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DEC Facile: Bringing Combinatory Explanatory Dictionaries to the Semantic Web

Andrea Bellandi, Abdelouahab Masbah, Silvia Piccini

Institute Of Computational Linguistics "A. Zampolli", Via G. Moruzzi 1, Pisa, 56122, Italy.

Contributing author(s). E-mail(s): andrea.bellandi@ilc.cnr.it;
abdelouahab.masbah@ilc.cnr.it; silvia.piccini@ilc.cnr.it

Abstract

This paper presents *DEC Facile*, a tool specifically developed for the construction of computational Explanatory Combinatorial Dictionaries (ECDs). Unlike existing dictionary editors, *DEC Facile* combines the theoretical rigor of Explanatory Combinatorial Lexicology with Semantic Web standards, being powered by LexO-server and extended with Ontolex-Lemon modules. By natively integrating Linked Data principles, it ensures that lexical and terminology resources are interoperable, reusable, and easily connected to other datasets. The platform provides a user-friendly interface supporting core lexicographic and terminological tasks such as dictionary search, sense editing, and the encoding of lexical functions. *DEC Facile* thus represents a novel environment for lexicography, terminography, and computational linguistics, bridging the gap between ECL-based resources and the Semantic Web ecosystem. The system is currently being applied within the PRIN project *Old Words for a New World. Translating Christianity to Baltic Pagans*, where it supports the construction of an ECD for the earliest Baltic catechisms (Old Lithuanian, Old Latvian and Old Prussian).

Keywords: Explanatory Combinatorial Dictionary, Ontolex-Lemon, Semantic Web, Linked Data

1 Introduction[1]

The development of accurate and computationally actionable linguistic resources has played a crucial role in Natural Language Processing (NLP) (Guthrie et al., 1996; Huang et al., 2010; Mititelu et al., 2025; Pustejovsky & Boguraev, 1993; Wehrli & Clark, 1995), and this remains true despite the advent of neural and Large Language Models (LLMs). Core NLP tasks, including word sense disambiguation, multilingual understanding, and semantic reasoning, still rely on large-scale lexical databases and semantic knowledge graphs, such as WordNet and BabelNet,[2] which provide structured, multilingual meaning representations.

[1] This work was carried out collaboratively. Silvia Piccini was responsible for Sections 1 and 2; Andrea Bellandi for Sections 3 and 6; Abdelouahab Masbah for Section 4; all authors contributed to Section 5. In terms of CRediT (Contributor Roles Taxonomy), the authors contributed as follows : Andrea Bellandi: Conceptualization, Supervision, Methodology, Project Administration, Software, Writing – Original Draft, and Writing – Review & Editing; Silvia Piccini: Conceptualization, Investigation, Supervision, Validation, Funding Acquisition, Writing – Original Draft, and Writing – Review & Editing; and Abdelouahab Masbah: Software, Validation, Visualization, Writing – Original Draft, and Writing – Review & Editing.

[2] For a discussion on the possibility of considering Wikipedia as a lexical resource, see Zesch et al. (2007).

Among these resources, Explanatory Combinatorial Dictionaries (ECDs), grounded in the theoretical framework of Explanatory Combinatorial Lexicology (ECL) (Mel′cuk et al., 1995), are particularly noteworthy. They provide a highly structured representation of meaning and combinatorial properties of lexical units, with a degree of description far beyond traditional lexicography. A key feature of this model is the formalism of lexical functions, which systematically capture paradigmatic and syntagmatic relationships between words. This approach has proven effective in resolving syntactic and lexical ambiguities, identifying idiomatic equivalents in machine translation, and generating paraphrases, among other applications (Gelbukh & Kolesnikova, 2013; Mel′cuk & Wanner, 2001; Wanner, 1996).

In terminology work, the adoption of ECL-based approaches is relatively recent, following a shift from the traditional concept-oriented perspective to a more lexicon-driven view (L'Homme, 2020). Early terminology resources developed between the 1970s and the 1990s—such as EURODICAUTOM,[3] IATE,[4] and TERMIUM Plus[5] —were based on an onomasiological paradigm, conceived as collections of concepts associated with lists of designations in multiple languages. Over time, the growing recognition of the central role of meaning in terminology[6] and its formalization led to what has been described as the "linguistic turn" (Bourigault & Slodzian, 1999; Castellví, 2003; L'Homme, 2020). This shift paved the way for the integration of insights from theoretical linguistics, with frameworks such as Generative Lexicon Theory (Pustejovsky, 1998), Frame Semantics (Fillmore, 1976; Fillmore & Baker, 2009), and Explanatory Combinatorial Lexicology being successfully applied to the structuring of specialized terminologies and domain-specific lexical resources (Faber, 2012; Piccini, 2015; Ruimy et al., 2013).[7]

Specifically, ECL principles have been applied in a number of projects to build large-scale digital resources. Notable examples include the *Diccionario de Colocaciones del Español* (DiCE),[8] a web-based Spanish collocations dictionary (Universidad de La Coruña) (Vincze et al., 2011), and the Papillon Project (Boitet et al., 2002), which aims to create a multilingual French-English-Japanese lexical database using interlingual links. At the *Observatoire de linguistique Sens-Texte* (OLST)[9] at the University of Montréal, the ECL model has been widely applied in specialized lexicography, resulting in resources such as DiCoEnviro (environmental terminology),[10] DiCoInfo (computer science terminology),[11] and JuriDiCo (legal terminology).[12]

However, creating ECDs remains a complex and time-consuming process. Previous attempts to develop ECD editors (Gader et al., 2012; Sérasset, 1996) have sought to support this task, but significant challenges persist regarding usability and interoperability. This is the reason why the present work introduces *DEC Facile*, the first prototype of a tool specifically designed for the construction of computational ECDs based on Semantic Web technologies (Berners-Lee et al., 2001) and the Linked Open Data (LOD) paradigm (Bizer et al., 2011), thus enabling the creation of ECDs natively designed for interoperability with other lexical resources and NLP applications. Its architecture will also make it possible to convert existing OntoLex-Lemon resources into ECD-compliant structures, while providing an intuitive interface for editing and enriching entries according to the theoretical principles of ECL.

The work presented in this paper is part of the Italian funded project "Old Words for a New World. Translating Christianity to Baltic Pagans",[13] which includes the creation of an ECD focused on the

[3] For more information, see https://web.archive.org/web/20050207084637/http://europa.eu.int/eurodicautom/Controller?ACTION=about

[4] For more information, see: https://iate.europa.eu/home

[5] For more information, see: https://www.btb.termiumplus.gc.ca/tpv2alpha/alpha-eng.html?lang=eng

[6] See, for instance, the volume *Le sens en terminologie* (Béjoint & Thoiron, 2000), which aims to restore the centrality of the linguistic dimension—and therefore of meaning—in terminology. The contributions collected in this work critically revisit the attempt, widespread in traditional approaches, to grant terminology autonomy from linguistics by drawing a sharp distinction between "terms" and "words," a distinction that has largely proved to be illusory.

[7] http://www.dicesp.com/consultageneral/lemas

[8] For more information, see: http://www.dicesp.com/consultageneral/lemas

[9] For more information, see: https://olst.ling.umontreal.ca/

[10] For more information, see:
https://olst.ling.umontreal.ca/dicoenviro/moteur/search-enviro.cgiui=en&mode=terme&lang=fr&prec=exact&equi=1&rq=

[11] For more information, see: https://olst.ling.umontreal.ca/dicoinfo/moteur/search.cgi

[12] For more information, see: https://olst.ling.umontreal.ca/?page_id=4385&lang=en

[13] Financed by the European Union – Next Generation EU, Mission 4 Component 2 CUP: B53D23014130006.

religious terminology extracted from the earliest Baltic catechisms (Old Lithuanian, Old Latvian and Old Prussian) as one of its primary objectives (Piccini et al., 2025). *DEC Facile* has been designed and implemented to support this goal, providing a promising environment for modeling complex lexical relations in historical and specialized domains.

The remainder of this article is organized as follows. Section 2 reviews the state of the art, focusing on tools that support the creation of lexical resources through Semantic Web technologies as well as those explicitly designed for ECDs. Section 3 describes the data model underlying *DEC Facile*, while Section 4 illustrates its architecture and interface. Section 5 presents a preliminary evaluation of the tool combining an assessment of its functional coverage, interoperability, and performance with a usability review. Section 6 discusses the implications of this work and outlines future research directions.

2 State of the Art

Since the 1990s, when Igor Mel'čuk's ECL was gaining wide recognition, several initiatives aimed to create dedicated environments for constructing ECDs. Among them are DECID (Sérasset, 1996) and DICET (Gader et al., 2012),[14] which were conceived to directly implement the principles of ECL and to provide lexicographers with specialized means for encoding lexical functions and combinatorial structures. More specifically, DECID is characterised by an interface that closely replicates the organization and layout of the printed version of an ECD, thus minimizing the cognitive shift for lexicographers accustomed to traditional format. Data can be exported in a variety of formats, including SGML/TEI, LISP, HTML, as well as RTF or MIF for typesetting and publication purposes. DICET on the other hand, is a knowledge-based lexicographic editor developed within the RELIEF project (2011–2014) to support the construction of the *Réseau Lexical du Français* (RL-fr) (Polguère, 2014), a large-scale lexical resource grounded in ECL principles and Meaning-Text Theory. Designed as a Java application interfacing with SQL databases, DICET allows lexicographers to encode lexical units and their paradigmatic and syntagmatic relationships—particularly lexical functions—through structured data entry. The editor provides dedicated modules for grammatical information, valency patterns, and collocational links, while displaying the data in dictionary-style views. Data can be exported in XML/HTML.

Neither DECID nor DICET, however, natively support Semantic Web technologies, a limitation that affects their interoperability with other lexical and terminology resources. This is particularly relevant in light of recent advances in computational lexicography and terminology, where increasing efforts have been devoted to developing tools and models that ensure semantic interoperability, data reusability, and integration with the Web of Data. The OntoLex-Lemon model (McCrae et al., 2017),[15] for example, developed by the W3C Ontology-Lexica Community Group, has emerged as the *de facto* standard for representing lexicons, terminologies, and lexical-semantic resources in RDF. Since its introduction in the form of *lemon*, several initiatives have aimed to develop tools capable of creating resources compliant with this model. At present, VocBench 3 (Stellato et al., 2020)[16] and LexO (Bellandi, 2021) stand out as two well-established tools in this domain, each designed for different use cases and user communities. VocBench 3 is a collaborative web-based platform for editing and managing ontologies, thesauri, and lexical resources. It is fully compliant with Semantic Web standards such as RDF, SKOS, OWL and OntoLex-Lemon, and provides multilingual support, validation, and workflow management. Its combination of collaborative features and standards compliance has made it a widely used tool for maintaining FAIR terminology resources.

LexO, on the other hand, is a web-based collaborative editor specifically designed for the creation and management of ontologies and lexical resources. It is oriented toward linguistics and digital humanities, supporting the OntoLex-Lemon model and enabling the structured representation of lexical,

[14] In 2018, the ItsyBitsy Editor project was launched to replace Dicet with a new-generation editor. Compared to its predecessor, ItsyBitsy is conceived as a web-based, open-source system with a modular architecture, offering interlingual connections via a pivot database of linguistic universals, support for both expert and general-public modes, crowdsourcing functionalities for data enrichment, and enhanced accessibility across browsers. Further information is available at: https://lexical-systems.atilf.fr/en/lexicography/

[15] https://www.w3.org/2016/05/ontolex/

[16] http://vocbench.uniroma2.it/

Table 1 Comparison among the main tools for compiling lexical resources and dictionaries

Tool	Scope	Standards & Models	Key Features	Typical Use Cases
DECID	Construction of computerized ECDs	ECL & Meaning-Text Theory; SGML/TEI (export), RTF (import/export)	Interface mirroring printed ECD; creation and modification of entries; RTF and structured export; data recovery from existing ECD files	Digitizing existing ECDs; producing print-ready dictionaries; lexicographic research in ECL
DICET	Large-scale lexical networks (RL-fr)	ECL & Meaning-Text Theory; SQL (storage), XML/HTML export; partial LMF compatibility	Graph-based editing of lexical units, lexical functions, grammar/valency/collocations; dictionary-style views	Encoding paradigmatic and syntagmatic relations; managing large-scale lexical networks; lexicographic research
VocBench 3	General ontology, thesauri, and lexicon management	RDF, SKOS, OWL, OntoLex-Lemon	Collaborative editing, workflow management, versioning, multilingual support, integration with triple stores	Managing FAIR ontologies, thesauri, and lexical resources
LexO	Lexical resources for linguistics & digital humanities	OntoLex-Lemon, Lexicog, Semantic Web standards	Creating and managing lexical resources and ontologies for DH research	Creating and managing lexical resources and ontologies for DH research
Maia	Text annotation and lexicon building	OntoLex-Lemon, Linked Data	Integrated environment for text annotation and lexicon creation, formal linking of corpus contexts to lexical entries/senses	Corpus-based lexicography, contextualized lexical resources, digital humanities annotation projects
DEC facile	Construction of computational ECDs	OntoLex-Lemon, Lexicog, LexFom, Linked Data	Web-based collaborative editor for ECD editing; import/export of OntoLex-Lemon lexicons	Creating ECDs from scratch; transforming existing Ontolex-Lemon lexicons into ECDs; collaborative work

morphological, and semantic information. The platform emphasizes usability, collaborative work, and interoperability with Semantic Web standards.

More recently, the MAIA tool (Giovannetti et al., 2024) has been developed as an open, collaborative web-based platform built on Semantic Web and Linked Open Data technologies, designed for text annotation, e-lexicography, and lexical linking. It enables users—especially digital humanists—to annotate texts and simultaneously construct computational lexicons within the same environment. It builds upon LexO-server (Bellandi, 2023), reusing its lexical management functionalities while extending them with modules for text annotation and contextual linking.[17] In Table 1, we summarize the main aspects of each tool, emphasizing scope, underlying models and standards, key features, and typical use

[17] This overview deliberately excludes tools such as FairTerm (1.0 and 2.0) (see https://shiny.dei.unipd.it/fairterm/), which allows the creation of terminological resources in compliance with the ISO 30042 (2019) - Management of terminology resources - TermBase eXchange (TBX). While such tools are valuable within the domain of terminology management, they are not based on Semantic Web technologies nor on the theoretical framework of ECL and therefore fall outside the scope of this comparison.

cases. For comparative purposes, *DEC Facile* has also been included, in order to highlight its innovative traits and to show how it differs from existing tools.

Table 1 clearly highlights the novelty of *DEC Facile* in the landscape of currently available tools. While VocBench 3, LexO, and MAIA are firmly grounded in Semantic Web standards and provide robust environments for ontology and lexicon management, they are not specifically designed to meet the requirements of ECL, particularly the formalization of lexical functions and combinatorial properties. Conversely, tools developed specifically for ECDs, such as DECID and DICET, offer strong theoretical compliance with ECL but were designed outside the Web of Data paradigm.

DEC Facile fills this gap by combining the theoretical rigor of ECL with the OntoLex-Lemon model and the Linked Open Data paradigm, ensuring that the resulting resources are natively structured for interoperability with other lexicographic and terminological datasets. In this respect, *DEC Facile* represents the first platform explicitly designed to bring ECD construction into the Semantic Web ecosystem.

3 Data Model Behind the Tool

The theoretical framework of the ECL, central to the development of *DEC Facile*, has made a significant contribution to lexicography and has also found notable applications in terminology in recent years, as mentioned in the Introduction. By providing a structured approach to modeling lexical relations, combinatorial properties, and semantic nuances, ECL offers a powerful tool not only for dictionary creation but also for broader applications such as computational linguistics, terminography, and specialized language analysis. At its core, an ECD entry is organized into three distinct sections, as illustrated by the Lithuanian entry *vesti* "to lead; to marry (referring to a man)" in Figure 1.

The first section (a) presents the definition of the lexeme *L*, formulated using a predefined metalanguage, where the semantic actants [SemAs] introduced by *L* are explicitly identified as variables (X, Y, Z, etc.). In our entry *vesti*, two senses are distinguished; here we focus on the second, which is specific to the matrimonial domain: "X leads [in his own home] Y [as wife]". In this sense, marriage is represented by the act of the man bringing his wife into his new home, thus actualizing the union. The second section (b) presents the government pattern of *L*, typically in a rectangular matrix, where columns correspond to the SemAs and rows specify their possible morphosyntactic realizations. More specifically, as indicated by the additional semantic constraints listed at the bottom of the table, the noun in the first column (C1), corresponding to SemA X, typically refers to the husband, whereas the noun in the second column, corresponding to SemAs Y, refers to the wife. Finally, the third section (c), which is pivotal in Mel'čuk's theory, focuses on lexical functions, which define the syntagmatic and paradigmatic relations that the lexeme *L* has with other dictionary entries. In our entry, we have identified four structural derivatives obtained through nominalization (S_0): *venčiavojimas I*, *venčiavonė I*, *venčiavonystė I*, *suliūbas venčiavonystės I* ("marriage"). The lexical function S_{1perf} represents the typical designation of DSyntA I[18] (*venčiavotasis vyras I*, 'groom'), while S_{2perf} represents the typical designation of DSyntA II (*venčiavotoji moteris I*, 'bride'), broadly corresponding, respectively, to the agent (syntactic subject) and patient (syntactic object) introduced by the verb *vesti*.

This theoretical structure is operationalized and implemented in a computationally actionable format through the OntoLex-Lemon model, a suite of RDF vocabularies (referred to as modules) specifically designed to represent and interlink lexicons, terminologies, lexical-semantic resources and, more broadly, language resources in the Linguistic Linked Open Data (LLOD) cloud (Chiarchos et al., 2013), in alignment with Semantic Web best practices and Linked Data principle. The OntoLex-Lemon modules encompass various aspects of linguistic representation, including morphology, syntax-semantics mapping, variation, translation, and linguistic metadata.

In *DEC Facile*, the data model is primarily structured around three key modules: the i) lexicography module, the ii) lexical functions module, and the iii) syntax-semantics module.

[18] The deep syntactic argument is defined in Explanatory and Combinatorial Lexicology as follows : "Nous appelons *actant syntaxique profond* [= ASyntP] de la lexie L un syntagme qui dépend de L syntaxiquement et en exprime un actant sémantique" (Mel'čuk et al. 1995, p. 11; Transl.: 'We call a deep syntactic actant [= DSyntA] of the lexeme L a syntagm that syntactically depends on L and expresses a semantic actant.').

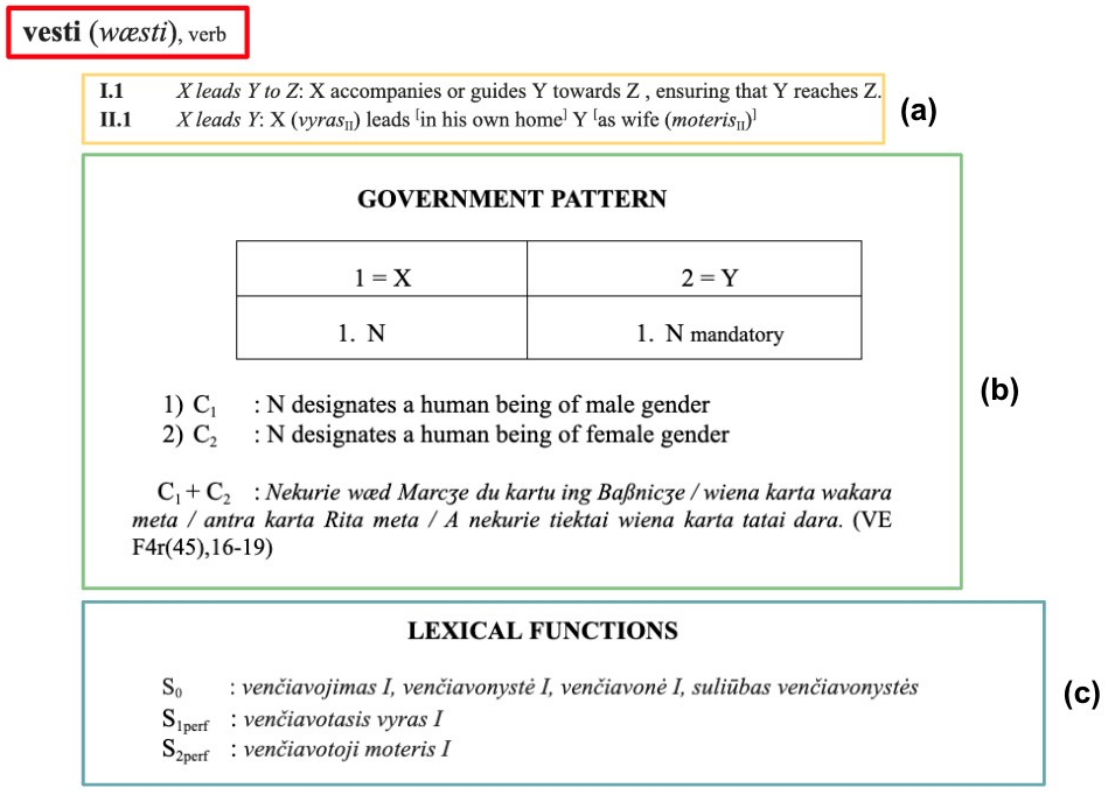

Fig. 1 ECD entry for *vesti* (a) senses definition – (b) government pattern – (c) lexical functions description

3.1 The Lexicography Module

The lexicography module (*lexicog*)[19] is specifically designed to represent existing dictionaries and lexicographic resources as Linked Data. It complements the Ontolex core module (often referred to as Ontolex), extending its functionality to manage the structures and annotations typical of lexicographic practices. As shown in Figure 2 (a), a lexical entry (`LexicalEntry`) is defined as an entry of a lexicon (`Lexicon`) characterized by a set of senses (`LexicalSenses`) and a set of written forms (not depicted in Figure 2 (a)). A dictionary (`LexicographicResource`), in turn, is composed of a set of dictionary entries (`Entry`), each corresponding to the description of a lexical entry. As shown in Figure 2 (c), beyond this linguistic layer, the model also enables the explicit representation of the conceptual dimension of the lexicon: lexical senses can be linked to concepts defined in an external ontology, thereby grounding dictionary meanings in a shared, formally specified conceptualization. This connection between senses and concepts supports richer semantic interoperability across resources and facilitates advanced querying and integration scenarios that combine linguistic information with domain knowledge.[20]

In *DEC Facile*, the lexicography module is particularly useful for modeling the ordering of senses, as an ECD requires lexical senses to be hierarchically organized, when applicable, according to three levels that reflect the semantic distance between lexemes: large distances, indicated by Roman numerals (I, II, III, etc.); medium distances, indicated by Arabic numerals (1, 2, 3, etc.); and small distances, indicated by lowercase letters (a, b, c).

[19] https://www.w3.org/2019/09/lexicog/

[20] It is worth underlying that this separation between the linguistic and conceptual levels aligns with the widely accepted view of terminology as a "twofold science" (Roche, 2012; Santos & Costa, 2015; Piccini et al., 2017; Piccini, 2023).

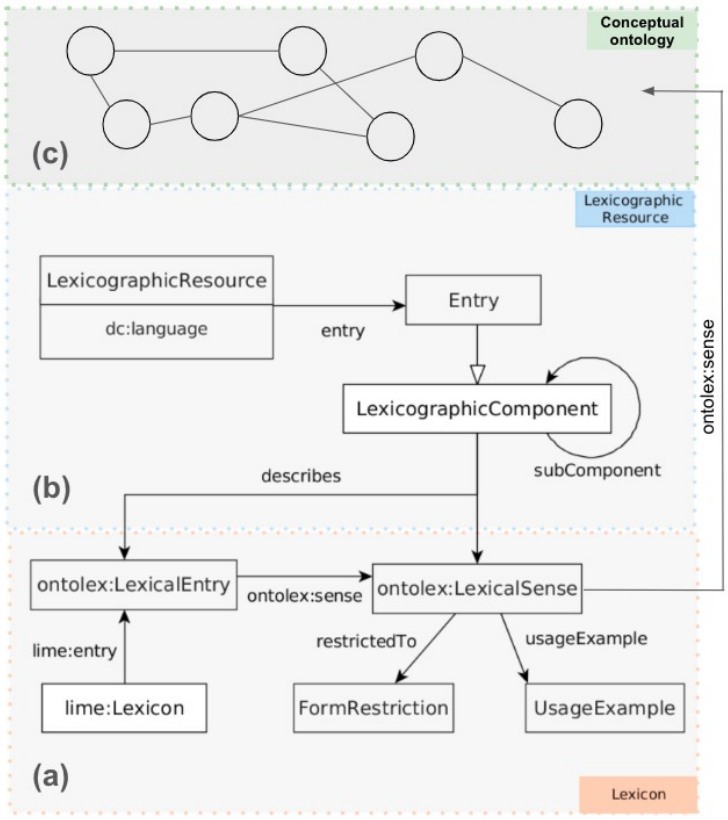

Fig. 2 (a) The OntoLex-Lemon core – (b) The lexicography module – (c) The conceptual layer

In the example entry *vesti* (Figure 1), only large distances are represented. To encode this ordering of senses in *DEC facile*, the `LexicographicComponent` class is used. This structural element captures the arrangement of descriptions provided in a lexicographic resource according to various aspects such as order, hierarchy, grouping, etc.

The representation of linguistic information within dictionary entries relies on LexInfo,[21] an ontology of linguistic categories that extends the OntoLex-Lemon model by offering a comprehensive set of data categories for parts of speech, morphological features, syntactic properties, and other linguistic annotations that are frequently required in lexicographic and NLP applications. By supplying a controlled vocabulary of linguistic descriptors, LexInfo ensures semantic interoperability across different lexical datasets and enables consistent integration of linguistic information with ontologies. This makes it a key component for building multilingual, semantically interoperable lexical resources on the Semantic Web.

Figure 3 illustrates a fragment of the encoding for the Lithuanian lexical entry vesti. In lines 01 - 04, *vesti* is defined as a verb with two lexical senses, the definitions of which are provided in lines 20-23. Note that the two references to senses of other dictionary entries in the definition of the second sense of *vesti* are formally encoded by the `rdfs:seeAlso` property (line 24). Lines 5-6 arrange the lexical entry as a lexicographic component of the suitable dictionary entry.

The lexicographic component makes it possible to order multiple lexical entries within a single dictionary entry. In fact, a one-to-one correspondence between dictionary entries and `LexicalEntry` instances in an OntoLex-Lemon lexicon cannot always be assumed. A single dictionary entry may cover more than one lexical entry—for example, a headword defined both as a noun and as an adjective. To capture this complexity, the class `Entry` is introduced, as shown in Figure 2 (b). This class structurally aggregates multiple lexical entries, thereby reflecting the organization established by the lexicographer.

[21] https://lexinfo.net/

```
01  :vesti_lex_entry a ontolex:LexicalEntry ;
02        lexinfo:partOfSpeech lexinfo:verb ;
03        ontolex:sense :vesti_sense_I1, :vesti_sense_II1 ;
04        rdfs:label "vesti"@lit .

05  :vesti_dict_entry a lexicog:Entry ;
06        rdf:_1 :vesti_entry_comp.

07  :vesti_entry_comp a lexicog:LexicographicComponent ;
08        lexicog:describes :vesti_lex_entry ;
09        rdf:_1 :vesti_sense_I_comp ;
10        rdf:_2 :vesti_sense_II_comp .

11  :vesti_sense_I_comp a lexicog:LexicographicComponent ;
12        rdfs:label "I" ;
13        rdf:_1 :sense_I1_comp .

14  :vesti_sense_I1_comp a lexicog:LexicographicComponent ;
15        rdfs:label "I1" ;
16        lexicog:describes :vesti_sense_I1 .

17  :vesti_sense_II_comp a lexicog:LexicographicComponent ;
18        rdfs:label "II" ;
19        rdf:_1 :vesti_sense_II1_comp .
```

```
17  :vesti_sense_II1_comp a
    lexicog:LexicographicComponent ;
18        rdfs:label "II1" ;
19        lexicog:describes :vesti_sense_II1 .

20  :vesti_sense_I1 a ontolex:LexicalSense ;
21        skos:definition "X leads Y to Z: X
          accompanies or guides Y towards Z,
          ensuring that Y reaches Z. " .

22  :vesti_sense_II1 a ontolex:LexicalSense ;
23        skos:definition "X  leads Y: X (vyrasII)
          leads [in his own home] Y [as wife]
          (moterisII). " ;
24        rdfs:seeAlso :vyras_sense_II ,
                       :moteris_sense_II.

25  :vesti_sense_II1 lf:S0 :venčiavojimas_sense_I,
                           :venčiavonystė_sense_I.

26  :vesti_sense_II1 lf:S1perf
                :venčiavotasis_vyras_senseI.

27  :vesti_sense_II1 lf:S2perf
                :venčiavotoji_moteris_senseI.
```

Fig. 3 Instantiation of the data model for *vesti* entry

The elements of this structuring are instances of `LexicographicComponent`. Different organizational strategies are possible: components may be ordered through the RDF list mechanism,[22] arranged hierarchically via the `subComponent` property of *lexicog*, or simply declared as unordered elements within a dictionary entry. Lines 7-19 set the ordering and the labelling (e.g., "I1", "II1") of the lexical senses. Each sense is referred to by a lexicographic component via the `describes` property. Finally, at the highest level, the dictionary is defined as an instance of `LexicographicResource`, composed of the set of `Entry` instances linked via the `entry` property.

3.2 The Lexical Functions Module

Lexical functions formalize relations between lexical units on both the paradigmatic (e.g., synonymy, antonymy, meronymy) and the syntagmatic level (e.g., collocations, support verbs, evaluative expressions). The Lexical Functions Ontology Model (*lexfom*) has been proposed to encode these relations, structured into four modules: representation, family, semantic perspective, and relations. When integrated with the OntoLex-Lemon model, *lexfom* makes it possible to convert lexical networks into Semantic Web formats. It specifies whether a lexical function is simple or complex, syntagmatic or paradigmatic, and formally identifies its constituents, among other aspects.

As illustrated in Figure 3, line 25, the lexical function S_o indicates two structural derivatives formed through nominalization: *venčiavojimas* and *venčiavonystė*, both meaning "marriage". Lines 26–27 introduce the lexical functions S_{1perf} and S_{2perf}, which capture semantically meaningful derivatives associated with specific syntactic roles. As we have already seen, S_{1perf} corresponds to the typical designation of DSyntA I (e.g., *venčiavotasis vyras* "groom"), broadly corresponding to the agent (or syntactic subject). By contrast, S_{2perf} corresponds to the designation of DSyntA II (e.g., *venčiavotoji moteris* "bride"), typically corresponding to the patient (the syntactic object) introduced by the verb *vesti*.

3.3 The Syntax-Semantics Module

The SynSem module of OntoLex is designed to capture the link between the syntactic behavior of a word and its meaning. It distinguishes between the way a word is used in sentences (e.g., its arguments and grammatical frames) and the concepts it denotes in an ontology. By keeping these two levels separated,

[22] The ordering property is rdf:_n

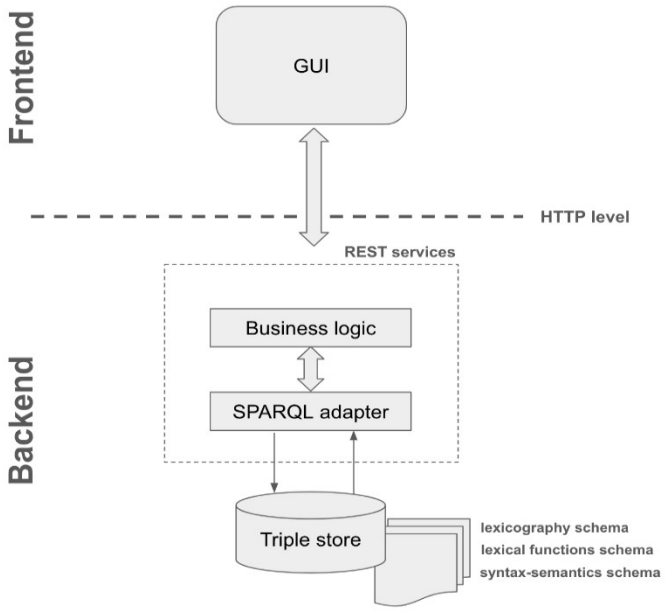

Fig. 4 The system architecture of *DEC Facile*

the module makes it possible to specify both how a word functions in language and how it relates to formal semantic descriptions. This is particularly relevant for modeling phenomena such as verb valency or subcategorization, while ensuring that lexical data can be consistently linked to domain knowledge. In this way, *SynSem* provides a bridge between linguistic variation and conceptual representation.

In the current version of *DEC Facile*, the government pattern of dictionary entries is not yet represented, but *SynSem* is expected to provide the necessary components for its future integration. Each government pattern can be modeled as a syntactic frame, specifying the number of arguments, their syntactic categories, whether they are obligatory or optional, and any required prepositions. In this context, the LexInfo ontology supplies the relevant linguistic categories, while each syntactic argument can be linked to a conceptual element (class, property, or individual) defined in an external ontology to capture the corresponding semantic aspects.

4 The Tool DEC Facile

This section provides a detailed description of *DEC Facile*, focusing on its architecture (Section 4.1) and user interface (Section 4.2).

4.1 System Architecture

The architecture of *DEC Facile*[23] follows a modular design inspired by modern web applications and is structured as depicted in Figure 4.

At the frontend level, the graphical user interface (GUI) provides a browser-based environment, implemented with TypeScript, HTML, and CSS, which allows lexicographers and terminologists to search, create, edit, and enrich dictionary entries across multiple languages. Communication between the GUI and the backend takes place through REST services over HTTP. The backend is powered by LexO-server, an open-source RESTful API layer based on the GraphDB semantic repository and compliant with the OpenAPI specification. Within this layer, the business logic manages the lexicographic operations, while a SPARQL adapter ensures seamless interaction with the triple store.

[23] *DEC Facile* is released as an open-source project; the code and documentation are accessible via Github at the following link: https://github.com/Abdoumasbah/DEC-Facile

Fig. 5 The main dashboard of *DEC Facile*

At the storage level, the system relies on GraphDB as a triple store, which not only guarantees persistence of RDF data but also hosts the three dedicated models introduced in Section 3: the lexicography module (Section 3.1), the lexical functions module (Section 3.2), and the syntax–semantics module (Section 3.3). Such a modular design ensures flexibility, scalability, and full compliance with Semantic Web standards, while also enabling integration with the broader Linguistic Linked Data Cloud in line with FAIR principles.

4.2 Functionalities

The main dashboard of *DEC Facile* is presented in Figure 5. On the left-hand side, the interface displays the list of lexical entries. Each row corresponds to a lexical unit, represented by its label and the associated language code (e.g., Adam @lav for Latvian, Adomas @lit for Lithuanian). For each entry, a set of action icons is available: an eye icon to view the entry details, a pencil icon to edit the entry, and a trash icon to delete it.

At the top of the panel, a search bar enables filtering of entries, while the plus button allows the creation of new ones. The navigation bar at the top of the interface provides additional controls, including language switching (currently between English and French) and a logout option. The central workspace, shown here as blank, dynamically updates to display and edit the contents of a selected lexical entry.

The interface of *DEC Facile* is composed of several panels, each dedicated to specific lexicographic tasks:

- **Search and Filtering Panel**
  The Search and Filtering Panel is illustrated in Figure 5. At the top, a search bar allows users to enter queries, with the total number of available entries (here 86) displayed to the right. Below the search bar, filtering options refine the query: users can select among different matching strategies (Equals, StartsWith, Contains, End) and further restrict results by Language, Editor, or Status.

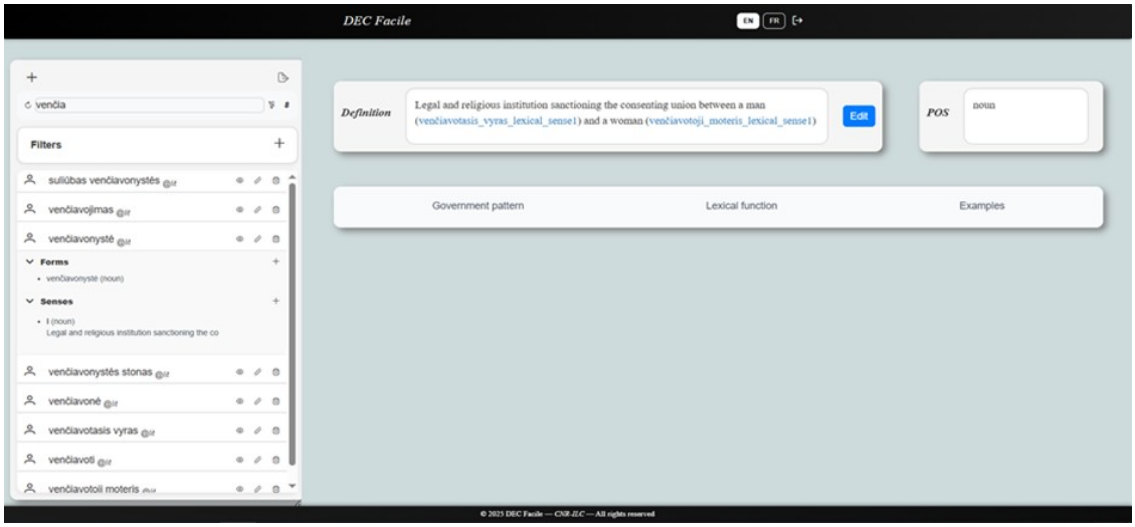

Fig. 6 The entry *venčiavonystė* "marriage"

- **Creation and Editing of Entries**
  The creation of new lexical entries in *DEC Facile* is designed to be straightforward and user-friendly. By clicking the plus button at the top of the left panel, the system opens a clean form where the user can specify the core properties of a new lexical unit. These include the label (lemma), language, type (distinguishing between lexeme and phraseme), part of speech (POS), and any relevant notes. Once the form is completed and saved, the new entry is immediately added to the list of dictionary entries in the left-hand panel.
- **Viewing a Dictionary Entry and Its Semantic Definition**
  When a dictionary entry is selected, *DEC Facile* displays its full structure and semantic information. In Figure 6, the entry *venčiavonystė* "marriage" is shown. In the left panel, the entry is expanded to reveal its components: one form, corresponding to the lemma itself and one sense, labeled I (noun), with a preview of its definition.
  Clicking on the sense opens its semantic definition in the central workspace. The definition is expressed in propositional form, identifying explicitly the two participants involved (here, a man and a woman). Both participants are linked to corresponding lexical senses stored in the database (e.g., *venčiavotasis vyras* I "bride" and *venčiavotoji moteris* I "groom"). On the right-hand side, the part of speech (POS) is displayed. Below, navigation tabs provide access to additional dimensions of the sense: Government Pattern, Lexical Functions, and Examples, each supporting further enrichment of the entry.
- **Insertion and Linking of Senses in Definitions**
  In *DEC Facile*, definitions are not treated as static text but as dynamic semantic structures that can include links to other lexical senses. This functionality reflects the core principle of ECL, where lexical meanings are inherently interconnected. By embedding links within definitions, the tool ensures consistency in the construction of entries and facilitates precise semantic interpretation for NLP applications.
  When a linked sense is clicked, the system opens an interactive popup displaying the full content of that sense. For example, in the definition of *venčiavonystė*, clicking on *venčiavotoji moteris* reveals its definition, which in turn contains a reciprocal reference to its male counterpart *venčiavotasis vyras*. This ensures that relational semantics are preserved and explicitly represented in the database. Additionally, the linked sense view may include authentic usage examples.

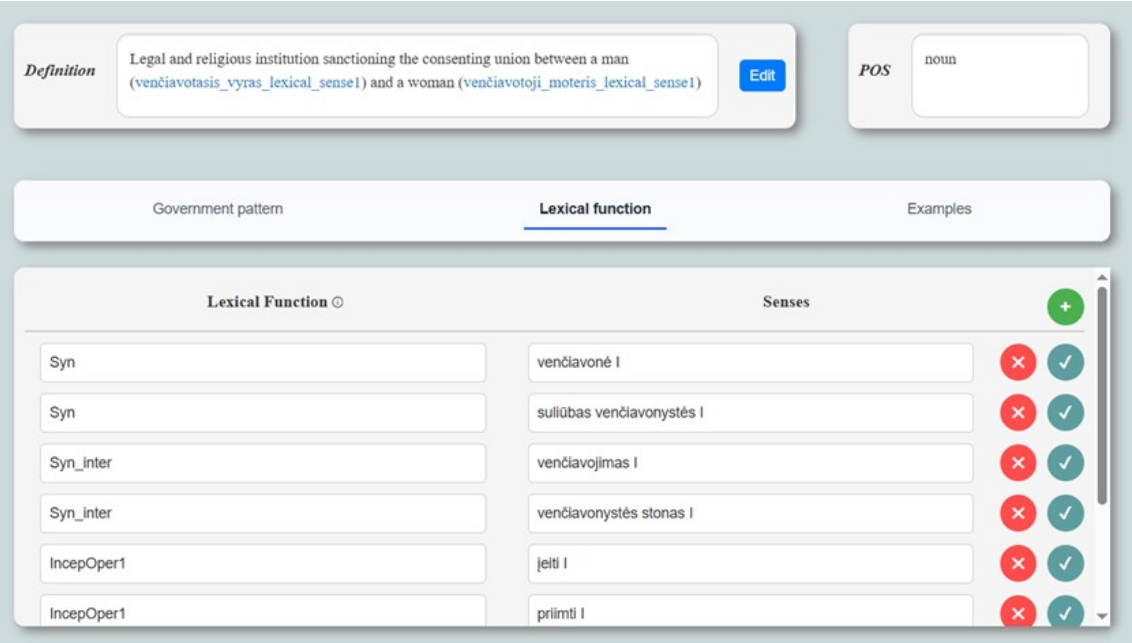

Fig. 7 The Lexical Functions Panel in *DEC Facile*

- **Government Pattern Panel** (under development)
  Currently under development, this panel will enable users to specify the syntactic regime of a sense by defining the morphological realizations of the SemAs introduced by that sense.
- **Lexical Functions Panel**
  Once a sense and its participants have been defined, *DEC Facile* enables its enrichment through Lexical Functions (LFs), which constitute the central formalism of ECL. Each lexical function encodes a regular, semantically meaningful relation between the main entry and another lexical unit. Each LF can be formally represented as a triple R (X, Y), where X is the keyword (here *venčiavonystė*), Y is the related sense, and R is the lexical function label.
  As illustrated in Figure 7, clicking on the Lexical Function tab opens a dedicated interface where functions can be created, inspected, and managed. On the left, the user selects the desired LF type (e.g., Syn, Magn, IncepOper1, CausReal1) from the standard ECL inventory. On the right, the function is linked to a target sense, ensuring that relations are established between structured senses rather than unstructured strings. For example, synonyms (Syn) of *venčiavonystė* include *venčiavonė* and *suliūbas venčiavonystės*.
  The panel further provides intuitive controls: green check buttons confirm the creation of new links, while red cross buttons allow their removal. The system also automatically filters available senses by language, so that when working on a Lithuanian entry, only Lithuanian senses are proposed. This guarantees semantic consistency and prevents unintended cross-language links.
- **Examples Panel**
  The final step consists of associating the sense with usage examples that the lexicographer/terminologist considers representative. *DEC Facile* allows users to associate each sense with attested sentences drawn from historical or contemporary corpora. As in Figure 8, we can select the examples tab for this sense *venčiavonystė*.
- **Dictionary Entry View**
  As shown in Figure 9, clicking the eye icon next to an entry opens a consolidated, read-only view of the entire lexical record. At the top of the panel, the entry *venčiavonystė* is displayed together with its part of speech, here identified as a noun. The record then follows the typical structure

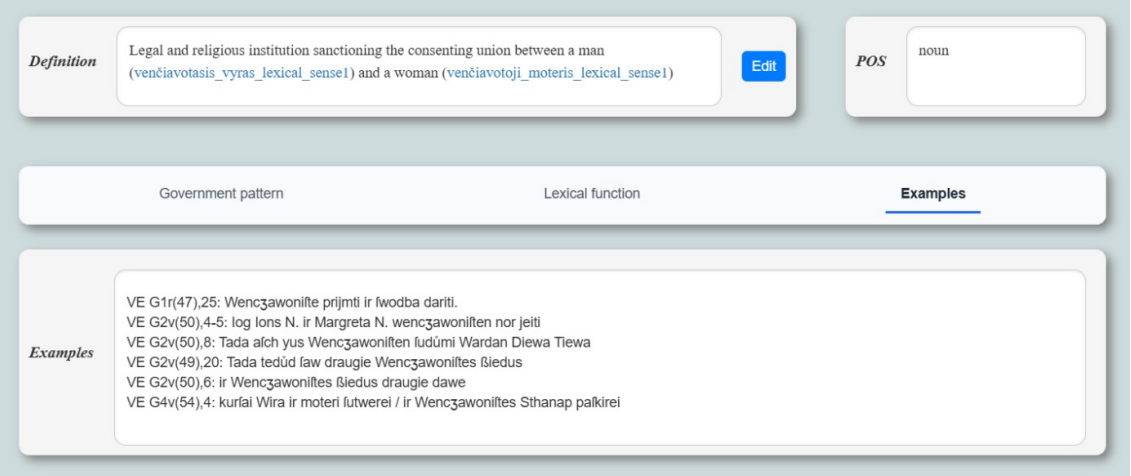

Fig. 8 The Examples Panel in *DEC Facile*

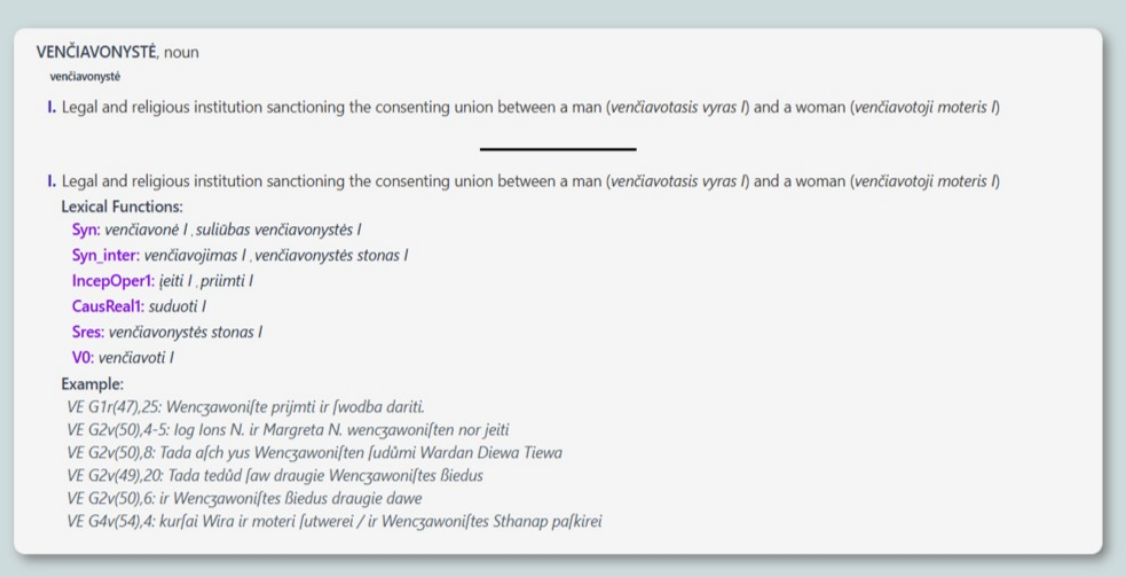

Fig. 9 Entry view of *venčiavonystė* "marriage"

of an ECD entry, listing the available senses (in this case only one) and, for each sense, displaying the associated lexical functions together with illustrative usage examples. At present, the section on government pattern is absent, since this functionality is still in the development phase. Overall, this view reproduces the familiar *printed-like* format of traditional ECDs, offering users an accessible way to consult and review entries without entering the editing mode.

5 Evaluation

This section presents an initial evaluation of *DEC Facile*. Specifically, Section 5.1. focuses on the characteristics of the tool across four main dimensions: compliance with ECL requirements, adherence to FAIR principles, performance and scalability, and applicability in real-world lexicographic and terminological work. Section 5.2 presents a usability assessment based on a heuristic evaluation following Jakob Nielsen's principles.

5.1 Characteristics and Measures of the Tool

As highlighted above, *DEC Facile* fully addresses the requirements of ECL. In particular, it supports: i) the representation of senses and definitions in propositional form; ii) the hierarchical organization of senses according to the principles of ECL; iii) the insertion and linking of senses across entries; iv) the encoding and retrieval of lexical functions; v) and, as part of ongoing development, the integration of government patterns.

DEC Facile has been designed in full compliance with the FAIR principles, ensuring that lexical data are *findable*, *accessible*, *interoperable*, and *reusable*. Metadata can be associated with resources, making them searchable on the Web by type, domain, and language. The data can be exported in open formats (RDF, OWL) and integrated into Linked Open Data resources such as WordNet, BabelNet, and Wikidata, thus demonstrating both interoperability and long-term reusability.

Preliminary tests confirm that *DEC Facile* offers responsive performance for typical lexicographic/terminological tasks. In terms of scalability, the GraphDB triple store ensures that the system can accommodate very large datasets, although further stress testing will be required.

The development of *DEC Facile* is closely tied to the PRIN project "*Old Words for a New World. Translating Christianity to Baltic Pagans*", which focuses on the lexicon of early Lithuanian, Latvian, and Old Prussian catechisms. At present, the system hosts approximately 86 entries, distributed across Lithuanian and Latvian. Each entry includes at least one form and one sense. Many entries are enriched by propositional definitions, lexical functions, cross-references to related senses within definitions, and historical examples drawn from the project corpus.

5.2 Usability Assessment

Even though *DEC Facile* is still in the early stages of development, a preliminary usability evaluation has been conducted through an expert-driven heuristic assessment based on a subset of Nielsen's 10 usability principles (Nielsen, 1994).[24] This evaluation was conducted by terminologists and linguists directly involved in the project and responsible for the creation of the DEC for the Baltic religious lexicon. The results, summarized in Table 2, provide an initial overview of strengths and potential usability issues.

Overall, the heuristic evaluation highlights several strengths of *DEC Facile*, such as the consistent use of ECL terminology, structured data entry forms, and effective error prevention mechanisms. Some areas for improvement have also been identified, including more descriptive error messages, undo/redo functionality, and embedded help documentation.

In the future, the evaluation will be complemented by a user study involving lexicographers, terminologists, linguists, and students. Participants will be asked to perform typical tasks such as creating entries, defining senses, adding lexical functions, and inserting examples. Feedback from this study will help validate and refine the tool, offering insights into ease of use.

6 Conclusion and Future Work

This paper has introduced *DEC Facile*, the first prototype tool specifically designed to support the creation of computational Explanatory Combinatorial Dictionaries within the Semantic Web and Linked Data ecosystem. By integrating the OntoLex-Lemon model with ECL principles, the tool enables the systematic representation of lexical functions and the modeling of complex paradigmatic and syntagmatic relations in a way that is both theoretically grounded and computationally actionable.

An initial, exploratory evaluation of the first version of the prototype suggests that it offers usability for lexicographers and terminologists while ensuring interoperability with other lexical and terminology resources.

Beyond its technical contributions, *DEC Facile* demonstrates the feasibility of building domain-specific and historically oriented ECDs—such as the one currently under development for early Baltic catechisms—thereby expanding the scope of ECL to specialized and under-resourced contexts.

[24] https://www.nngroup.com/articles/ten-usability-heuristics/

Table 2 Usability evaluation of *DEC Facile* based on a subset of Nielsen's principles

Heuristic	Current Situation	Issues identified	Suggested Improvements
Match between System and the Real World	The interface consistently adopts ECL terminology (e.g., lexical functions, government pattern) in both English and French, thus avoiding RDF/OntoLex-Lemon specific terms. A reference table of lexical functions with definitions and usage examples is included.	No major issues identified.	Enrich the reference table with additional illustrative examples to better support novice users; ensure ECL terminology is consistently multilingual in the interface.
User Control and Freedom	Entries can be created, modified, and deleted with real-time feedback; confirmation dialogs appear before destructive actions. Entries can be displayed in a dictionary-style view, closely resembling the printed format of traditional ECDs.	No undo/redo functionality; deletion of entries is irreversible unless re-created manually.	Implement undo/redo; allow recovery of recently deleted entries.
Error Prevention	Users cannot enter invalid data: lists of parts of speech, lexical functions, and entry types are drawn from controlled vocabularies and presented via dropdown menus. Lexical relations must target existing senses, selected from a dropdown menu. Mandatory fields cannot be left empty.	No major issues identified.	Alert users when adding an entry with an existing lemma, allowing confirmation in case of homonyms; provide suggestions to guide users toward valid inputs (e.g., synonymy).
Aesthetic and Minimalist Design	The interface is simple, not overloaded and works consistently across all major browsers. It adopts a form-based paradigm, a consolidated technique familiar to most users. Progressive disclosure is applied: when editing an entry, details are revealed on demand.	No major issues identified.	No immediate improvements required.
Help and Documentation	Basic documentation is available: source code, description, and installation guide are provided on GitHub.	Lack of integrated help, tutorials, or examples may hinder new users.	Develop a user manual and quick-start guide; provide online tutorials/FAQ.

Future work will focus on the management of government patterns in dictionary entries and the enhancement of collaborative features. In doing so, *DEC Facile* aims to consolidate its role as a promising environment for the creation of interoperable, theory-driven lexicographic and terminology resources that contribute to both linguistic research and applied language technologies.

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