

Lexical Conceptual Structure of Literal and Metaphorical Spatial Language: A Case Study of *Push*

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Abstract

Prior methodologies for understanding spatial language have treated literal expressions such as *Mary pushed the car over the edge* differently from metaphorical extensions such as *Mary's job pushed her over the edge*. We demonstrate a methodology for standardizing literal and metaphorical meanings, by building on work in Lexical Conceptual Structure (LCS), a general-purpose representational component used in machine translation. We argue that spatial predicates naturally extend into other fields (e.g., circumstantial or temporal), and that LCS provides both a framework for distinguishing spatial from non-spatial, and a system for finding metaphorical meaning extensions. We start with MetaNet (MN), a large repository of conceptual metaphors, condensing 197 spatial entries into sixteen top-level categories of motion frames. Using naturally occurring instances of English *push*, and expansions of MN frames, we demonstrate that literal and metaphorical extensions exhibit patterns predicted and represented by the LCS model.

1 Introduction

This paper explores representation and distribution of spatial metaphoric language, by identifying instances from the MetaNet (MN) repository of metaphors (David and Lakoff, 2013; Dodge et al., 2015; Stickles et al., 2015), clustering them according to common expressions (e.g., “change of location”), and representing both the literal and metaphorical senses of these expressions as combinations of primitives from Lexical Conceptual Structure (LCS) (Jackendoff, 1983, 1990; Dorr, 1993; Dowty, 1979; Guerssel et al., 1985).

We leverage the *LCS Verb Database* (Dorr et al., 2001), taking LCS as the underlying spatial language meaning representation for literal senses, and aligning these with representations for their corresponding metaphorical representations. For

example, the expression *push over the edge* has a literal (spatial) MN sense, “change of location,” that is represented as *CAUSE GO Loc* in the LCS, but its metaphorical MN sense, “change of state,” is represented as *CAUSE GO Ident*. As an illustration of this contrast, the expanded LCS representations that include these primitive combinations are shown below:

- Literal (spatial): Mary pushed the car over the edge

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[Cause MARY  
 [Go Loc CAR  
  [Toward Over <location>]],  
 <location>=EDGE]
```

- Figurative (metaphorical): Mary's job pushed her over the edge

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[Cause JOB  
 [Go Ident MARY  
  [Toward At <result(property)>]],  
 <result(property)>=CRAZY]
```

The focus here is not on the processes necessary for distinguishing between literal and metaphorical senses, but rather on the representational formalism and organizing principles underlying both. The intention is to lay the foundation for subsequent application of additional context and higher order processes for disambiguation, such as visual grounding (Wilks, 1995) or beliefs and inference (Ballim et al., 2007). The main lesson of this study is that there are similarities between the literal and metaphorical expressions, and that these can be seen through analysis into LCS primitives without extra visual/reasoning evidence.

As a starting point for exploring metaphoric language, 197 spatially grounded metaphors were identified in MN from the total collection of 684 MN entries. These were organized into a smaller set of classes (139) through automatic identification of duplicated phrases (e.g., “change of location”), and then further reduced to 16 classes of metaphorical LCS representations, paired with

their corresponding spatially grounded counterparts in the Loc(ational) field.

To explore the diversity in naturally occurring texts, we used a corpus of around 30k Word documents from the Microsoft language resource library, and available for research. The documents had been harvested from an approved index of websites (excluding sites that are copyrighted, marked do not crawl, adult content, and other restrictions)¹ and targeted specific English locale settings,² as represented by properties of the file format.

An initial search with text processing tools for Windows (public and proprietary) yielded more than 10k en-us sentences for the following spatial and motion strings: *extend, span, contain, come, go, push, pull, enter, exit, rise, fall, skyrocket, plummet, turn back, forge ahead, headway, get out of, get into, drive, be down, be up, be in, be out, guide, follow, sprint, creep, drain, move along, advance*. We scoped this to just under 2k “Push Sentences” – small enough to review, but large enough to present an interesting distribution of forms.

The availability of these two resources enabled the systematic division into LCS classes based on common pairs, and the exploration of naturally occurring instances of them, without requiring a large-scale manual annotation effort. The 16 resulting LCS classes correspond to groupings based on common pairs of metaphorical and spatial LCS’s, as extracted from the LCS Verb Database, as in the example above: *CAUSE GO Loc* (literal) ↔ *CAUSE BE Ident* (metaphorical).

Examples of derived classes are shown here:

- **Class 1 (Being at a Location)**

- Spatial/Literal: The ice *pushed away* from the Arctic and into the Atlantic (GO LOC TOWARD).
- Metaphorical: My mind *pushed away* all the frustration (GO IDENT STATE)

- **Class 4 (Manner of Motion)**

- Spatial/Literal: The woman *pushed aside* the book and fell asleep (CAUSE GO LOC MANNER)

¹Nevertheless we may not share the extracted sentence corpus without seeking permission from the document authors. We do not think this negates the conclusions of this paper, as the corpus is referential, and the examples not unusual.

²English locales include US, Australia, Canada, New Zealand, Great Britain, and others.

- Metaphorical: The team should *push aside* thoughts of failure (CAUSE GO PERC MANNER)

- **Class 5 (Movement along a path)**

- Spatial/Literal: Mary *pushed* the car *over* the edge (CAUSE GO LOC PATH)
- Metaphorical: Mary’s job *pushed* her *over* the edge (CAUSE GO IDENT STATE)

We used the *Push Sentences* to examine these derived classes systematically, analyzing their spatial/metaphorical distribution, as well as the coverage of the spatially based derived metaphor classes. This systematic comparison identified missing metaphor entries in MN, as well as metaphorical instances of *push* not occurring in the corpus, that we found attested in a general web search of the pattern.

The pairing of MN entries with their LCS representations has enabled identification and representation of literal/metaphorical pairs that can be used for downstream natural language understanding. Our corpus-based research both supports the derived classes, and suggests expansion of them. This treatment of both literal and metaphorical extensions of the predicates also provides a framework for a structured search of both possible gaps in the metaphor inventory, and possible metaphoric extensions of individual predicates.

Prior work (Jackendoff, 1996; Levin, 1993; Olsen, 1994; Kipper et al., 2007; Palmer et al., 2017) has suggested that there is a close relation between underlying lexical-semantic structures of predicates and their syntactic argument structure. It has been claimed that prepositional argument constraints on motion predicates need not distinguish between literal and metaphorical senses (Chang et al., 2007, 2010). We take this earlier work a step further by examining generalizations of systematicity at the syntax-semantics interface between literal and metaphorical senses of spatial and motion predicates.

Section 2 provides background on metaphor and how it has been represented, generally and for computational applications. We introduce the LCS representation and MN resource, and describe how we extracted spatial metaphors from the latter and represented them by the former. We illustrate the work with an excerpt of a table provided in the supplemental material. Sec-

tion 3 describes the mapping of spatial metaphors to LCS. Section 4 discusses the *Push* Sentences. We show how to represent *push* metaphors in LCS according to the derived spatial metaphor classes, extend the classes to address cases of *push* absent from MN examples, and the converse: examples predicted to occur that were absent from the corpus. We conclude that the richness of the syntactic patterns available to Spatial (literal) uses of verbs and related nominals are also available to their metaphorical counterparts, thus providing a structured way to investigate and represent metaphorical data, including future work exploring whether and why distributional differences may occur. In Section 5 we discuss related work (Cascades (David et al., 2016)) and future explorations (multilingual representation, for which LCS was originally designed).

2 Background

Lexical Conceptual Structure (LCS) (Jackendoff, 1983, 1990; Dorr, 1993; Dowty, 1979; Guerssel et al., 1985) has been used for a range of different applications, including interlingual machine translation (Habash and Dorr, 2002), lexical acquisition (Habash et al., 2006), cross-language information retrieval (Levow et al., 2000), language generation (Traum and Habash, 2000), and intelligent language tutoring (Dorr, 1997).

LCS primitives are defined so that their combination captures syntactic generalities: actions and entities must be systematically related to a syntactic structure. Constraints operate on three dimensions: (1) spatial, (2) causal, and (3) field. The primitive building blocks include GO, STAY, BE, GO-EXT, ORIENT, and also an ACT primitive developed by Dorr and Olsen, (1997). These primitives come from the spatial dimension and have the following syntactic and semantic argument selection constraints:

Events (Argument1, Argument2):

GO(Thing, Path) *Jen ran home*
 STAY(Thing, Position) *Jen remained home*
 ACT(Thing, Thing) *Jen ate dinner*

States (Argument1, Argument2):

BE(Thing, Position) *Jen was home*
 ORIENT(Thing, Path) *The sign points to the exit*
 GO-EXT(Thing, Path) *The highway runs through Montana*

In the Causal dimension, predicates CAUSE and LET have two arguments: a Thing or Event,

and a State or Event. The Field dimension describes Argument relations as:

(Loc)ational (pertaining to space/motion)
 (Poss)essional (ownership)
 (Temp)oral (time)
 (Ident)ificational (state)
 (Circ)umstantial (situation)
 (Exist)ential (existence)
 (Perc)eptual (perception)
 (Comm)unicational (communication)

The latter two fields (Perceptual and Communicational) correspond to two domains added by Olsen et al. (1997) beyond the original LCS conceptualization of Jackendoff (1983; 1990), enabling coverage of a wider range of metaphorical extensions.

Within the LCS framework, both literal (spatial) and figurative (metaphorical) meanings are captured for a wide range of verbal constructions. The spatial dimension of the LCS representation (i.e., the (Loc)ational field) serves as the basis of the *literal* meaning, thus enabling straightforward extension to the other fields to represent the *metaphorical* meaning. This extension supports a systematic mapping of spatial meaning to surface realizations. This systematicity correspondingly carries over to metaphorical counterparts and a systematic surface realization is available for both types of meanings.

For example, the GO primitive in the Loc field projects a prepositional phrase containing a location, such as *over the edge*, whereas the GO primitive in the Ident field projects an adjectival phrase containing a property, such as *crazy*. Additional examples of the three dimensions above are discussed in Section 3.

This paradigm is consistent with that of Neuman et al., (2013) in large-scale metaphor identification, which takes meanings of the word as literal (or non-metaphorical) based on “how close the word’s sense is to its embodied origins,” vs. determining the same by frequency, commonsense, or selectional preference strategies.³

Representations of spatial relations and their metaphorical extensions to other domains have been the subject of numerous studies (Talmy, 1985; Gentner, 2001). The benefit of this LCS-based grounding of metaphorical expressions in their spatial counterparts is that it is possible to leverage a set of principled mappings from LCS to

³Even so they acknowledge that identifying metaphors is difficult even for humans.

Class 1: Be at Location (MN: EXPERIENCED STATE IS PROXIMATE OBJECT)	
Examples: ... <i>a headache approaching</i> (MN); ... <i>migraine pushed itself through skull</i> (Push Sentences)	
Spatial/Literal:	Metaphorical:
LCS: go loc [state] toward y RED: GO LOC TOWARD	LCS: go ident y toward [state] RED: GO IDENT STATE
Class 4: Manner of Motion (MN: GUIDED ACTION IS GUIDED MOTION ALONG PATH)	
Examples: ... <i>guided through the task</i> (MN); ... <i>pushed products to marketplace</i> (Push Sentences)	
Spatial/Literal:	Metaphorical:
LCS: cause x go loc y toward z [manner] RED: CAUSE GO LOC MANNER	LCS: cause x go perc y toward z [manner] RED: CAUSE GO PERC MANNER
Class 5: Change of Location (MN: CHANGE OF STATE IS CHANGE OF LOCATION)	
Examples: ... <i>fell into depression</i> (MN); ... <i>pushed her over the edge</i> (Push Sentences)	
Spatial/Literal:	Metaphorical:
LCS: cause x go loc toward y [location] RED: CAUSE GO LOC PATH	LCS: cause x go ident y toward [state] RED: CAUSE GO IDENT STATE

Table 1: Sample of LCS-Based Classification for Literal (Spatial) and Metaphorical Senses with Examples from MN and ‘Push’ Sentences

syntactic realizations for a wide range of verb semantics within 192 verb classes of (Levin, 1993), augmented by 44 additional classes that were subsequently added (Dorr, 1997) and further enhanced for aspectual composition (Olsen, 1994; Dorr and Olsen, 1997; Dorr et al., 2001).

For a rich source of metaphoric constructions, we leveraged MetaNet (MN), a repository of metaphors represented in accordance with principles of conceptual metaphor theory, introduced by Lakoff and Johnson (1980). The metaphors each map a Source domain (e.g. “life”) to a Target domain (e.g. “journey”), yielding metaphors like *Life is a journey*.

Both Source and Target domains are themselves represented as rich conceptual frames in MN. For example, *someone* lives a life, with a *span*, possibly with a *companion*, and a *goal*, etc. These map to elements of the ‘journey’ frame as, respectively, *journey-er*, the *journey* event and *companion*, and the *destination*.

Additional MN mappings in the network of concepts include stops, paths, locations along the way, vehicles, etc. Examples of surface realizations are also included with the metaphor, e.g. *His life has taken a good course* and *He has changed his direction in life, and taken a more spiritual path*. (Neuman et al., 2018; David and Lakoff, 2013; Dodge et al., 2015; Stickles et al., 2015)

In addition, frames can be linked to frames, and metaphors to metaphors, defining larger networks. For example, “CAUSED CHANGE OF STATE” is subcase of “CAUSATION”, and makes use of “CHANGE OF STATE” (Neuman et al., 2018).

We look at metaphors comprised of a mapping between a concept for a literal expression typi-

cally related to space or motion like “CHANGE OF LOCATION,” and the corresponding concept for the metaphorical sense, e.g., “CHANGE OF STATE.” So, for example, the surface realization *pushed him over the edge* is an (adapted) example associated with a mapping between the literal meaning of *push* (CHANGE OF LOCATION) and the metaphorical meaning of *push* (CHANGE OF STATE) which, in this case, could be paraphrased as *go crazy*.

3 Spatial Language Metaphors: Mapping to Lexical Semantic Representations

Understanding how spatial expressions relate to objects and situations in the real world can enable an understanding of abstract notions that “inherit” properties of their spatial analogues. Even without the context of a visual stream (Wilks, 1995) or access to beliefs and inferential processes (Balin et al., 2007), it is possible to support sentence-processing applications (e.g., grammar checking) by relying on a lexical-semantic representation that enables uniform syntactic analysis, within a framework that supports downstream processing for disambiguation.

We conducted an analysis of the MN metaphor repository, identifying 197 spatially grounded metaphors and collapsing these into 139 unique spatial expressions. We then categorized these into 16 semantically motivated classes based on pairings between LCS primitives for the spatial/literal sense and LCS primitives for the metaphorical sense. Table 1 shows representative spatial and metaphorical cases for the three derived classes introduced in Section 1, together with examples

Class Name	Spatial/Literal	Metaphorical	Examples	PUSH EXAMPLE
1. (Being at) Location / Position /	be loc x not_at y [REDUCED: BE LOC NOT_AT]	be exist x not_at [exist] [REDUCED: BE EXIST NOT_AT]	He's gone/departed	~He's <i>pushed off</i> [=-left]
	go loc [state] toward y [REDUCED: GO LOC TOWARD]	(1) go ident y toward [state<property->] [REDUCED: GO IDENT STATE] (2) be poss y at [state<condition->] [REDUCED: BE POSS STATE]	I feel /a head ache approaching/	~[headache] <i>feels like a creature pushing itself through my skull</i>
2. Force Acting on Motion	cause x go loc y toward [event] [REDUCED: CAUSE GO LOC TOWARD]	(1) cause x go ident y toward [event<property->] [REDUCED: CAUSE GO IDENT STATE] (2) cause x go circ y toward [event<partnership->] [REDUCED: CAUSE GO CIRC EVENT]	Her parents pushed her into marriage	~parents <i>pushed her into marriage</i> ~[project] <i>helped pushing forward industry structure adjustment</i> ~pushed to <i>détente</i> ~pushed our country into the <i>muck of depravity</i>
	cause x go loc y toward z [REDUCED: CAUSE GO LOC TOWARD]	cause x go exist y toward [exist] [REDUCED: CAUSE GO EXIST TOWARD]	Democrats pushed through historic legislation	~A <i>coalition group ... [is] trying to push along the referendum</i> ~Hollywood media moguls are <i>pushing an agenda</i> ~a <i>delegation to push against delays and ... taxes</i>
	cause x go loc y toward z [manner] [REDUCED: CAUSE GO LOC MANNER]	act_on x y [result_of_manner_toward_z] [REDUCED: ACT_ON RESULT_OF_MANNER_TOWARD]	They drove the country into a ditch	~help <i>push downtown [business area] to upgrade</i>
3. (Change of) Possession	cause x stay loc [state] at x [REDUCED: CAUSE STAY LOC STATE]	cause x stay poss x at [state] [REDUCED: CAUSE STAY POSS STATE]	The president kept hold of power	~youth who have been <i>pushed out of their homes</i>
	cause x go loc y away_from z [REDUCED: CAUSE GO LOC AWAY_FROM]	cause x go poss y away_from z [REDUCED: CAUSE GO POSS AWAY_FROM]	Radicals seized control of the city from the ruling party	~control these thoughts, or <i>push them out of your mind</i>
4. Manner of Motion	cause x go loc y toward z [manner] [REDUCED: CAUSE GO LOC MANNER]	cause x go perc y toward z [manner] [REDUCED: CAUSE GO PERC MANNER]	She guided him through the problem	~push yourself to places you have never been before
	go loc x toward y [manner] [REDUCED: GO LOC MANNER]	go perc x toward y [manner] [REDUCED: GO PERC MANNER]	We slogged through it	~pushed products into the marketplace ~push students past their current language level
	act loc x along y [manner] [REDUCED: ACT LOC ALONG MANNER]	go circ x toward y [result_of_manner_on_y] [REDUCED: GO CIRC RESULT_OF_MANNER]	We will smoothly sail along for the rest of the process	~pushing down decision making to lower levels ~a group needs to be <i>pushed forward</i> or a path to follow.
	cause x go loc x [path] z [REDUCED: CAUSE GO LOC PATH]	go circ x toward z [REDUCED: GO CIRC TOWARD]	She successfully navigated her way through negotiations	~push your brother out for his walk

Table 2: Excerpt of Derived Classes for Literal (Spatial) and Metaphorical Senses with MN and ‘Push’ Examples

from MN and Push Sentences. Each class has one of 16 labels (e.g., “Be at Location” or “Manner of Motion”). A single MN entry is shown in the table for each class, e.g., “EXPERIENCED STATE IS PROXIMATE OBJECT”, although, in general, each class may be associated with multiple MN entries.

In each class, an LCS representation is provided for the **Spatial/Literal** sense and another LCS is provided for the **Metaphorical** sense. These LCS’s are indexed by a set of “reduced” primitives (RED), such as “GO LOC TOWARD,” that represent the salient components of the full LCS. The coupling of the reduced primitives for the literal sense with those of the metaphorical sense are what enabled the development of each of the 16 classes. For example, the “Be at Location” class emerged from the coupling of “GO LOC TOWARD” with “GO IDENT STATE,” as well as additional couplings that are further fleshed out in a supplemental resource described in Section A. The 16 derived classes were named once they emerged from these couplings.

It is interesting to note that the three Push examples in Table 1 (one per each of Class 1, 4, and 5) were not available in MN, but were mined from the *Push* Sentences. Out of all 16 classes, only Class 2 (Force Acting on Motion) contained MN sentences with the word *push*. These were in fact

the only sentences in the entire MN inventory that contained the word *push*:

- ...her parents kept **pushing** her [into an arranged marriage]⁴
- ...Democrats **push** through historic, controversial healthcare legislation⁵
- ...Bloomberg goes to Washington to **push** gun laws⁶

As such, this study has revealed several cases of Metaphors containing the word *push* that were not found in MN, but were systematically identified and accordingly classified. More specifically, with the exception of the derived classes 7, 8, and 13, examples were extracted anew from *Push* Sentences and assigned to the appropriate derived classes per LCS-based predictions (e.g., *migraine pushed itself through her skull*).⁷ We therefore systematize the MN representation of Space/Motion and extend its coverage. Coupled with the LCS Verb Database this extended MN provides a framework for future research in English and other languages.

⁴from MN entry “CAUSED CHANGE OF STATE IS CAUSED CHANGE OF LOCATION”

⁵from MN entry “ENACTING LEGISLATION IS CAUSING MOTION ALONG A PATH”

⁶from MN entry “INCITING GOVERNING ACTION IS FORCED MOVEMENT”

⁷For Classes 7, 8, and 13, no example was found in the *Push* sentences.

Table 2 shows an excerpt of a table provided in the supplemental material. The first column provides the name of the newly emerged class from this study. The next two columns contain the LCS's and corresponding reduced primitives for the Literal (Spatial) and Metaphorical senses, respectively. The "Examples" column contains examples from MN. The "PUSH EXAMPLE" column contains additional metaphorical expressions extracted from the *Push Sentences*—a representative sample of the total number of 1655 sentences containing the word *push*. The supplemental material also includes hyperlinked MN entries for each example associated with each class, enabling the addition of new metaphors to MN.

Note that metaphorical extensions of spatial notions such as *up, down, into, from, to, over* to abstract notions in MN such as *go crazy, become depressed, feel badly* can enable realizations of metaphorical expressions that mirror those of their literal (spatial) counterparts. Motion frames are systematically realized in language with motion syntax. Metaphorical extensions of spatial language analogously would similarly permit a variety of motion expression forms.

This observation has been leveraged for natural language analysis in writing assistance applications (Chang et al., 2007, 2010), relying on the subcategorization frame parallels in literal and metaphoric language. For example, consider the derived Manner of Motion class 4 (*guide, lead, launch, shove, roll, walk, run, climb, hike,...*). Verbs in this class describe translational motion of a particular type, in the spatial (literal) meaning. In the spatial domain, these verbs may also have complements that signify the PATH of the motion, as well as the beginning and ending points of the Path (SOURCE, GOAL). If the motion is self-propelled, the verbs appear in intransitive constructions⁸ with various verb-phrase arguments expressing the beginning, extent, and end of the motion:

- We're running.
- We're walking on the Burke-Gilman Trail.
- We're rolling on the Burke-Gilman Trail from Golden Gardens Park.
- We're hiking to the Ballard Locks on the Burke-Gilman Trail.

⁸(Levin, 1993)'s class of *Roll Verbs* has finer-grained classifications.

Similarly, verbs like *push/pull* inherently encode an exertion of force,⁹ patterning like motion verbs with all the predicted complements (generally appearing transitively).

- We're pushing (the stroller).
- We're pushing the stroller on the trail
- We're pushing the stroller on the trail from the park.
- We're pushing the stroller to the locks from the park.

Additionally, these verbs can have temporal adjuncts, e.g. *on Tuesday, this summer*. Therefore we expect (and see) a wide variety of prepositional phrases associated with verbs, and natural language understanding needs to be appropriately constrained. Chang et al. (2007; 2010) observed that complements of motion verbs appeared in the same constructions, whether the meanings were literal or metaphorical, and therefore attachment in parsing of prepositional phrases could be guided by similar constraints, permitting (but not requiring) a beginning, extent, and end of the motion.

- He's just walking through life. [PATH]
- We're running the conference from Friday, June 1, through weekend, to Monday June 4.
- The responsibility drove her over the edge.
- We're pushing the meeting back to next Friday.

In the *Push Sentences* we see similar variety in the derived classes that employ these verbs. For example, *Push your way through finals* is understood by metaphorical extension of spatially-related motion examples such as *Push your way through the crowd*. More generally, organizing metaphors into LCS-based classes enables the prediction of possible syntactic realizations on the surface.

An important contribution of this work derives from the LCS-based organizational structure, which enables enrichment and expansion of MN, as discussed further in Section 5.

4 Case Study: push

Prior work (Chang et al., 2007, 2010) was designed to enable writing assistance (e.g. grammar

⁹(Levin, 1993)'s *Verbs of Exerting Force*

Part of Speech	Spatial	Metaphorical	Unknown
Verbs: 998	46% (459)	52% (514)	2% (25)
Nouns: 637	70.6% (450)	26.5% (169)	2.8% (18)
Adjectives: 20	45% (9)	55% (11)	(0)

Table 3: Summary of Spatial and Metaphorical Usages for *push* in 1655 sentences/lines of the Corpus

checking) as an application for deep understanding of lexical conceptual structure, including directional and spatial language. This earlier work proposed that spatial expressions enable structural realizations across both literal and metaphorical usages across languages, with examples from English, Spanish, German, French, and Japanese. In this section we illustrate the validity of this assumption for spatial expressions involving *push*, exploring both spatial and metaphorical usages derived from the *Push Sentences*.

In our analysis, we found that 52% of the verb occurrences of in the *Push Sentences* were used in their metaphorical sense. So, although only 28% of metaphors in MN had spatial origins, spatial expressions involving *push* were prevalent in the form of metaphorical extensions and, moreover, even in these extended senses adhered to syntactic structures and complements of their spatial counterparts. Therefore, it is important to capture the cross-field units of meaning (something akin to *exert force against some form of resistance*) while also supporting predictable cross-field surface realizations.

After discarding 71 instances from the 1726 sentences with the string *push* as irrelevant (lines of code, *Pushkin*, etc.), we categorized the remaining 1655 instances by part of speech, and identified, context permitting, whether the use was spatial or metaphorical.

The results in Table 3 show almost 40% of the uses across parts of speech were metaphorical, with 52% of the 998 Verbs and 55% of the Adjectives (20). Of the 998 verbs, the metaphorical uses included technical terms (*push notifications (to someone)*), political advocacy (e.g. *push legislation, a referendum, an agenda*),¹⁰ marketing (*push a brand, Christmas specials*), and motivation (*push into college, push through AP classes*). Spatial uses included *push a button/laundry cart/box*. Sentences with Unknown verb uses did not provide enough context to identify whether they referred to spatial or metaphorical *pushing*, for ex-

¹⁰See (David et al., 2016) for extensive discussion of advocacy pertaining to *gun rights*.

Noun type	Spatial	Metaphorical	Unknown
Simple: 118	36.4% (43)	54.2% (64)	9.3% (11)
Agentive: 7	0% (0)	57% (4)	43% (3)
Compound: 512	79.3% (406)	18.5% (100)	1.2% (6)

Table 4: Noun Spatial and Metaphorical Usages for *push* by Subtype

ample (*you push through and nature sings; always push and do not pull, the work done in pushing back the atmosphere*).

We note, in particular, that both the verbal and nominal uses exhibit similar syntactic structures to **both** the literal (spatial) and figurative (metaphorical) usages. For example, as shown in Table 4, the 637 nouns included simple spatial/metaphorical examples terms (*a push into college/the door*) and metaphorical agentives (*drug/token/domino pusher*).¹¹ Compounds included spatial phrases (*push button, push-button, pushbutton, push/pull handle, pushpin, push-ups, push piers*) and metaphorical phrases (*push factor, push-notification, push web services, push promotion strategies, push-in class services, push subscription*).^{12,13}

In LCS, these would be treated as conflational variants or divergences (Dorr, 1993). The nominal would express a conflated EVENT that could be the subject of a predicate, for example *A push into college gave Mary her start*.

Finally, we discovered that *push* can appear in most spatial/motion metaphor categories, as indicated in italicized examples inserted into Table 2, and also into supplemental material. We show examples in English, and suggest meanings that may not be idiomatic in English, but could be predicted in other languages (e.g. based on fields). In each of these cases, the meaning of *push* was consistent with its role as a verb of exerting force, potentially causing motion. With the addition of these examples, it is clear that our LCS-based structuring of MN has allowed us to systematically predict and find Metaphors not found in MN.

We do not claim that the categorization is ready to be standardized, or that the distribution is representative—be it across texts, across spatial/motion predicates, across languages for verbs meaning ‘push’, of all the metaphors involving

¹¹The other examples *toolpusher, pedal pusher* cannot be analyzed with confidence given the short contexts.

¹²Unknown again had limited context, e.g. “*short response plyo push-up*.”

¹³Hyphenated, closed, and open compounds were included in each case.

‘push’ in English, or in any other way. We offer the numbers and text examples¹⁴ as qualitative evidence of the breadth and variety of metaphorical extensions in naturally occurring texts.

5 Discussion and Future Work

The work presented in this paper is complementary to, and not incompatible with, downstream visual grounding for disambiguation (Wilks, 1995) or belief ascription for metaphor identification (Ballim et al., 2007). The LCS framework aims to provide a systematic mapping to surface realizations, without requiring disambiguation, but still enabling further distinctions to be made between literal and metaphorical meanings through additional context such as visual inputs or higher order beliefs and reasoning and others, including selectional restrictions and word embeddings (Dinh and Gurevych, 2016).

Collapsing the spatially-motivated metaphors into semantic classes is similar to the Cascade approach (David et al., 2016) that uses the MN foundation as a starting point. Both LCS and Cascades provide a framework within which to bring order to the collection of observations: hierarchical concepts in the case of Cascades and lexical-conceptual structure in the case of the framework described in this paper. The lexical conceptual structure focuses on how the semantics of literal and metaphorical verbs projects into syntax, whereas Cascades describe how the semantics of individual metaphors organize hierarchically, and how they relate to grammatical constructions.

The LCS framework offers consistent structure across literal and metaphoric domains within and between languages. It may be that the variation we see in *which* lexical elements are used in languages can be attributed to the different perspectives on the events they name, similar to the particulars in the two perspectives on gun rights. For example, are there meaningful differences in the use of *push* in English, mirroring Spanish uses of *promover*, *impulsar*, *inculcar*, *esforzar* in Table 5?

The Cascades approach suggests there is a continuum from literal to metaphorical—that the dividing line is not clear. Our data analysis of spatially motivated metaphors revealed the validity of this continuum. This suggests future research on adding a continuous dimension beyond what

¹⁴Examples have been truncated or otherwise adapted in accordance with Microsoft company policy

E: The NRA pushed the pro-gun legislation (through congress).
S: La NRA promovió / impulsó la legislación pro- armas (en el congreso).
E: My parents pushed me to succeed.
S: Mis padres me inculcaron el tratar de ser exitoso.
E: I pushed myself through my AP classes.
S: Me esforcé mucho con las clases avanzadas.
E: The ice cream shop pushed peppermint for the holi- days. (as in encouraged sales).
S: La heladería promovió / intentó / colocó / insistió mucho con el helado de menta en las fiestas.

Table 5: Spanish Usages of English *push*

is provided in the LCS framework. For example, when one army pushes another back to a position, or the US pushes the indigenous peoples to a reservation, there is no contact involved, but the pushing seems more direct (and probably would involve contact if challenged) than pushing someone over the (metaphorical) edge or pushing a bill through congress.

Another promising avenue for future research would be the identification of multilingual equivalents of the 139 unique spatial expressions that were extracted from MN in this study. Such an endeavor would involve the construction of analogous representations of these 139 cases for other languages—thus enabling a cross-lingual mapping that would yield potential metaphorical extensions. Testing these metaphorical extensions would proceed in each language by examining cross-field analogues, as in the English case. Ultimately, it would be critical to demonstrate the multilingual relevance of this representational mapping for processes such as PP attachment.

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References

- Afzal Ballim, Yorick Wilks, and John Barnden. 2007. Belief Ascription, metaphor, and Intensional Identification. *Words and Intelligence I: text, Speech and Language technology* 35:217–253.
- Su Chin Chang, Ravi C. Shahani, Domenic J. Cipollone, Michael V. Calcagno, Mari J. B. Olsen, and David J. Parkinson. 2007. [Linguistic Object](#)

- Model.** 7,171,352. <http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fmetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=7171352.PN.&OS=PN/7171352&RS=PN/7171352>.
- Su Chin Chang, Ravi C. Shahani, Domenic J. Ciplone, Michael V. Calcagno, Mari J. B. Olsen, and David J. Parkinson. 2010. **Lexical Semantic Structure.** 7,689,410. <http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fmetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=7689410.PN.&OS=PN/7689410&RS=PN/7689410>.
- Oana David and George Lakoff. 2013. Wikis, Beans and Cats: The Cascade Theory of Metaphor. In *12th International Cognitive Linguistics Conference (ICLC 12)*. Edmonton, Canada.
- Oana David, George Lakoff, and Elise Stickles. 2016. Cascades in Metaphor and Grammar: A Case Study of Metaphors in the Gun Debate. *Constructions and Frames* 8(2):214–253.
- Erik-Lân Do Dinh and Iryna Gurevych. 2016. Token-Level Metaphor Detection using Neural Networks. In *Proceedings of The Fourth Workshop on Metaphor in NLP, Association for Computational Linguistics / San Diego, CA, 17 June 2016*. pages 28–33.
- Ellen Dodge, Jisup Hong, and Elise Stickles. 2015. MetaNet: Deep Semantic Automatic Metaphor Analysis. In *Proceedings of the Third Workshop on Metaphor in NLP*. Association for Computational Linguistics, pages 40–49.
- Bonnie J. Dorr. 1993. *Machine Translation: A View from the Lexicon*. MIT Press, Cambridge, MA.
- Bonnie J. Dorr. 1997. Large-Scale Dictionary Construction for Foreign Language Tutoring and Interlingual Machine Translation. *Machine Translation* 12:271–322.
- Bonnie J. Dorr, Mari Olsen, Nizar Habash, and Scott Thomas. 2001. **LCS Verb Database Documentation.** http://www.umiacs.umd.edu/~bonnie/Demos/LCS_Database_Documentation.html.
- Bonnie J. Dorr and Mari Broman Olsen. 1997. Deriving Verbal and Compositional Lexical Aspect for NLP Application. In *Proceedings of the 35th Annual Meeting of the Association for Computational Linguistics and Eighth Conference of the European Chapter of the Association for Computational Linguistics*, pages 151–158.
- David Dowty. 1979. *Word Meaning and Montague Grammar*. Reidel, Dordrecht.
- Dedre Gentner. 2001. Spatial Metaphor in Temporal Reasoning.
- M. Guerssel, K. Hale, M. Laughren, B. Levin, and J. White Eagle. 1985. A Cross-linguistic Study of Transitivity Alternations. In W. H. Eilfort and P. D. Kroeber nad K. L. Peterson, editor, *Papers from the Parasession in Causatives and Agentivity at the Twenty-first Regional meeting of the Chicago Linguistic Society*, pages 48–63.
- Nizar Habash and Bonnie J. Dorr. 2002. Handling Translation Divergences: Combining Statistical and Symbolic Techniques in Generation-Heavy Machine Translation. In *Proceedings of the Fifth Conference of the Association for Machine Translation in the Americas*. Tiburon, CA, pages 84–93.
- Nizar Habash, Bonnie J. Dorr, and Christof Monz. 2006. Challenges in Building an Arabic GHMT system with SMT Components. In *Proceedings of the 7th Conference of the Association for Machine Translation in the Americas*. Boston, MA, pages 56–65.
- Ray Jackendoff. 1983. *Semantics and Cognition*. MIT Press, Cambridge, MA.
- Ray Jackendoff. 1990. *Semantic Structures*. MIT Press, Cambridge, MA.
- Ray Jackendoff. 1996. The Proper Treatment of Measuring Out, Telicity, and Perhaps Even Quantification in English. *Natural Language and Linguistic Theory* 14:305–354.
- Karin Kipper, Anna Korhonen, Neville Ryant, and Martha Palmer. 2007. A Large-scale Classification of English Verbs. In *Language Resources and Evaluation*.
- George Lakoff and Mark Johnson. 1980. *Metaphors we live by*. Univ. of Chicago Press, Chicago.
- Beth Levin. 1993. *English Verb Classes and Alternations: A Preliminary Investigation*. The University of Chicago Press.
- Gina Levow, Bonnie J. Dorr, and Dekang Lin. 2000. Construction of Chinese-English Semantic Hierarchy for Cross-language Retrieval .
- Yair Neuman, Dan Assaf, Yohai Cohen, Mark Last, Shlomo Argamon, Newton Howard, and Ophir Frieder. 2013. **Metaphor Identification in Large Texts Corpora.** <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0062343>.
- Yair Neuman, Dan Assaf, Yohai Cohen, Mark Last, Shlomo Argamon, Newton Howard, and Ophir Frieder. 2018. **MetaNet Metaphor Wiki, Version updated 3 January.** https://metaphor.icsi.berkeley.edu/pub/en/index.php/MetaNet_Metaphor_Wiki.

Mari Broman Olsen. 1994. The Semantics and Pragmatics of Lexical and Grammatical Aspect. *Studies in the Linguistic Sciences* 24(1–2):361–375.

Mari Broman Olsen, Bonnie J. Dorr, and Scott Thomas. 1997. Toward Compact Monotonically Compositional Interlingua Using Lexical Aspect. In *Proceedings of the Workshop on Interlinguas in MT*. San Diego, CA, pages 33–44.

Martha Palmer, Claire Bonial, and Jena D. Hwang. 2017. VerbNet: Capturing English Verb behavior, Meaning and Usage.

Elise Stickles, Oana David, and Eve Sweetser. 2015. Grammatical Constructions, Frame Structure, and Metonymy: Their Contributions to Metaphor Computation. In *Proceedings of the 11th Meeting of the High Desert Linguistics Society (HDLS)*. pages 317–345.

Leonard Talmy. 1985. Lexicalization patterns; Semantic Structure in Lexical Forms 3:56–149.

David Traum and Nizar Habash. 2000. Generation from Lexical Conceptual Structures. In *Proceedings of the Workshop on Applied Interlinguas, North American Association for Computational Linguistics / Applied NLP Conference*. pages 34–41.

Yorick Wilks. 1995. Language, Vision and Metaphor. *Artificial Intelligence Review* 9:273–289.

A Supplemental Material: Metaphor Classes, Examples, LCSs

A supplemental resource (spreadsheet) has been provided in .zip format at:

https://www.dropbox.com/s/4vm0ddulemcbnoa/NAACL-2018_Camera_Ready_Metaphor_Classes.zip?dl=0

The top level file inside of the .zip file above is:

20180314-Final_Metaphor_Classes&Examples&LCSs(NAACL-18).htm

This is a worksheet that contains two tabs, covering both Spatial Classes and Mappings into LCS structures for literal and metaphorical meanings:

- **Tab 1:** Spatial Classes - 16 spatial classes, divided according to 139 unique spatial expressions, with members corresponding to 197 hyperlinked MN metaphors. MN Metaphor categories that have been mapped into LCS structures in Tab 2 are listed at the top of each class in column B and highlighted in orange.
- **Tab 2:** LCS Mappings - Mappings from 16 spatial classes into LCS structures for both the physical/literal meaning and the metaphorical meaning. Includes examples, variables and constants, sample verbs, and

hyperlinks to the relevant MN metaphor cases. Examples in Column I are either found on the web (links provided) or adapted from the *Push* sentences.