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
  [Cause MARY
  [Go Loc CAR
  [Toward Over <location>]]],
  <location>=EDGE]
- Figurative (metaphorical): Mary’s job pushed her over the edge
  [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: \(\text{CAUSE GO Loc (literal)} \leftrightarrow \text{CAUSE BE Ident (metaphorical)}\)

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 LMC MANNER)
  - 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-

\(^1\)Nevertheless 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.

\(^2\)English locales include US, Australia, Canada, New Zealand, Great Britain, and others.
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 (Cascade (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)ation*al (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)ation 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

\(^3\)Even so they acknowledge that identifying metaphors is difficult even for humans.
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 metaphorical 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 (Bali-m 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.

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

| Class 1: Be at Location (MN: EXPERIENCED STATE IS PROXIMATE OBJECT) | Examples: ...a headache approaching (MN); ...migraine pushed itself through skull (Push Sentences) |
|---|---|
| Spatial/Literal: | LCS: go loc [state] toward y  
RED: GO LOC TOWARD |
| Metaphorical: | LCS: go ident y toward [state]  
RED: GO IDENT STATE |
| Class 4: Manner of Motion (MN: GUIDED ACTION IS GUIDED MOTION ALONG PATH) | Examples: ...guided through the task (MN); ...pushed products to marketplace (Push Sentences) |
| Spatial/Literal: | LCS: cause x go loc y toward x [manner]  
RED: CAUSE GO LOC MANNER |
| Metaphorical: | 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: ...fell into depression (MN); ...pushed her over the edge (Push Sentences) |
| Spatial/Literal: | LCS: cause x go loc toward y [loc]  
RED: CAUSE GO LOC PATH |
| Metaphorical: | LCS: cause x go ident y toward [state]  
RED: CAUSE GO IDENT STATE |
Table 2: Excerpt of Derived Classes for Literal (Spatial) and Metaphorical Senses with MN and ‘Push’ Examples

| Class Name | Spatial/Literal                                                                 | Metaphorical                                                                                             | Examples                                                                                                                                          | Push Example |
|------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| 1. (Be at) Location/Position | be loc not at y [REDUCED: BE LOC NOT AT] | be exist not at [REDIST: BE EXIST NOT AT] | He’s gone/departed                                                                                                                                | “He’s pushed off [left]” |
|            | [REDUCED: GO LOC TOWARD]                                                      | [REDUCED: GO IDENT STATE]                                                                                   |                                                                                                                                                    |              |
|            | (1) go ident y toward (state-property)                                         | (2) be proy y (state-condition)                                                                             |                                                                                                                                                    |              |
|            | [REDUCED: BE POS STATE]                                                        | [REDUCED: BE EXIST NOT AT]                                                                                        |                                                                                                                                                    |              |
|            | I feel (a head ache approaching)                                               |                                                                                                           |                                                                                                                                                    |              |
| 2. Force Acting on Motion | cause x go loc y toward [event] [REDUCED: CAUSE GO LOC TOWARD] | (1) cause x go ident y toward (state-property)                                                            | Her parents pushed her into marriage                                                                                                               | “parents pushed her into marriage” |
|            | [REDUCED: CAUSE GO IDENT STATE]                                               | (2) cause x go proy y toward (state-property)                                                              |                                                                                                                                                    | “parents pushed her into marriage” |
|            | [REDUCED: GO LOC TOWARD]                                                      | [REDUCED: GO IDENT STATE]                                                                                   |                                                                                                                                                    | “project helped push forward industry structure adjustment” |
|            | (1) go ident y toward (state-property)                                         | (2) be proy y (state-condition)                                                                             |                                                                                                                                                    | “pushed our country into the muck of depravity” |
|            | [REDUCED: BE POS STATE]                                                        | [REDUCED: BE EXIST NOT AT]                                                                                        |                                                                                                                                                    |              |
|            | Democrats pushed through historic legislation                                   |                                                                                                           |                                                                                                                                                    |              |
|            | [REDUCED: CAUSE GO IDENT STATE]                                               |                                                                                                           |                                                                                                                                                    |              |
|            | Democrats pushed through historic legislation                                   |                                                                                                           |                                                                                                                                                    |              |
|            | (1) go ident y toward (state-property)                                         | (2) be proy y (state-condition)                                                                             |                                                                                                                                                    |              |
|            | [REDUCED: GO LOC TOWARD]                                                      | [REDUCED: GO IDENT STATE]                                                                                   |                                                                                                                                                    |              |
| 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                                                                                                                  | “pushing downtown [business area] to upgrade” |
|            | [REDUCED: CAUSE STAY LOC STATE]                                               | [REDUCED: CAUSE STAY POSS STATE]                                                                            |                                                                                                                                                    |              |
|            | (1) go ident x toward y (state-property)                                       | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    | “youth who have been pushed out of their homes” |
|            | [REDUCED: GO LOC TOWARD]                                                      | [REDUCED: GO IDENT STATE]                                                                                   |                                                                                                                                                    |              |
| 4. Manner of Motion | cause x go loc y toward x [man] [REDUCED: CAUSE GO LOC NAMENER] | cause x go proy y toward x [man] [REDUCED: CAUSE GO PERC MANER] | She guided him through the problem                                                                                                                | “push yourself to places you have never been before” |
|            | [REDUCED: GO LOC NAMENER]                                                      | [REDUCED: GO PERC MANER]                                                                                    |                                                                                                                                                    | “push yourself to places you have never been before” |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    | “pushed products into the marketplace” |
|            | [REDUCED: GO LOC NAMENER]                                                      | [REDUCED: GO POSITION]                                                                                        |                                                                                                                                                    | “pushed products into the marketplace” |
|            | (1) go loc x toward y (state-property)                                        | (2) be proy y (state-condition)                                                                             |                                                                                                                                                    | “pushed products into the marketplace” |
|            | [REDUCED: CAUSE GO IDENT STATE]                                               | [REDUCED: CAUSE GO PROPER MANER]                                                                           |                                                                                                                                                    | “pushed products into the marketplace” |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    | “pushed products into the marketplace” |
|            | [REDUCED: GO LOC NAMENER]                                                      | [REDUCED: GO POSITION]                                                                                        |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |
|            | (1) go proy x toward y [man] [REDUCED: GO PERC MANER]                         | (2) be proy x (state-condition)                                                                             |                                                                                                                                                    |              |

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). 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.

4 from MN entry “CAUSED CHANGE OF STATE IS CAUSED CHANGE OF LOCATION”
5 from MN entry “ENACTING LEGISLATION IS CAUSING MOTION ALONG A PATH”
6 from MN entry “INCITING GOVERNING ACTION IS FORCED MOVEMENT”
7 For 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 theLiteral (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.

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

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

9(Levin, 1993)’s Verbs of Exerting Force
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 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 effort 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), 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 example (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). 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).

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

| 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

| Noun type  | Spatial | Metaphorical | Unknown |
|------------|---------|--------------|---------|
| Simple: 118 | 36.4% (43) | 54.2% (64) | 9.3% (11) |
| Agentive: / | 0% (0) | 57% (4) | 43% (3) |
| Compound: 512 | 79.3% (460) | 18.5% (100) | 1.2% (6) |

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

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

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 examples 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 metaphorical 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

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

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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### A Supplemental Material: Metaphor Classes, Examples, LCSs

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

[https://www.dropbox.com/s/4vm0ddudemcbnoa/NAACL-2018_Camera_Ready_Metaphor_Classes.zip?dl=0](https://www.dropbox.com/s/4vm0ddudemcbnoa/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.