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AUTOMATED SEMANTIC FRAME ANNOTATION

An Exploratory Study in the Health Domain

Abstract A medication package insert is a legal healthcare document with important information about medications. In Brazil, the National Health Surveillance Agency (ANVISA) requires two versions of the package insert: one for patients and another one for healthcare professionals. In this study, we manually evaluated the performance of an automatic frame annotator on a corpus consisting of 100 sentences targeting patients and 100 sentences targeting healthcare professionals. The aim was to evaluate whether the parser's output evidenced correct assignment of semantic frames and their frame elements (FEs) in each input sentence and to what extent human post-annotation would be necessary to improve the output. Text target audience was defined as a variable potentially impacting frame detection given differences in the language of package inserts. Overall, the findings demonstrate the efficacy of the automated annotation process, revealing challenges that have to do with the same form being capable of classification under different categories and/or frames. Few differences were found when comparing sentences for the two distinct audiences targeted in the texts.

Keywords FrameNet; FrameNet Brasil; Large Ontology Multilingual Extraction (LOME); FrameNet parser; automated semantic frame annotation; manual annotation; health domain

1. Introduction

The theory of Frame Semantics (Fillmore, 1982) relates lexical meaning to human experience, whether perceptual, social, or cultural. Semantic frames are structures which organize such knowledge. Through FrameNet, we can relate context and meaning in a multidimensional and multimodal approach (Torrent et al., 2022).

FrameNet, which originated with an interest in computational lexicography, has now expanded to various uses in language technology (Belcavello et al., 2024; Viridiano et al., 2024). In this work, we present initial contributions on the results of a semantic parser powered by FrameNet's linguistic annotation data (Das et al., 2014).

To this end, we explored the use of a semantic frame parser and human evaluation of its output in an annotation effort towards developing resources for Brazilian Portuguese. Our aim was to assess whether the parser's output showed correct assignment of semantic frames and their frame elements (FEs) in each input sentence and in cases of incorrect assignment what type of human post-annotation would be necessary to improve the output. Additionally, we wanted to find out if the parsing output would be impacted by the register of the texts used.

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In this annotation task, a small corpus of 200 sentences was compiled from the dosage and administration section in medication package inserts written in Brazilian Portuguese and published by Brazil's National Health Authority ANVISA. Our study focused on texts targeting two distinct audiences, with 100 sentences addressing lay users/patients and 100 sentences addressing healthcare professionals. Target audience was defined as a variable potentially impacting frame detection as the parser is modelled upon language input which does not necessarily include samples of text with the characteristics of the language used to address each targeted group.

The sampled sentences were automatically annotated using the semantic frame parser in the LOME system (Xia et al., 2021), a multilingual information extraction system, fine-tuned with a corpus of annotated texts in Brazilian Portuguese. The texts are part of FrameNet Brasil database, which includes a model as well as texts annotated for the health domain (Dutra et al., 2023).

The paper is organized as follows: Section 2 presents the semantic annotation process of FrameNet. In this section, we outline the key concepts of the FrameNet model and describe the semantic annotation process within this framework. Section 3 describes the annotation task, providing information on the compiled corpus, the parser used, the manual annotation stages, and the types of post-editing performed. In Section 4, we discuss the annotation and post-editing results, illustrating our findings with examples. Finally, Section 5 concludes the paper and outlines future projections for this work.

2. FrameNet Semantic Annotation

2.2 FrameNet Model

FrameNet is a semantically oriented computational resource drawing on Frame Semantics (Fillmore, 1982; 1985) for the following concepts: frame, frame element, lexical units, and frame-to-frame relations.

Frame: a frame is a linguistic-computational system used for knowledge representation, modelling concepts and situations across different domains. For instance, the `Waking_up`[1] frame describes the transition from a state of consciousness where an individual is largely unaware of their environment to a wakeful state.

Frame Element (FE): a frame consists of elements, so-called frame elements. They are participants, props, and other fundamental elements that define the frame. Within its structure, FEs are categorized into nuclear and non-nuclear elements. In the `Waking_up` frame, the nuclear FEs are SLEEP_STATE and SLEEPER, which are essential for conceptualizing the sleeping event. Other FEs, such as TIME, PLACE, and CIRCUMSTANCES, can be instantiated within the scope of a sentence, though not necessarily so, and are hence considered non-nuclear.

[1] Following established conventions, frame names are set in `Courier`, frame elements in SMALL CAPS.

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In the process of semantic annotation, FrameNet identifies instances of null instantiation of FEs, namely Definite Null Instantiation (DNI), Indefinite Null Instantiation (INI), and Constructional Null Instantiation (CNI). Briefly stated, a DNI is an example of anaphoric omission, where the missing FE has been previously mentioned in the linguistic or discursive context. An INI comprises situations where the FE cannot be inferred from the context. A CNI is characterized by a non-realization licensed by a grammatical construction, such as a subject not realized by a pronoun in imperative sentences.

Lexical Unit: a lexical unit is the linguistic material that instantiates a frame, i.e., a lemma endowed with a specific meaning (form + meaning). In the sentence, "*This morning, Maria woke up from a long dream*", we analyse the lexical unit *wake up*.v as evoking the `Waking_up` frame. "*Maria*" occupies the slot of the nuclear FE SLEEPER, while "*from a long dream*" occupies the slot of the nuclear FE SLEEP_STATE. "*This morning*" occupies the slot of the non-nuclear FE TIME.

In Framenet, there are generally two ways to view the semantic annotation of lexical units, as shown by the two representations of the sentence in Example 1 "This morning Maria woke up from a long dream."

Representation 1
[This morning $_{\text{TIME}}$], [Maria $_{\text{SLEEPER}}$] **WOKE UP** [from a long dream $_{\text{SLEEP\_STATE}}$]
Representation 2
This morning, Maria **WOKE UP** from a long dream[2].

Associations between form and meaning which evoke lexical frames may involve multiword expressions (MWEs). An MWE is the association of two or more lexemes that implicate a unit of meaning and evoke a frame. Some idiomatic expressions are good examples of MWEs, such as 'middle of nowhere,' as explained in Ruppenhofer et al. (2016). If we consider the study of specialized domains from a terminological perspective, multi-word units are defined based on the relevance of a given terminological unit to the technical domain in question. In this work, although we are dealing with texts belonging to a specific domain, we have not annotated terminological units; rather, we have focused on lexical LUs and relied on annotations previously stored in our database.

To the basic concepts hitherto presented we should add that of frame to frame relation.

Frame to frame relation: the relationship between frames reinforces the assumption that language knowledge is interconnected and that a frame interacts with other frames. Fillmore & Baker (2009) present a set of frame to frame relations in three major groups: generalization (inheritance, perspective_on, using), event structure (subframe, precedes) and systematic relations (causative_of, inchoative_of).

[2] Each label has a colour corresponding to a Frame Element instantiated in sentences from corpora. Examples of corpus annotation in English are found in the original FrameNet (framenet.icsi.berkeley.edu). For linguistic data in Brazilian Portuguese, these can be accessed through the webtool annotation platform (webtool.frame.net.br).

Returning to our example, `Waking_up` is a subframe of `Sleep_wake_cycle`, meaning it is a sub-event of a more complex event. `Waking_up` precedes `Being_awake` and is preceded by `Sleep`. Frame to frame relations are detailed in Ruppenhofer et al. (2016).

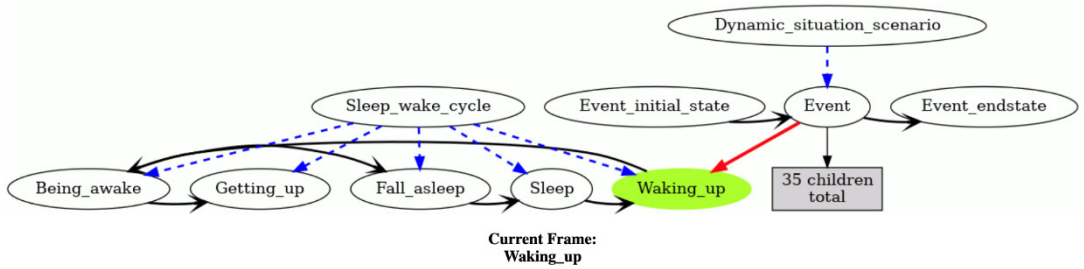

Fig. 1: `Waking_up` frame to frame relation[3]

2.3 FrameNet Annotation

FrameNet linguistic annotation records semantic and syntactic information of a Lexical Unit. Depending on the purpose, the annotation can be carried out in two modes: lexicographic or full text annotation. In lexicographic annotation, the annotator annotates various instances of corpora of the same lexical unit. This is the most common form of annotation. The purpose is to evaluate the semantic and syntactic behaviour of the same lexical item from a specific meaning.

The second mode is full text annotation, whereby all the frames evoked within the scope of a sentence are annotated.

In our work, we carried out full text annotation to evaluate the performance of an automatic annotator in assigning frames and their elements in sentences retrieved from text in medication package inserts. Figure 2 shows a full text annotation performed by our frame semantic parser for Example (2), and Figure 3 shows a screenshot of our software interface where sentence (2) was manually revised and edited.

The sentence in Example (2) was retrieved from a patient medication package insert

1. Lave suas mãos após a aplicação do produto

   Wash your hands after the application of the product

   "Wash your hands after applying the product"

[Lave $^{\text{GROOMING FRAME}}$] suas [mãos $^{\text{BODY\_PART FRAME}}$] [após $^{\text{TIME\_VECTOR FRAME}}$] a [aplicação $^{\text{PLACING FRAME}}$] do [produto $^{\text{ENTITY FRAME}}$].

Note that each Lexical Unit (LU) is identified by its corresponding frame followed by its Part of Speech (POS), for example, Grooming.lave.v. (Grooming = frame; *lave [wash]* = word form of the verb *lavar [to wash]*; v=verb).

[3] https://framenet.icsi.berkeley.edu/node/5039

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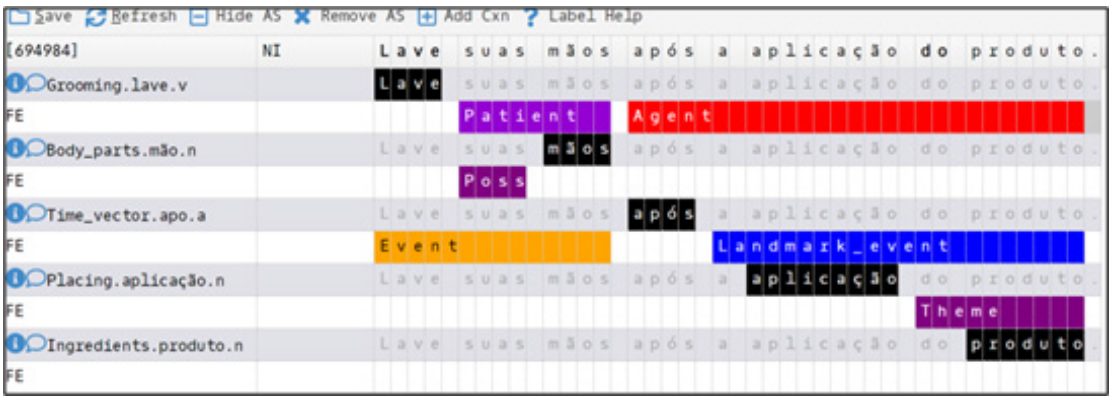

Fig. 2: Screenshot showing full text annotation performed in a frame semantic parser [webtool.framenetbr.ufjf.br]

The output of the automatic annotation was post-edited for different types of error using the FrameNet interface. For example, post-editing was carried out to fix tokenization errors (*apo*.a instead of *após [after]*) as well as POS tagging errors (verb *dosar [to dose]*.v instead of noun *dose [dose]* .n). Incorrect frame assignment was also edited. For instance, in Figures 2 and 3, we can see five frames being evoked in each. Except for *produto [product]*.n, all other lexical items were correctly assigned to their frames.

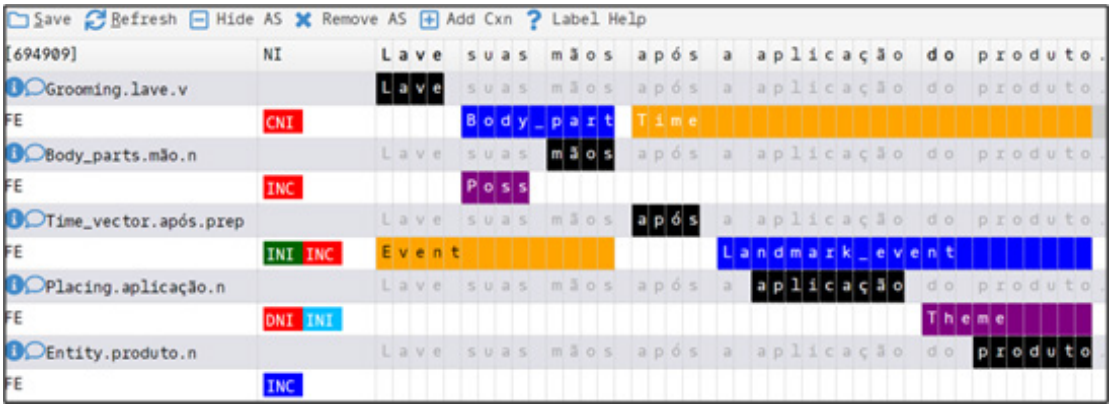

Fig. 3: Full text annotation manually revised and edited [webtool.framenetbr.ufjf.br]

Regarding the Frame Elements (FEs), they were correctly assigned, except for the FEs of the LU *lavar [to wash]*.v, where "*suas mãos*" [your hands] was tagged as PATIENT, while the correct tag should be BODY_PART, and "*após a aplicação do produto*" [after the aplication of the product] was marked as AGENT, whereas the correct tag is TIME. Table 1 shows the semantic annotation for that sentence. During the review and editing process, manual insertion of null instantiations was performed.

Table 1: Semantic annotation for sentence in Example 2

Lexical Unit	Frame	Frame Element
lavar.v	Grooming	BODY_PART, TIME
mãos.n	Body_part	POSSESSOR
após.prep	Time_vector	EVENT , LANDMARK_EVENT
aplicação.n	Placing	THEME
produto.n	Entity	-

3. The Annotation Task

Given the centrality of developing tools for automating semantic annotation, this work undertook the task of post-editing annotations in order to evaluate types of necessary modifications upon automatic annotation, following FrameNet's semantic annotation criteria.

3.1 Corpus

A medication package insert is a relevant text for obtaining safe information about the safe use of a medication and its potential risks. In Brazil, this text is available in a more technical version aimed at healthcare professionals and a less technical version intended for patients or their caregivers, such as in the case of medication for children.

The text in a medication package insert comprises several sections. Examples of these sections include presentation, composition, contraindications, dosage and administration, among others. Each country has its own regulatory agency. In the United States, the Food and Drug Administration is the agency that sets the guidelines for these documents. In Brazil, the National Health Surveillance Agency (ANVISA) is responsible for controlling such information. Package inserts can be accessed online at: https://consultas.anvisa.gov.br/#/bulario/, a website frequently updated by ANVISA.

In our study, we retrieved medication package inserts from ANVISA's website. We chose the dosage section to compile 200 sentences for analysis, with one hundred sentences aimed at healthcare professionals and one hundred at patients. Our corpus totals 3615 words and is sentence-aligned, so that for each sentence collected from the dosage section in the text addressing healthcare professionals there is a counterpart sentence in the text addressing the patient. The task of collecting and aligning the corpus was carried out manually by junior researchers participating in the project.

Unlike studies which conducted a quantitative evaluation of automatic frame parsing performance (Das et al., 2010; Zadeh et al., 2019), our work pursued a qualitative approach and due to the small size of the corpus, a statistical approach that would allow for measuring the parser's performance was not conducted. However, important insights were gathered from the output.

3.2 Automated Semantic Frame Annotation

For the automatic annotation of frames and frame elements in this work, the LOME (Large Ontology Multilingual Extraction) system was used. Its pipeline includes a full FrameNet parser, capable of identifying the frames and frame elements in a sentence (with their occurring spans), as well as performing coreference resolution, entity typing and temporal resolution between events (Xia et al., 2021).

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Because it is designed for multilingual information extraction, LOME is trained on top of the XLM-RoBERTta multilingual large language model (Conneau et al., 2020), allowing it to learn in one language and perform semantic parsing in others.

In this work, we used a version of LOME trained with full-text annotations from Berkeley FrameNet 1.7 and full-text annotations from FrameNet Brasil 1.7. The training data from FrameNet Brasil includes a set of recently created frames for the healthcare domain (Dutra et al., 2023) and their related full-text annotations for Brazilian Portuguese.

What distinguishes LOME from other parsers is having only a sentence as input. Other parsers, for example, can only identify a frame if the trigger span is part of the input. A trigger span is a continuous part of the sentence (one or more tokens) that evokes a frame. These are expected to be the spans of lexical units. The main difference is that in human-annotations, the lexical units of a frame are defined and then used to annotate. LOME does not have any kind of information on lexical units, so it just searches for spans that evoke a frame. In a scenario where the model is 100% accurate, every trigger span is the span of a lexical unit.

3.3 Manual Annotation Effort

The LOME results were imported into the FN.Br annotation software for the task of manual post-editing. Figure 4 illustrates the revision workflow. Initially, annotators verified whether the target was correctly identified, followed by checking if the segmentation of the target unit and part-of-speech tagging were correctly done. If not, manual revisions were performed. Subsequently, the assessment of frame assignment was conducted. If the lexical item had been correctly assigned to the frame, the next step was to evaluate whether nuclear and non-nuclear frame elements were identified and consequently labelled.

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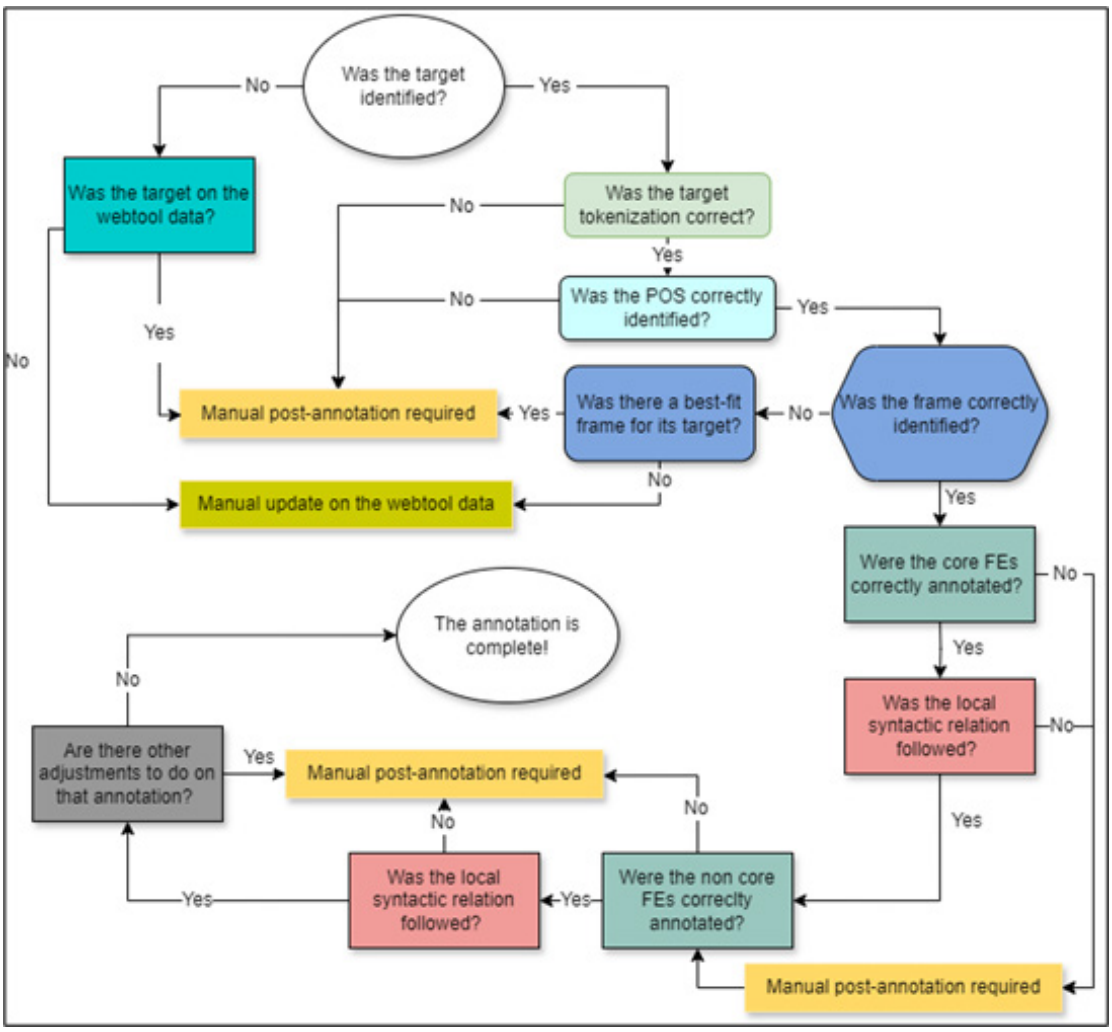

Fig. 4: Post-annotation flowchart

Among the post-annotations made based on the results of the automatic annotation, the main ones are as follows:

- **Target**: target identified or not.

In the sentence in Example 2, the target *dever*.v was the only one recognized as a target by LOME, and the `Desirable_event` frame was assigned to the target. That sentence was post-annotated and Example 3 shows the other targets that evoke frames.

2. JANUMET **deve** ser administrado duas vezes ao dia, durante as refeições.
   JANUMET should be administered twice a day, during meals
   'JANUMET should be administered twice a day, during meals.'
3. JANUMET **deve** ser **administrado duas vezes** ao **dia**, **durante** as **refeições**.

- **Tokenization**: correctly identified or not.

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Errors in target tokenization were identified in several sentences, as shown in Figure 2 and illustrated in Example 4 with the target *após*.prep.

4. Não utilize nenhuma bandagem (faixa) a**pós a**plicação do medicamento.

   Do not use any bandage after applying the medication

   'Do not use any bandage after applying the medication.'

- **Part-of-speech**: correctly identified or not.

The LOME system was not trained for Part of Speech (POS) recognition. In many instances of correct semantic frame assignment, manual intervention was required to properly assign the POS of the word under analysis. In Example 6, *uso*.n (*use*.n) was identified as *usar*.v (*use*.v) in the `Using` frame. Through manual editing the POS tag was changed to *uso*.n in `Using` frame.

5. Evitar o **uso** de roupas íntimas de tecido sintético (como nylon), utilizar as de algodão.

   Avoid the use of underwear synthetic fabric (such as nylon) prefer those of cotton

   'Avoid the use of synthetic fabric underwear (such as nylon), prefer cotton ones.'

- **Frame**: correctly inferred or not.

In Example 6, the best-fit frame is `Change_position_on_a_scale`, as this frame indicates the change in position of an item on a scale from an initial point to an end point. The semantic frame parser directed the target to the `Health_condition` frame. However, *depressão*.n (*depression*.n) in the `Health_condition` frame refers to a psychiatric disorder, which is not the case in Example 6.

6. Os pacientes devem ser bem monitorados quanto ao desenvolvimento de **depressão** profunda da medula óssea.

   The patients should be closely monitored for the development of depression deep marrow bone

   'The patients should be closely monitored for the development of deep bone marrow depression.'

- **Frame Element (core or non-core)**: addition, suppression, modification of FE.

Example 7 illustrates the identification of the frame and its FEs by manual post-annotation and by the semantic frame parser. The lexical unit is *usar*.v and the frame is `Using`. This frame involves an agent manipulating an instrument to achieve some purpose. The core FEs are AGENT, INSTRUMENT, and PURPOSE. Among the non-core FEs are PLACE, TIME, FREQUENCY, and several others.

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7. Semantic parser annotation:

Use ~~USO.N~~ USAR.V: USING FRAME [o aplicador $_{\text{INSTRUMENT}}$] [apenas uma vez ~~TEMPO~~ FREQUENCY].

Manual post-annotation:

Use USAR.V: USING FRAME [o aplicador $_{\text{INSTRUMENT}}$] [apenas uma vez $_{\text{FREQUENCY}}$].

Use the applicator only once

'Use the applicator only once.'

The AGENT and PURPOSE are not instantiated in the sentence. In this case, the AGENT is marked in the manual annotation as CNI due to the imperative. The INSTRUMENT FE is instantiated and was correctly identified as "*o instrumento*" (*the instrument*). On the other hand, what the parser identified as TIME is the FE FREQUENCY, "*apenas uma vez*" (*only once*). Based on the types of edits performed, this example includes a FE modification.

4. Results

A series of errors were identified regarding the assignment of frames and FEs. Among them, polysemous targets stood out. In the sentence presented in Table 2, there is a warning for patients in case they forget to take their medication: they do not need to take the missed dose, but should follow the usual schedule for the next dose.

Table 2: The polysemy of *esquecido*.a (*missed*.a)

PATIENT	HEALTHCARE PROFESSIONAL
Caso você se esqueça de tomar rosuvastatina cálcica, não é necessário [tomar a dose ACTION] **esquecida**.	Se o paciente se esquecer de tomar uma dose de rosuvastatina cálcica, não é necessário tomar a dose esquecida, deve-se apenas tomar a próxima dose, no horário habitual.
'If you forget to take rosuvastatin calcium, it is not necessary to take the missed dose.'	'If the patient forgets to take a dose of rosuvastatin calcium, it is not necessary to take the missed dose; simply take the next dose at the usual time.'

Considering FN.BR database, the *esquecido*.a lemma can be associated with different conceptual frames, such as `Remembering_information`, `Remembering_to_do`, `Remembering_experience`, and `Abandonment`. The frame semantic parser assigned *esquecida*.a to the `Abandonment` frame. In this frame, an AGENT leaves behind a THEME effectively rendering it no longer within their control or of the normal security as one's property. However, `Remembering_to_do` seems to be the best-fit frame, since a COGNIZER thinks of and performs an ACTION that is a self- or other-imposed task or some other kind of desirable behavior. The action may involve a SALIENT_ENTITY in some way affected by the cognizer. If a SALIENT_ENTITY is mentioned, the ACTION is left unexpressed.

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Table 3: The polysemy of *dever*.v (*should*.v)

PATIENT	HEALTHCARE PROFESSIONAL
No caso de se esquecer de uma dose de OTEZLA, tome-a assim que se lembrar. 'If you miss a dose of Otezla, take it as soon as you remember.'	Se o paciente esquecer uma dose, [a próxima dose REQUIRED_SITUATION] **deve** [ser tomada REQUIRED_SITUATION] [o quanto antes TIME]. 'If the patient misses a dose, the next dose should be taken as soon as possible.'
Em bebês e crianças de até 4 anos de idade, [o produto não REQUIRED_SITUATION] **deve** [ser aplicado REQUIRED_SITUATION] [por período superior a 3 semanas TIME], [especialmente em áreas cobertas por fraldas PLACE]. 'In infants and children up to 4 years of age, the product should not be applied for more than 3 weeks, especially in areas covered by diapers.'	Em lactentes e crianças abaixo de 4 anos, [o tratamento não REQUIRED_SITUATION] **deve** [prolongar-se REQUIRED_SITUATION] [por mais de 3 semanas TIME], [especialmente nas zonas cobertas por fraldas PLACE]. 'In infants and children under 4 years old, the treatment should not extend beyond 3 weeks, especially in areas covered by diapers.'
Tome os comprimidos por via oral com pouca quantidade de líquido não alcoólico. 'Take the tablets orally with a small amount of non-alcoholic liquid.'	[As gotas REQUIRED_SITUATION] **devem** [ser dissolvidas em um pouco de líquido não alcoólico REQUIRED_SITUATION]. 'The drops should be dissolved in a small amount of non-alcoholic liquid.'
[Você REQUIRED_SITUATION] **deve** [usar este medicamento exclusivamente nos olhos REQUIRED_SITUATION]. 'You should use this medication exclusively in the eyes.'	Este medicamento é de uso oftálmico. 'This medication is for ophthalmic use.'

Table 3 shows the case of the target *dever*.v in the sense of presenting a situation required for medication use. This was recurrent in the corpus, both in the texts addressing patients and those addressing healthcare professionals. Almost all automatic annotations assign *dever*.v to the `Desirable_event` frame, which suggests that a particular state of affairs is desirable.

Since these are medication package inserts, usage instructions for a medication are guidelines that must be followed and carefully observed by the patient. If they are not, negative consequences may occur. Given this context, the `Required_event` frame is the appropriate one, because in this frame the state of affairs obtained by the required situation prevents a negative consequence from occurring. This is the main difference between the `Desirable_event` and `Required_event` frames.

A further example is illustrated in Table 4.

Table 4: The polysemy of *diminuir.v* (*reduce.*v) / aumentado.a (increased.a)

PATIENT	HEALTHCARE PROFESSIONAL
Tome JANUMET durante as refeições, para **diminuir** [a possibilidade de [distúrbios estomacais $_{\text{ITEM}}$] $_{\text{ATTRIBUTE}}$]. 'Take JANUMET with meals to reduce the possibility of stomach upset.'	JANUMET deve ser administrado duas vezes ao dia, durante as refeições. 'JANUMET should be administered twice a day, with meals.'
Pacientes com insuficiência do fígado podem apresentar [risco de toxicidade $_{\text{ATTRIBUTE}}$] **aumentado**. 'Patients with liver failure may have an increased risk of toxicity.'	Pacientes com insuficiência hepática podem apresentar [risco de [toxicidade $_{\text{ITEM}}$] $_{\text{ATTRIBUTE}}$] **aumentado**, particularmente mielossupressão graus III-IV. 'Patients with hepatic insufficiency may have an increased risk of toxicity, particularly Grade III-IV myelosuppression.'

The frame assigned by the automatic parser in the sentences shown in Table 4 was `Cause_expansion`, in which an AGENT or a non-human CAUSE causes an ITEM to change its physical size. However, there is no physical size change in reducing the chance of stomach disorders. Therefore, the best-fit frame is `Change_position_on_a_scale`, as this frame indicates the change in position of an ITEM on a SCALE from an INITIAL_VALUE to a FINAL_VALUE.

5. Conclusions and Future Work

Our analysis of automatically annotated sentences revealed some of the challenges faced by an automatic frame parser. These range from tokenization and part-of-speech tagging to assignment of a correct frame. Some of the problems found, as is the case of tokenization and part-of-speech tagging, have an impact on downstream tasks, such as frame and frame element assignment. These cases are likely to be solved in the near future with better tokenization and part-of-speech models. Other problems, however, are more complex to solve, as they demand interpretation, as seen in cases of polysemy.

Overall, using automatic frame parsers seems promising and their output is illuminating regarding polysemous language and the need to further expand the frames available in FrameNet. We believe our work is relevant as a first look at the types of post-editing an automatic annotator requires. Human/manual annotation is a time-consuming process and qualitatively identifying the types of errors made allows for effective curation of automatic annotations in the near future of annotation.

As further steps in our research, we plan to conduct a new training of the parser based on the edits made and to perform post-editing on 200 new sentences to evaluate whether there were improvements, particularly in cases of polysemous lexical items.

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Regarding the analysis of the language of medication package inserts, our results showed that the frames evoked in the texts addressing healthcare professionals and patients are similar, although the lexical structure is presented differently. Future work will be carried out to assess the level of semantic similarity between the two types of texts.

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