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What the analysis of extended meaning of terms can reveal about verb semantic frame structure

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ABSTRACT

By disabling two traditional constraints on general-language one-verb sub-events, Goldberg shows that: (i) a verb can specify both manner *and* result or change of location; and (ii) the profiled event of one verb need not be causally related to the evoked background frame event. This study develops Goldberg's claims further to show that a single verb can meet (i) *and* (ii) at the same time. For this purpose, two polysemic terminological verbs and their arguments were analyzed as they occur in concordances extracted from a corpus of naturally running texts from the specialized knowledge domain of environmental science. The meanings of these verbs and of their arguments were formalized in the Environmental Event Frame as described by Faber et al. The basic senses of the verbs in ordinary language were compared with their extended terminological meanings to determine how meaning extension structures and constrains the event-based semantic frame evoked by each of the sub-senses of the verbs. Striking differences were found in the nature and composition of the semantic frames of the pairs of senses compared. This type of semantic frame asymmetry in polysemic verbs that satisfy criteria (i) and (ii) further enriches Goldberg's theory of verb semantics and event-structure construal.

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Manner *and* result/change of location verbs; one-verb sub-event structure; frame-based terminological polysemy; semantic frame structure representation; corpus analysis

1. Introduction

1.1 Lexical semantics and event-structure construal of verbs

Traditionally, there are verbs that only designate simple events (e.g. *read*); verbs that designate two sub-events that entirely overlap temporally (e.g. *sauté*, which involves a heat-with-a-small-amount-of-fat event and a stirring event); and verbs including an event that is sufficient to lead to a new state or event (e.g. *smash*, which entails directing a force onto a rigid object [causing event] with the consequence that the object breaks into many pieces [resulting event]). In the latter case, these are verbs referring to complex events in which the sub-events are causally related, regardless of whether those events are part of the profile or background frame. According to Croft (1991; 2005), this is the only way in which two sub-events can co-exist in the lexicalization of a verb. In other words, there is a constraint on the combination of sub-events designated by a single verb, according to which the two sub-events are *always* causally related.

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Another common constraint on lexical verb meaning is that a verb can only specify manner *or* result, but not both aspects at the same time (Levin & Rappaport Hovav 2006; Rappaport Hovav & Levin 2010). Because the specification of both manner and result or change of location by a single root is disallowed (Rappaport Hovav & Levin 2010: 26), at least in English, we can only have manner verbs, which designate a non-scalar change (e.g. *laugh*, *sweep*, *nibble*), and separately, result verbs, such as *freeze, clean* and *cover*, which designate a scalar/directed change (i.e. an ordering relation of sub-stages or scalarity).

Goldberg (2010) demonstrates that these two types of constraint do not always apply. As she observes, there are many English verbs whose profiled event is not causally related to an event that is part of its background frame (44), and manner and change of location are allowed to combine in certain terms because the two facets tend to co-occur as a single culturally recognized unit (49). For example, the verb *double-cross* profiles an event of betrayal following a state or event of understood cooperation. The betrayal is not caused by the state of trust, nor does the betrayal cause the state of trust (45). Goldberg (46) identifies verbs encoding both manner and result because of her consideration of lexical semantic factors, whereas Rappaport Hovav & Levin (2010) give more importance to grammatical factors.[1] For instance, in one of its three prototypical senses, *climb* entails both directed motion (upward) and manner (clambering). Rappaport Hovav & Levin only consider the other two scenarios (either as a manner verb or as a verb entailing directed motion). Another example is the ski term *schuss*, which means to ski straight downhill (directed change of location) intentionally and very fast (manner) (Goldberg 2010: 48). She concludes that the only constraint that actually applies to these verb categories is that the two sub-events combined in a single verb *or* the two encoded aspects of manner and result must constitute a coherent and established semantic frame, which is called the *Conventional Frame Constraint* (39).

This research applies Goldberg's claims to terminological verb meanings in the environmental science domain. Specifically, we develop Goldberg's (2010) theory on the lexical meaning of verbs further by showing that one predicate in specialized language can encode not only manner and result, but *also* two sub-events, the profiled and the background ones, which are temporally and causally unrelated. Two *separate* claims made by Goldberg about the semantics and event-structure construal of lexical verbs (i.e. the combination of manner and result, on the one hand, and two causally and temporally unrelated sub-events, on the other) are thus shown to conflate in a number of specialized verbs from the domain of environmental science.

1.2 Frame-based terminology: Verb-argument semantics representation in scientific language discourse

Core lexical meaning of predicators is central to describing their semantic content and accessing the underlying event structure for its construal. However, valency patterns (sentence verbal distribution) are also necessary for this purpose, especially when building definitional templates of verbs. This fact highlights the significance of the close

[1]Rappaport Hovav & Levin (2010: 21–22) argue that manner and result verbs differ in their argument patterns. The action described by manner verbs can be augmented, further specifying the event, whereas result verbs cannot be augmented with a sub-event from another domain.

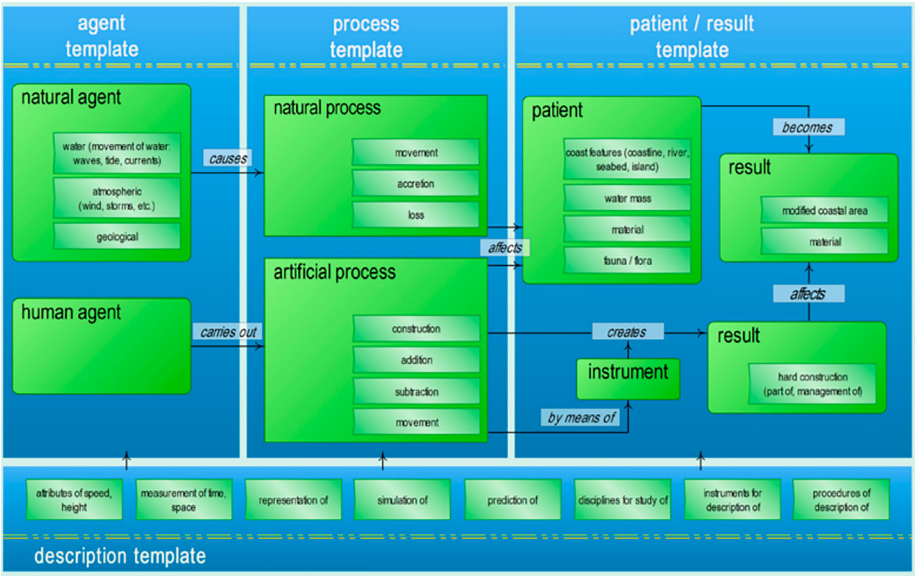

Figure 1. Environmental Event Template (Faber 2011: 15).

relationship between argument structure and verb lexical semantics, and thus, the need for a formal representational model that codifies such relationships.

The strong connection between grammatical structure and verb meaning in specialized language – and consequently, the importance of pinning down the argument structure of terms for semantic and conceptual description – is one of the premises of Frame-based Terminology (FBT) as a way to *conceptually* structure the environmental knowledge domain (e.g. Faber 2011; Faber et al. 2006; 2012). FBT uses a modified version of Fillmore's frames (Fillmore 1982; 1985; Fillmore & Atkins 1992). Drawing on information extracted from the *EcoLexicon* corpus (see §2), FBT represents the specialized environmental knowledge as conceptual networks, based on an underlying prototypical domain event frame (or action–environment interface) and on a closed inventory of both hierarchical and non-hierarchical semantic relations (Faber 2011: 15). The event frame is known as the *Environmental Event Template* (Figure 1).

The application of FBT to the object of study of this paper is justifiable because FBT is a robust model of both conceptual *and* linguistic representation, which helps us complement more rigid, semantically-laden approaches to event-structure construal, such as Goldberg's. More specifically, FBT frames can be regarded as situated knowledge structures and are linguistically reflected in the lexical relations codified in terminographic definitions. These frames are the *dynamic* (Faber 2011; Faber et al. 2005) context in which FBT specifies the semantic, syntactic and pragmatic behaviour of specialized language units. FBT provide frame-like representations in the form of conceptual templates underlying the knowledge encoded in specialized texts (Faber 2011: 21; 2012). It is then necessary to underline that Frame Semantics – the theoretical framework in which FBT is embedded – is not restricted and cannot be equalled to FrameNet since Frame Semantics proposes a wider variety of analytic tools for the systematic description of natural language meanings. Frame Semantics studies how linguistic forms evoke or activate frame knowledge – which is immanently associated with conceptual structures – and

how the frames thus activated can be integrated into an understanding of the passages that contain these forms. This process includes the integration of *non*-linguistic information.

This paper relies on the EcoLexicon corpus – comprising naturally running environmental sciences texts – and on the Environmental Event Template to assign semantic roles to the array of concepts activated by the set of terminological verbs extracted from the corpus. This task thus implies determining the prototypical argument structure of the verbs analyzed, and exploring their combinatorial potential within the environmental domain. As an *event*-oriented model, FBT stresses the significance of and the need to represent the dynamicity of conceptualization, which requires event-type categorization (Faber 2011: 9). As will be shown, the formal representation of event types is central to our study. In fact, this research further enriches the FBT codification system by also considering (the construal of) *background* events and their relationship with profiled ones in the semantic frames of the verbs.

Particularly revealing were the corpus verbs whose specialized meanings arise as polysemic extensions of their basic senses in ordinary language. There is an important body of research on verbal polysemy involving lexical-semantic and argument realizations from a Frame-Semantics and a Construction-Grammar perspective (e.g. Boas 2008; Iwata 2005; Nemoto 2005). For example, by comparing a verb's meaning interaction with different syntactic patterns, Nemoto (2005: 5) shows that Goldberg's (1995) notion of argument structure constructions is too broad because it does not fully account for all of a verb's subsenses. In studying the sources of polysemy in English locative alternations, Iwata (2005) concludes that although the constructional layer of meaning of a polysemic verb is important to its semantic characterization, more attention should be paid to the role of the semantic frames of a verb in contributing to its multiple interpretations (*sensu* Fillmore (1982; 1984) and Fillmore & Atkins (1992) in general-language description; and Faber (2011) and Faber et al. (2006; 2012) in specialized knowledge representation).

There are relatively few terminology studies that look into the polysemic nature of domain-specific verbs from a Frame-Semantics perspective. To fill this gap, this paper shows that a context-based analysis of polysemic terminological verbs and their arguments in the environmental science domain not only identifies and describes the subevents which activated the verbs, but also reveals fundamental differences in the event composition of the semantic frames of the pairs of senses under comparison.[2] Therefore, apart from demonstrating that manner-*and*-result integration as well as two temporally and causally unrelated sub-events can co-exist in the semantics of a single verb, this study also shows that the semantic frames evoked by the sub-senses of a polysemic verb can differ in terms of the quality and number of their constituents. Polysemic verb sense differences of this sort are thus another contribution to Goldberg's (2010) theory of verb semantics and event-structure construal.[3]

[2]Our frame-based approach to polysemy understands this phenomenon as the meaning extension mechanism whereby a lexical item can be used both in general and specialized language with no causality of figurative thought (metaphor and metonymy). See Sullivan (2013) for a detailed, frame-based account of metaphor- and metonymy-induced expressions and constructions.

[3]It should be noted that although accounting for event structure from lexical and constructional semantics is a valid strategy, event construal is a polyhedral process arising from different constructive formats. In fact, there is a trend in cognitive research to view events as dynamic agentive phenomena rather than simply pockets of meaning attached to specific verbs and argument-structure constructions. Events are, therefore, dynamic in the sense that they are not simply out there and ready-made, waiting to be seen, recognized or described, but they are what we make of them

The rest of the article is structured as follows. §2 describes the corpus and explains the methodology used for contextualized language exploitation (data retrieval and processing). Next, §3 presents the results of an in-depth analysis of the semantic and conceptual profiles of two corpus verbs and their arguments. This analysis involves the allocation of the verbs' conceptual contents as interrelated semantic roles in the EcoLexicon Event Frame template. §4 presents the conclusions that can be derived from this research.

2. Materials and method

2.1 Data

FBT exploits both corpus and dictionary data to build definitional templates of the specialized concepts that make up the environmental knowledge domain. In the case of terminological verbs, the core and peripheral thematic elements that form a part of their definitional templates are identified by examining the verbs' arguments as they occur in naturally running texts. This bundle of conceptual materials is next codified as interrelated semantic categories within the dynamic Environmental Event frame.

For the purposes of our study, we used the EcoLexicon English Corpus (EEC), a 23.1-million-word specialized repository of contemporary environmental texts (belonging to sub-disciplines such as (marine) biology, meteorology, ecology, geology, hydrology, environmental engineering and environmental law). The EEC was compiled by the LexiCon research group[4] for the development of EcoLexicon (ecolexicon.ugr.es) (Faber et al. 2016; San-Martín et al. 2017), a terminological knowledge base on the environment. The EEC texts were manually annotated with tags according to a set of XML-based metadata. Tagging allows users to constrain corpus queries based on conceptual and pragmatic factors (cf. León-Araúz et al. (2018) for more details about the annotation system and a list of tags and their purposes). This study also used the *English web 2015 (enTenTen15)* corpus, comprising 15.1 trillion words of texts extracted from the Internet, to enrich corpus searches and back up results when necessary.

Both the EEC and the *enTenTen15* corpus were exploited as open resources on *Sketch Engine*, an online lexical analysis software application that automatically retrieves single and multi-word lexical items from the selected corpus or set of corpora available on this online system.

2.2 Data processing and strategies for analysis

Sketch Engine generated a frequency list (*Word list*) of verbs from the EEC. The 100 most frequent verbs on the list were selected for examination (Figure 2). Those terminological verbs whose potentially polysemic nature allowed their usage both in general and

(Schwartz 2008: 54). In addition, authors in favour of a situated-simulation approach to meaning within the Cognitive Linguistics strand (cf. Barsalou 2003; Bergen & Chang 2005 in Embodied Construction Grammar) hold that the meaning of a construction consists of the simulation and the inferences that it produces. In this simulation-based approach to language understanding, constructions need only specify simulation parameters, allowing features of the current context and of richer embodied and world knowledge to influence the result of the understanding and communicative act. Logically enough, this is a topic that should be addressed in a different paper.

[4]This research group from the University of Granada (Spain) is specialized in terminology, lexicography, scientific translation and lexical semantics (also including metaphor). LexiCon has built large-scale specialized multi-lingual knowledge bases and ontologies on environmental sciences (EcoLexicon) and medicine (OncoTerm) for terminologists, lexicographers, linguists and translators. The Lexicon webpage is available at www.lexicon.ugr.es.

WORDLIST Coastal Engineering

verb (2,507 items | 1,157,055 total frequency)

	Lemma	Frequency		Lemma	Frequency		Lemma	Frequency
1	be	330,616	11	follow	8,040	21	take	5,938
2	have	40,254	12	measure	7,879	22	require	5,898
3	use	31,638	13	increase	7,857	23	represent	5,789
4	show	17,412	14	do	7,629	24	compare	5,541
5	give	10,606	15	consider	7,628	25	define	5,516
6	include	10,429	16	occur	7,476	26	present	5,515
7	see	9,333	17	find	7,255	27	describe	5,467
8	provide	9,237	18	make	6,578	28	apply	5,211
9	base	8,304	19	determine	6,303	29	calculate	5,120
10	obtain	8,219	20	develop	6,259	30	predict	4,925

Figure 2. *Sketch Engine* frequency list of the most frequent verbs in the ECC.

specialized language were selected as candidates for analysis. To this aim, the *Sketch Engine Search* permits users to constrain the corpus searches by means of complex filtering features. A default filtering option of this software is the word-category search function, which allowed us to query the system for verbs only. Further search features were exploited based on automatic tag-driven data retrieval. The features *Domain* and *User* were used to constrain conceptual and pragmatic factors, respectively (see §3). To filter co-text, the *Concordance* and *Word Sketch* functions provide the collocational and grammatical behaviour of the single or multi-word lexical units searched for (see Figures 3 and 4 with the verb *spew* as an example).

This set of linguistic information was examined to determine the verbs' terminological meanings and pin down their most frequent arguments in the environmental science

Left context	KWIC	Right context
into the air in what is known as a geyser. Deep-ocean vents	spew	out water rich in many minerals such as iron , lead , and cop
the midocean ridge system , where hot hydrothermal vents	spew	heated nutrient-rich waters into the benthic realm. In these
on columns can reach 28 miles (45 km) in height , and they	spew	hot turbulent mixtures of ash , gas , and tephra into the atm
st-moving flows and liquid rivers of lava , lava fountains that	spew	fingers of lava trailing streamers of light hundreds of feet int
conduits to form hot black and white smoker chimneys that	spew	the nutrient rich waters at temperatures of up to 680oF (35
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Figure 3. Concordance sample of the terminological verb *spew* on *Sketch Engine*.

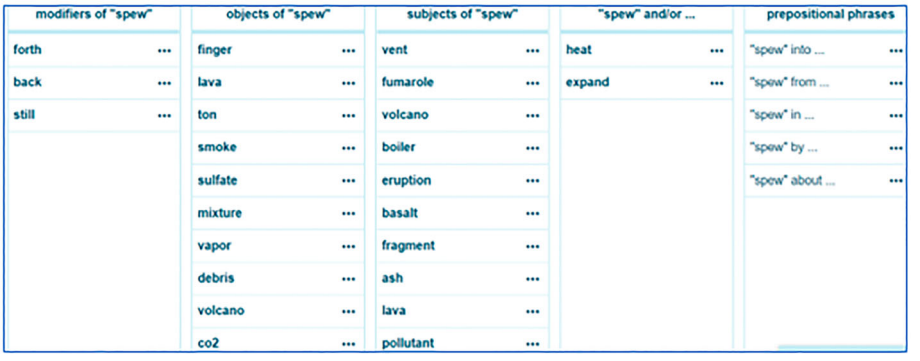

Figure 4. Word sketch of the terminological verb *spew* on *Sketch Engine*.

domain. In the case of *spew*, Figures 3 and 4 show that the definitional template (including the core argument participants) of the verb can be formulated as "to eject gaseous, pyrolytic (e.g. rock, lava, ash) or hydrothermal (hot water) materials by land or aquatic geological openings or apertures, such as volcanoes and sea vents".

The EEC includes texts for three types of user, depending on levels of expertise (i.e. expert, semi-expert, general public). Apart from making use of this specification, some of the verbs under examination were also searched for in the *enTenTen15* corpus to identify their general-language senses through the retrieval of concordance and word sketch data. In addition, the consultation of lexical entry dictionary definitions supplemented corpus data reporting. Figure 5 shows a linguistic context (an extended *enTenTen15* corpus concordance) of *spew*, which suggests the body-related, ordinary-language sense of this verb as a synonym of *vomit*.

The first sense of *spew* given by *Collins English Dictionary* is the following: "(Physiology) to eject (the contents of the stomach) involuntarily through the mouth; vomit". This definition confirmed that *spew* is synonymous with *vomit*, and together with corpus data examination, it permitted us to determine the core arguments of the verb. Unlike the terminological meaning of *spew*, the core arguments in general language refer to a human or animal agent expelling bodily fluids out of his/her mouth.

Finding the polysemic grounding of the selected verbs – and thus, the specification of their semantic profiles – in a parallel way assisted in (i) assigning the definitional template constituents of terminological verbs to semantic categories within the Environmental Event Frame; and (ii) establishing their interrelationships. This complex procedure allowed us to verify whether or not the verbs fulfil Goldberg's (2010) manner *and* result criterion, to identify the number of sub-events in their semantic frames, and to determine whether the background and profiled events in single semantic frames are temporally and causally *un*related (Goldberg's second criterion). As previously noted, the combination of

her was caked in goup and the spare one was still in the washing from the holiday. So, as Daddy snored away, Mummy changed Babba and was then woken on the hour as she no doubt missed her swaddlie security blanket – well you shouldn't have **spewed** on it should you! At 4am, I decided to put her in a zip up sleeping bag with a sash to swaddle her. It was the answer to my prayers. She finally settled. Thirty minutes later, I regretted this. Her painful cry woke

Figure 5. Context (extended concordance) of the general-language verb *spew* on *Sketch Engine*.

these criteria in one verb is the first contribution to Goldberg's theory by this research. To develop the theory even further, the verbs meeting the criteria were analyzed in search of asymmetric semantic frames in terms of number of sub-events lexicalized by one verb. This test required a comparison between the general-language and the extended environmental-science senses.

For space restrictions, all of the tasks mentioned above were implemented for the verbs analyzed in §3.

3. Results and discussion

This section presents the analysis of the verbs *cement* and *scour*. Both of these verbs meet all three of the previously specified criteria. The results of the analyses are discussed with respect to the main claims of the study.

3.1 Cement

The EEC corpus concordances and word sketches of *cement* show that this verb occurs in three sub-domains of the environmental knowledge field: environmental engineering, soil science (pedology or soil formation and edaphology) and marine biology.

The usage of *cement* in environmental engineering texts (see extended concordance in Figure 6) was obtained by customizing the corpus query with the *Domain* filtering function on *Sketch Engine*, which allowed us to create and search sub-datasets that only dealt with this sub-domain of expertise. It was found that the meaning of *cement* in this specialized sub-domain corresponds to the most basic sense of the verb in everyday communication, as confirmed by the general-language dictionary definition in *Collins English Dictionary*: "(Building) to join, coat or cover with cement". This dictionary defines the noun *cement* as "a building material made by grinding calcined limestone and clay to a fine powder mixed with water and poured to set as a solid mass for making mortar or concrete". Another definition is the following: "A building material that hardens to act as an adhesive" (*American Heritage® Dictionary of the English Language*). This cluster of linguistic information activates a rich semantic frame in which the basic meaning of cement is embedded. This semantic frame was compared to the semantic frame of the extended meaning of *cement* in marine biology.

To retrieve data on *cement* within the marine biology sub-domain, the corpus search was filtered by setting the *Domain* function to *Oceanography*, *Ecology* and *Biology* – the latter encompassing narrower knowledge sub-domains, such as *Zoology* and *Microbiology*. The *User* feature was also set to *Expert* in order to only deal with specialized terminology. This option allowed us to filter corpus data depending on levels of expertise (i.e. expert, semi-expert and general public). This filtering was done with a view to detecting highly specialized definitions and descriptions of the concept.

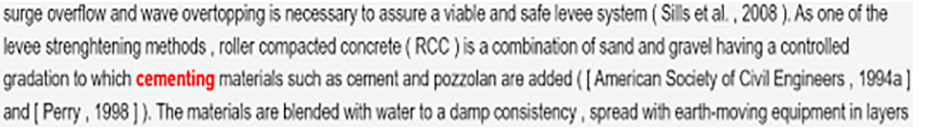
surge overflow and wave overtopping is necessary to assure a viable and safe levee system (Sills et al. , 2008). As one of the levee strenghtening methods , roller compacted concrete (RCC) is a combination of sand and gravel having a controlled gradation to which **cementing** materials such as cement and pozzolan are added ([American Society of Civil Engineers , 1994a] and [Perry , 1998]). The materials are blended with water to a damp consistency , spread with earth-moving equipment in layers

Figure 6. *Sketch Engine* context of *cement* as an environmental engineering verb.

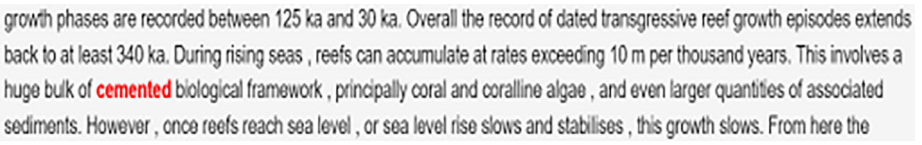

Figure 7. *Sketch Engine* context of *cement* as a marine biology verb.

Within the marine biology sub-domain, it was found that the verb *cement* can designate different event types, depending on the organisms involved (e.g. bivalves, polychaetes and corals). Our study addressed the scientific meaning associated with coral cementing, whose verb *cement* is shown to gather all of the semantic and conceptual criteria that were tested. The *Sketch Engine* context in Figure 7 is given for textual evidence of the coral-related marine biology usage of *cement*.

A definitional template of the marine biology sense of (coral) *cement*, including the arguments and specific facets of the semantic concept, was built by exploring the word sketch of the verb and examining EEC concordances containing detailed descriptions and explanations from the marine biology research papers. These descriptions provide information regarding the activity, manner of action and result expressed by *cement* as well as about the entities evoked by this verb in the marine biology sub-domain. For instance, contexts (1) and (2), extracted from academic research articles, show that *cement* designates the action and result of a particular type of algae bringing together coral skeletons into a single solid structure. Consequently, this meaning extension, licensed by the polysemic nature of the verb, arises on the basis of topology, by virtue of which a physical structure comes into being as an extended and expanded surface with a solid and uniform configuration (see Figure 8).

(1) [C]oral reefs are mostly constructed by scleractinian corals, whose skeletons constitute the calcareous framework of the reef and the coralline algae **cementing** it. (Titlyanov & Titlyanova 2002: 1)

(2) **Calcification** by crustose coralline algae is crucial to the formation and maintenance of coral reefs (Wray 1971; Littler 1972). Coralline algae bind adjacent substrata and provide a calcified tissue barrier against erosion. (Chisholm 2000: 1476).

This is thus a very specific kind of sea biotic cementation, whose event-structure construal requires accurate description and subsequent codification of its conceptual participants in the Environmental Event Template. As previously mentioned, a proper frame-based codification procedure implies making specifications about manner and result as well as the nature, particulars and interrelations of the profiled and background sub-events lexicalized by the verb. Following Goldberg (2010: 46), *cement* is a result verb because it involves a *scalar change* (an ordering relation from separate materials to a single mass or continuum). Specifically, this is an accomplishment verb, which involves gradability towards culmination (the end state), or as Croft (2012: 51) puts it, a description of a measurable incremental change toward the final state. *Incremental* should be interpreted here as gradual adherence of neighbouring substrata and final connection of coral skeletons through calcification, as explained below. In terms of Breu (1994: 26), who establishes a fine-grained classification of verbs based on boundaries underlying the aspectual features of predicates, *cement* is a *gradually terminative* verb (as is *drown*)

Figure 8. Coral reef resulting from calcification-based cementation by coralline microalgae.

because it involves "exhaustion of an inherent 'quantity', rather than to the temporal probability of the termination of an action". As he goes on to explain, for this kind of inherent boundary, it is typical that an *end result* is attained (26). In the case of *cement*, exhaustion of the activity of corals results in full connection of them.

At the same time, *cement* is also a manner verb involving a *non-scalar relation* (Goldberg 2010: 46), according to which the specialized meaning of the verb implies the manner in which discrete items (coral skeletons) are bound together into a *forged* or unified structure. Concretely, this unification results from specific physicochemical interactions of coralline algae hosted by the corals, such as Hydrolithon and Sporolithon, with sea water, non-organic particles of carbon and detrital fragments (e.g. semi-digested food remains) (Round 1984: 140; Titlyanov & Titlyanova 2002: 8). All these elements are chemically manipulated and processed by coral microalgae, which adhere them to each other and convert them into a solid, expanded material through calcification (see Figure 8). This hard material serves as the scaffold or platform that connects and binds coral skeletons together. This naturally staged process ties in perfectly with Goldberg's (2010: 49) claim that "verbs of creation generally allow both manner and result, since the creation itself is a type of result". Indeed, *cement* is a verb that entails both the manner of creation (it specifies the nature and modality of the event's internal phase) and its result.

The identification and analysis of the manner–result integration in the marine biology verb *cement* revealed the close relationship between coral binding, which results in cementation and the subsequent emergence of coral reefs, and the formation *of individual* coral skeletons. As explained in context (3) and taking into account context (2), for coral reef construction (corals joining to give rise to a hard, expanded platform), coral polyps (sessile, tiny, soft animals related to anemones and jellyfish) and their symbiotic coralline algae first need to build individual, self-standing, cup-shaped, calcified skeletons, which polyps and algae make a solid home of.

Figure 9. Calcium carbonate skeleton built by coral polyps and coralline microalgae.

(3) Scleractinian corals **build** skeletons of aragonite, a polymorph of calcium carbonate ($CaCO_3$), and rely on carbonate ions for **calcification**. (Drenkard et al. 2013: 728)

Figure 9, which features a coral skeleton, is provided for visual support and clarification.

It can thus be claimed that the relationship between coral polyps and coralline microalgae is vital for coral skeleton formation and coral binding through calcification. It then follows that coral skeleton calcification is an essential stage to the cementation process, which entails calcification of neighbouring substrata. It can be argued that *cement* involves a temporal sequence of two *non*-causally related, distinct sub-events. The first event – the background frame – consists of coral polyps (such as coelenterates) and their symbiotic coralline microalgae building calcareous skeletons, which become identifiable to the naked eye under the sea. Once the individual skeletons have been built, the symbiotic microalgae *normally* cement the skeletons into a unified framework or single structure. This is the second (profiled) sub-event, an independently describable phenomenon that does not temporally overlap with the first one. *Normally* has been highlighted above because skeleton construction does not necessarily result in coral reef cementation, as there are corals, such as *Fungia scutaria*, which are solitary and non-colonial in nature (Bucher et al. 2015: 7).

This verb can be compared to general-language predicates, such as *return*, and verbs from other specialized knowledge fields, such as *appeal* in law, which also evoke non-casually related sub-events that do not overlap in time (Goldberg 2010: 42, 44). For instance, *appeal* presupposes a complex background frame involving a trial which resulted in a verdict of culpability, and profiles a subsequent act of filing legal papers for the purpose of a retrial. This act does not necessarily follow after the judge gives a verdict, and thus, the two sub-events are not causally related. By the same token, the specialized marine biology verb *cement* presupposes an event A (skeleton construction) and a subsequent event B (binding skeletons together) that is not caused by A since skeleton construction does not necessarily result in coral reef cementation.

The complex network of semantic-conceptual relationships triggered by the comparison of the two senses of *cement* can be visually represented in terms of their semantic frames. These contain the participants in the events with their respective semantic roles, namely, AGENT, PATIENT and INSTRUMENT (Figure 10). Manner and result elements are also represented in the schema. The arrows direct left to right to indicate meaning extension from the basic, general-language meaning to the extended, terminological one.

It should be noted that the background sub-event of the terminological verb *cement* (formation process of individual coral skeletons) does not take part in the set of cross-frame mappings because this sub-event has no natural counterpart in the semantic frame of *cement* as a general-language verb. As shown by corpus contexts (1)–(3), the marine biology meaning of *cement* activates and lexicalizes two separate though closely interrelated sub-events in the semantic frame. In this frame, one constituent, the microalgae, is an agent performing an action in each of the two sub-events (dashed arrow in Figure 10) since these organisms not only bind coral calcareous structures together (sub-event B), but also help polyps construct such structures (sub-event A) through

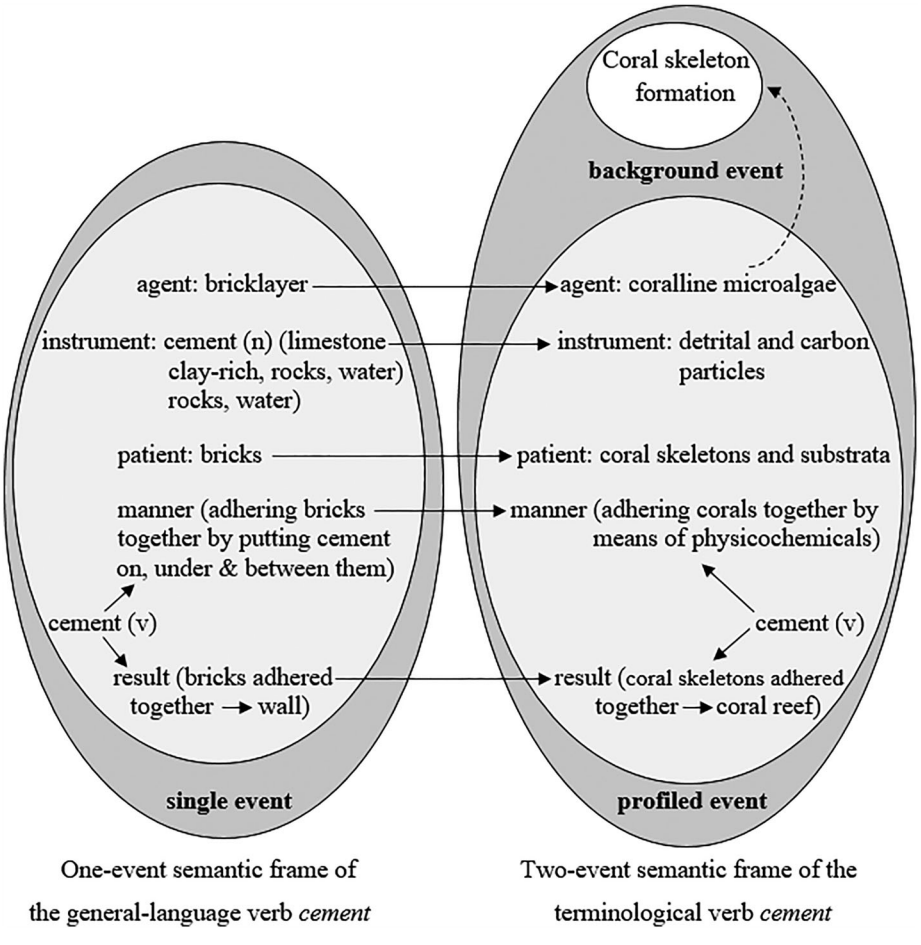

Figure 10. Correlation of constituents across the semantic frames evoked by the general-language and the marine biology meanings of *cement*.

calcification in both stages. As with the profiled event frame, the nature of the background sub-event frame in the semantics of *cement* is complex, also involving cascades of multiple-agent, physicochemical reactions unfolding over a long time period. This property of the *cement* background event frame is thus consistent with Goldberg's (2010: 40) claim that background frames, particularly in the case of verbs, may involve complex events that are spread out over time.

In contrast, the semantic frame of *cement* as a general-language verb does not include a specific, perfectly delineated and identifiable, background sub-event that is consubstantial to the event expressed by this verb. As a result, there is no profiled sub-event either, but only one event evoked by the verb. The reason why there is no entailment between sub-events in this semantic frame is that *bricklayer*, the agent in the semantic frame, is an entity external to *bricks*, the patient undergoing modification. In other words, the idea of a bricklayer potentially manufacturing bricks (not just joining them together by means of a hardening material) is not lexicalized in the general-language verb *cement* because the agent will not end up being a part of the forged structure, whereas coralline algae, the co-agent of coral skeleton construction, will.

As can be observed, the comparison of the basic and extended senses of the verb *cement* not only assists in identifying and describing the sub-events recalled by said verb, but also in revealing differences between the nature and composition of the semantic frames evoked by the two senses. Consequently, the scientific meaning of a terminological verb in a particular specialized knowledge domain does not necessarily encode the same type, and importantly, the same number of sub-events lexicalized by the verb's general-language meaning. This finding adds to the claims made above about the capacity for certain verbs to integrate manner-*and*-result structure as well as two temporally and causally unrelated event frames in their semantic profile.

With the full range of semantic and conceptual materials provided above, we can now formalize the profiled conceptual elements underlying the lexical meaning of the marine biology verb *cement* in conjunction with the semantics of its prototypical arguments in the Environmental Event Template. The codification is enriched with the background event frame activated by this verb. Figure 11 includes the semantic roles within their

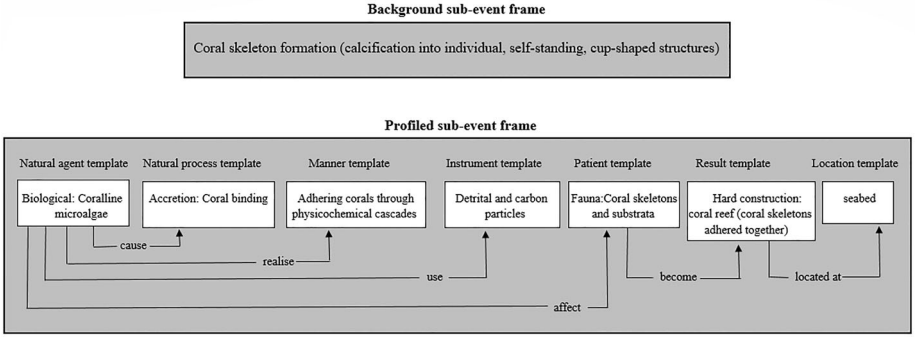

Figure 11. Environmental Event template including the conceptual participants encoded by the semantics of the marine biology verb *cement*. The template includes both the background and the profiled sub-event frames lexicalized by *cement*.

corresponding sub-templates in a Nature-driven (rather than Human-driven) macro-template, and makes their interrelationships explicit.

Since manner and result are featured as important, stand-alone values of the verb's semantics, both have gained a sub-template of their own in the Environmental Event model. This means that the standard patient/result sub-template has been broken down into two separate sub-templates. Another adjustment to the traditional model is the fact that the semantic category HARD CONSTRUCTION can also occur within the RESULT template in the Nature-induced event system. The standard Environmental Event model only considers this category as part of the Human-driven event system (see Figure 1).

3.2 Scour

Scour is the second corpus verb that was analyzed. The same methodological procedure as with *cement* was implemented to fully account for the semantic and conceptual underpinnings of *scour*, both as a general-language and a terminological verb. The first EEC query was performed by setting the *User* function to *expert* level to better identify the core argument structure of *scour* as an environmental science verb and detect the conceptual participants in its definitional template. For a broader linguistic perspective, we searched for the lemma *scour,* the lexeme from which all derived word forms – inflected, tensed and bare-infinitive verb forms – stem. Figure 12 provides textual evidence of the terminological usage of *scour* within the environmental knowledge field.

The scientific definition of *scour* was narrowed down by finding key corpus information. For example, context (4) provides a description of this verb within sedimentology, which is a sub-domain of geology, oceanography and marine engineering, as indicated by the phrase *a current of water or air*. As Allan (2003: 594–595) explains, we can speak of three types of scouring, depending on the weight and size of the materials being removed: entrainment (gravel), stripping (mud) and corrasion (heavy debris, such as rocks). For space restrictions, context (4) only includes the description of *entrainment*.

(4) **Scour** is a general sedimentary process which brings about the sustained lowering of a surface by the direct or indirect action upon it of a current of **water or air**. The process normally acts differentially, resulting in a range of distinctive forms, called

ɔssive rainstorms , the rills gradually become deeper. They	**scour**	the soil to form distinct gullies , which can no longer be obs
nsity , and Sf is an empirical slope factor. Rill erosion is the	**scouring**	and transport of soil by a concentrated flow of water (Schw
ete lining of channels (or conveyance in pipes) to prevent	**scouring**	, clogging , and stagnation of the water as well as animal w
e eighteenth century most of the world 's oceans had been	**scoured**	by explorers who took a strong interest in the whale popula
ɔf the Earth 's surface by water is called water erosion. The	**scouring**	of a waterfall 's edge is another powerful example of water
ckwash. Depending on the strength of the surf , swash can	**scour**	sand , pebbles , and even rocks off the surface of the beac
ɲ sô1 have been recorded and are responsible for both the	**scouring**	of the channels and the deltaic reefs at both ends of them.
ween the Pompeys hard-line reefs offshore. Such currents	**scour**	away sediments , progressively depositing them in less en
ə in the GBR and is accompanied by extreme currents that	**scour**	sediments away , exposing rubble , stones and rock. Offsh
idal range below 1 meter). Near-shore currents. Sediments	**scoured**	from the seabed are transported away from their original loc

Figure 12. Concordances of the lemma *scour* filtered by setting the *User* function to *expert*.

from version 5.1 to 5.6 on a very important database cluster. During the past two weeks I have spent something along the lines of 20 hours making my old apartment ready for inspection by the landlord. My weapons were cleaning agents, a mop, cleaning cloths, **scouring** pads, assorted solvents, spackling paste and an eraser. I didn't have to paint the place. Today my hard

Figure 13. Concordance showing the general-language meaning of *scour*.

> scour or erosional marks. Differential solution, as of […] The mechanisms of scour (Allen 1982a) are: (1) entrainment; (2) stripping; and (3) corrasion. Entrainment affects surfaces composed of sand or gravel, and sees particles removed one by one as the result of the direct action of the shear and pressure forces exerted by the moving fluid, to which may be added impacts due to particles already in transport as they return toward and strike the bed. (Allan 2003: 594)

This research analyzed the verb *scour* as it occurs within the oceanography and marine engineering sub-domains, focusing on the specialized hyponymic concept *tidal scour*. This concept designates a specific type of scouring action carried out by strong tidal currents, which cause sea-floor erosion through the removal of *inshore* sediments and formation of deep holes and channels (Shaw et al. 2012: 123). When narrowing the concept down to shore environments, the prototypical scour type in this situational context is entrainment since shores are normally made up of gravel and sand (comprising granules, pebbles, cobbles and boulders).

The basic, ordinary-language sense of *scour*, and thus, the conceptual profile of the verb, was obtained by examining concordances, its word sketch and dictionary entries. For example, Figure 13 shows an extended concordance drawn from the *enTenTen15* corpus, which gives textual evidence of the general sense of *scour*.

The two first senses of the verb in *Collins English Dictionary* are the following: (i) "To clean or polish (a surface) by washing and rubbing, as with an abrasive cloth"; (ii) "To remove dirt from or have the dirt removed from". As shown below, comparing the ordinary-language and the terminological senses makes the meaning extension clear. Based on the data given above, the comparison of the terminological and general-language meanings of *scour* was made by creating their semantic frames and correlating their contents (Figure 14).

This frame construction enabled us to identify fundamental convergences – and interestedly – divergences between the two senses of the verb. As for convergences, the two *Collins English Dictionary* definitions indicate that manner *and* result (change of state) facets are both present in the lexicalization of the verb in the two senses, strengthening the argument for a meaning extension process from general to specialized language. In general language, *scour* entails intense scrubbing, in other words, an aggressive, repetitive manner of rubbing[5] a stained or deteriorated surface, so that it becomes cleaned and/or polished (result). In other words, scouring renders a (previously stained or deteriorated) surface cleaned/polished. Tidal scouring as entrainment involves repeated rubbing (a type of friction) by a strong natural force or seawater current and the shore surface, resulting in erosion as a consequence of gravel and sand removal. The resultative value of the verb, which entails a change of state of the entity undergoing the effects of the action (the

[5]As a hypernym of *scour*, the definition of the verb *rub* in the *Collins English Dictionary* only refers to manner, not to result: "To apply pressure and friction to (something) with a circular or backward and forward motion".

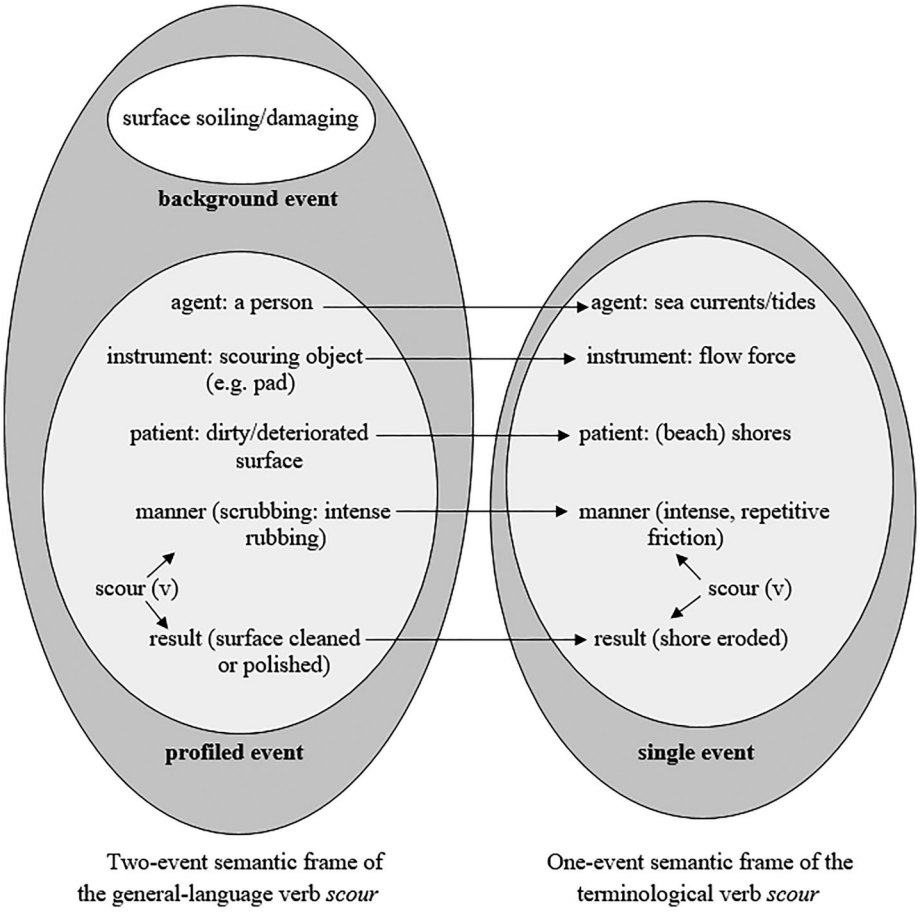

Figure 14. Correlation of constituents across the semantic frames evoked by the general-language and the sedimentology meanings of *scour*.

patient), is activated when this entity has the grammatical role of DIRECT OBJECT and the semantic role of PATIENT. This structure may or may not include other grammatical structures, such as the OBJECT COMPLEMENTS *smooth* (context 5) and *wider* (context 6), which take on the semantic roles of RESULT.

(5) It is colored and layered in every shade of red, brown, tan, and white, as if painted by the hands of the gods. The wind and rain has **scoured** the surfaces **smooth**, carving out canyons and gulleys and caverns.
(6) The model results showed that during flood flow the high crested long jetty causes water to pile up then flow out next to the jetty. This in-conjunction with the high velocities from the increased ebb flow resulted in **scouring** a secondary channel **wider**, directed south southwest (SSW) and extending the area of sediment deposition further south of the jetty.

Argument structure provides valuable insights into the conceptualization of an event (Fillmore & Kay 1993; Nemoto 2005: 127). As Nemoto (2005: 120) points out in her study of verb

and argument-structure polysemy, it is necessary to consider "how much of the idiosyncratic properties of an individual verb can be thought of as associated with the meaning of that verb and how much can be thought of as explainable in terms of other facts". On this basis, opting for a caused-motion construction with *scour* as a predicator brings new argument participants into the picture, as the prepositional-phrase ADJUNCTS in contexts (7) and (8). These adjuncts have the role of LOCATION in the event-structure construal. This rearrangement in the argument structure causes a change in the way events are characterized. Specifically, a shift from *result/change of state* (see contexts 5 and 6) to *change of location* takes place.

(7) In conclusion, this invention provides a membrane test probe [10] designed for **scouring** oxides **off electrical contact pads**, thus enabling formation of an effective electrical contact between the membrane and a semiconductor device under test (DUT).

(8) Once swash runs out of energy, it flows back toward the surf zone as backwash. Depending on the strength of the surf, swash can **scour** sand, pebbles, and even rocks **off the surface of the beach**.

The alternation of event construals in *scour* provides evidence that (i) for certain event types codified by terminological verbs there is no clear default construal (although we can always establish one, at least for convenience of exposition); and that (ii) grammatical context plays a role in this regard, as with general-language verb description (cf. Croft 2012: 37). In any case, the change of event construal in *scour* does not discredit our claim (following Goldberg 2010) that a single verb can lexicalize both manner and result *or* change of location. *Or* is emphasized because *scour* is not limited to only *result* or only *change of location*. Rather, it can encode one or the other, as the case may be.

Differences between the basic and the extended senses of *scour* arise when it comes to establishing the number of recruited sub-events. The evoked background sub-event in the semantic frame of the general-language verb is *surface staining/denting* since it makes no sense to scour a surface that has not previously been stained with dirt (grease, grime, dust) or deteriorated with little holes or scratches because of ill- and overuse (see concordance in Figure 13). These soiling substances and physical defects are not inherent constituents but extraneous or foreign elements to objects being scoured (e.g. a pan or a bathtub). The background sub-event *surface staining/denting* is thus essential for the profiled sub-event *scouring* to arise. Nevertheless, the two sub-events are not causally related because surface staining does not necessarily lead to surface scouring; moreover, the two events do not temporally overlap. This is the same case documented by Goldberg for *return*: going is a prerequisite for returning to take place, but going does not necessarily lead to returning.

In contrast, the terminological verb *scour* in the sense of *tidal scour* only activates its profiled event. This means that no background sub-event is lexicalized by this verb because shore sand and gravel (the materials typically scoured by entrainment) are inherent, integrative constituents of shores, and thus, no predetermined background event, prior to scouring, is evoked by the verb. Human scouring implies counteracting a previously performed action or string of actions that repeat over time (staining and/or hitting a surface), whereas in tidal scouring, no previous action is intrinsically encoded by the verb. This asymmetry in the event structure of the two senses of the verb is made explicit in Figure 14. Interestingly, one major reason why *scour* was chosen for

analysis is that, unlike *cement*, it is in the semantic frame evoked by the general-language sense of verb that two sub-events, the background and the profiled ones, operate. By contrast, *cement* only triggers the two types of sub-event in the terminological (domain-specific) sense of the verb, not in the general-language one.

The fact that dirt is not an intrinsic constituent of a cooking pan (i) and the fact that gravel and sand are part of a shore (ii) are both common knowledge. Therefore, with the example of *scour*, this study provides evidence that polysemic verbs may also be constrained by world knowledge in scientific discourse. In fact, a user's knowledge of events in specialized communication plays a central role in sentence processing and understanding (Faber 2011: 16). However, in the examples analyzed in this study, only in the case of fact (i) is background world knowledge *also* linguistically encoded/motivated by the semantics of the verb.

The relevance of world knowledge and its relationship with purely lexical material has also been reported in the context of polysemy by formal approaches to copredications (two or more predictions on the same object). In Generative Lexicon Theory, for example, Asher & Pustejovsky (2013: 44ff) exploit the notion of *dot object* to explain how the two constituent types (e.g. eventualities) of an object highlight different, incompatible aspects/dimensions of the object, allowing for predications that are licensed over either of the two dot element types. This is done within an articulate codification system that formalizes the linguistic *and* non-linguistic information of predicates.

4. Conclusions

This study further develops Goldberg's (2010: 44) theory on verb semantics and event-structure construal in the specialized language discourse of environmental science. Terminology research tends to be limited to nouns, and thus, there are relatively few studies of verbs. The number of terminology studies dealing with polysemic verbs from a Frame-Semantics perspective is even scarcer. This research fills the gap by relying on the EcoLexicon Environmental Corpus and on premises of Frame-based Terminology (Faber 2011; Faber et al. 2006; 2012). Based on a corpus and context-based analysis of the semantics of the polysemic verbs *cement* and *scour* and their argument structure, it was shown that there are terminological verbs (i) whose meaning involves manner and result or change of location; and (ii) whose profiled events are not causally or temporally related to their background sub-event frames. This claim stresses the fact that (i) and (ii) are *both* combined in the semantics of a single verb. This is a contribution to Goldberg's (2010) theory, which traditionally approaches (i) and (ii) separately for verb semantics and event construal description.

The results of this study make another contribution to Goldberg's (2010) theory by revealing fundamental differences in the number of sub-events activated by the general and the specialized language senses of verbs. Specifically, it was found that a terminological verb can lexicalize both the profiled event and the causally unrelated background event within the same semantic frame, whereas the general-language usage of the same verb can only lexicalize the profiled event (e.g. *cement*). The reverse phenomenon was also shown to be true (e.g. *scour*). The background and profiled sub-events evoked by the specialized meaning of *cement* were formalized within the Environmental Event Frame template – proposed by Frame-based Terminology – making this codification

system more comprehensive and robust. Along the lines of scholars such as Nemoto (2005) and Iwata (2005), our results showed that Goldberg's (2010) view of the background and profiled semantic frames evoked by a particular verb should account for extended senses more thoroughly since these senses sanction the emergence of differing semantic frames associated with a given verb. A Frame-Semantics approach is thus shown to be highly instrumental to this aim.

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