonstrative Alternation construction, cued by *let alone* or *needless to say*. There are, however, some realizations present in our corpus, but these can be accounted for syntactically, such is the case of the Cause-construction realized by means of [S], *because* [S] or [S], *because* [NP], or the Concessive Complementary-Contrastive Construction triggered by *although*, as in (32) and (33).

[3] To further support this analysis it is worth mentioning that the ASD-STE100 specification (2017: 2-1W1) prescribes against the use of the verb *warn*, providing as an approved alternative the speech verb *tell*.

(32) The two links do the same function as a panel, because there is no panel attached to the top part of the forward leg.
(33) Although the pressure decreases, the valve must stay closed.

This type of structures with subordinating conjunctions can be elucidated at the level of the sentence. Martín-Díaz (2019) and Martín-Díaz and González Orta (2020) propose to treat them as linkage marker conjunctions, providing their description and the syntactic structures in which they participate.

The whole catalogue of L4-Constructions is, therefore, redundant for ASD-STE100 instruction manuals. From our analysis, we conclude that the only discourse level connectors that are minimally relevant are conjuncts, of which we could only find two instances, *then* and *also.* These two connectors will link two independent sentences which will conform a higher node, the text:

(34) Do a visual inspection of the NLG torque-link assembly for signs of damage or corrosion. *Also* examine that it is correctly attached.
(35) For the L and R aft WoW sensors, do a search of the Parameter Names that follow. *Then*, select the applicable parameters.

The lack of explicit connectors in the corpus can be explained bearing in mind that this type of perlocutionary texts are organized as step-by-step procedures which adhere to the iconicity principle: what is mentioned first is what has to be done first. Predictably, conjuncts do not play a crucial role in this type of discourse where the sequential order of events is mirrored in the speech chain, as in the procedural text in (36).

(36) Disassemble the MLG lateral links (3): […]
Disassemble the MLG panels (2): […]
Do an inspection of the components that follow: […]
Assemble the MLG panels (2): […]
Assemble the MLG retraction actuators (1): […]
Install the related components on the aircraft.

5. CONCLUSIONS

In this paper we sought to provide a formalized account of non-propositional meaning in a corpus of aviation maintenance manuals written in the controlled natural language ASD-STE100. Following the theoretical principles of the LCM, we assessed the presence of constructions belonging to the four constructional levels as described in the FunGramKB Constructicons. In doing so, we have seen that ASD-STE100 behaves as a natural language in some aspects, but that it is also strongly constrained by the technical nature of the documentation in others. Although further quantitative analysis of the corpus needs to be implemented, we have discovered that it is at argumental level (L1) where the catalogue of constructions is less restricted by the type of language, to the point that a new L1-construction had to be proposed. At the same time, technical discourse seems to neutralize all those constructions which involve interpersonal meaning. This affects all constructional levels, but is much more obvious in the absence of L2 or implicational constructions, and in the restrictions imposed on the L3 and L4-Constructicons. It is at L3, the illocutionary level, where constructions seem to play a fundamental role, as they turned out to be of major importance to formalize the main rhetorical functions associated with aviation manuals: giving instructions

and warning. Finally, the iconicity inherent to instructional sequences highly limits the scope of the L4-Constructicon, which for the purposes of describing ASD-STE100 only envisages the use of the conjuncts *then* and *also*. With the description provided we hope to have demonstrated the suitability of the FunGramKB Constructicons for the computational treatment of non-propositional meaning within a specialized domain characterized by a specific type of discourse.

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