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Changes *in the midst of* a construction network: a diachronic construction grammar approach to complex prepositions denoting internal location

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Abstract

Linguists have debated whether complex prepositions deserve a constituent status, but none have proposed a dynamic model that can both predict what construal a given pattern imposes and account for the emergence of non-spatial readings. This paper reframes the debate on constituency as a justification of the constructional status of complex prepositional patterns from a historical perspective. It focuses on the *Prep NP_{IL} of NP_{lm}* construction, which denotes a relation of internal location between a located entity (a trajector) and a reference entity (a landmark). Four subschemas of the Internal Location construction are examined: $MIDDLE_{cxn}$ (*in the middle of*), $CENTER_{cxn}$ (*in/at the center of*), $HEART_{cxn}$ (*in/at the heart of*), and $MIDST_{cxn}$ (*in the midst of*). All occurrences are extracted from the COHA, along with their co-occurring landmark NPs. Using vocabulary growth curves, all patterns are shown to be productive over the whole period covered by the corpus, although at different levels. Using *word2vec*, a semantic vector space with the landmark collocates of each pattern is made. Curves indexed on association scores are plotted to see how densely semantic areas have been populated across four consecutive periods: 1810s–1860s, 1870s–1910s, 1920s–1970s, and 1980s–2000s. Two divisions of labor have emerged. $MIDST_{cxn}$ and $HEART_{cxn}$ are in complementary distribution and operate mostly at the level of abstract locations whereas $MIDDLE_{cxn}$ and $CENTER_{cxn}$ are in parallel distribution and operate at the level of concrete locations.

Keywords: collocations, density maps, diachronic construction grammar, distributional semantic models, internal location, semantic vector space

1 Introduction

Construction Grammar (CxG) holds that linguistic knowledge consists of a network of symbolic units, i.e. form-meaning pairings known as constructions. Although these have been recognized to exist at various levels of complexity, schematicity, and analyzability in the network (Goldberg 2003: 220), pride of place has been given to the study of language phenomena that are “often idiosyncratic, unpredictable and riddled with exceptions” (Hilpert 2021: 37). If it is indeed the case that “the network of constructions captures our grammatical knowledge of language *in toto*”

(Goldberg 2006: 18), CxG must confirm its added value by accounting for patterns that are less idiomatic and more analyzable in terms of general syntactic mechanisms.

Complex prepositions (e.g. *ahead of*, *in spite of*) are a good case in point. Although very common in English (Hoffmann 2005; Leitner 2011), their status is problematic with respect to form and meaning. With respect to form, their constituency has been a matter of debate. On the one hand, formal approaches deny complex prepositions a unit status on the grounds that the string of contiguous words can always be broken by at least one manipulation at the level of underlying syntactic representations (Huddleston 1988; Huddleston & Pullum 2002; Seppänen et al. 1994). Whether such manipulations are attested is never envisaged because deep-parsing effects are considered independent from local constraints and immutable. On the other hand, descriptive grammars subscribe to a continuum ranging from free assemblies to fixed units (Quirk & Mulholland 1964; Quirk et al. 1985; Biber et al. 1999). This idea of a continuum has received empirical validation from corpus-based and usage-based studies (Hoffmann 2005; Beckner & Bybee 2009).

With respect to meaning, most complex prepositions commonly extend beyond the expression of spatial location (Tyler & Evans 2003; Langacker 2010). Gréa (2017) studies five prepositional patterns in French (*parmi* 'among', *au centre de* 'at the centre of', *au milieu de* 'in the middle of', *au cœur de* 'at the heart of', and *au sein de* 'at the breast/bosom of'). They denote a relationship of inclusion between a trajector (tr), i.e. a located entity, and a landmark (lm), i.e. a reference entity that is the secondary focal participant (Langacker 1987: 225–228). Gréa shows that each construes inclusion in its own way. Strikingly, none of the criteria that distinguish them is geometrical. What is decisive is not so much that the trajector is equidistant from the boundaries of the landmark but a system of interacting parameters: the landmark's internal plurality, its boundedness, the magnitude of its referent, and the degree of functional dependence between the trajector and the landmark. Although Gréa develops a model that can predict which semantic facets of a given landmark NP are activated by a given preposition, the model itself is static and it is not clear what drives the semantic change and how the division of labor among the patterns has unfolded over time.

The benefit of a constructional approach to complex prepositions is that it allows us to address the formal and functional issues identified above within a unified theoretical framework. More precisely, it reframes the issues of constituency, meaning change, and division of labor as a justification of constructional status from a historical perspective, along the lines laid out by the Construction Grammar framework (CxG) (Goldberg 1995, 2006, 2009) and its most recent offshoot: Diachronic Construction Grammar (DCxG) (Traugott & Trousdale 2013; Barðdal et al. 2015).

This paper investigates four complex-prepositional patterns that denote a relation of internal location between a trajector and a landmark: *in the middle of NP*, *in/at the center of NP*, *in/at the heart of NP*, and *in the midst of NP*. They are exemplified below:¹

- (1) He stops suddenly **in the middle of the stage** and seems to consider. (1815-FIC)²
- (2) Marvin walked to the chalk mark **in the center of the ring**. (1934-FIC)
- (3) (...) we were **in the heart of Norwalk**. (1827-FIC)
- (4) We see St Eustace praying **in the midst of the river**. (1980-FIC)

My first goal is to justify the unit status of these complex prepositions from a CxG perspective. Four corresponding constructions are hypothesized to exist: MIDDLE_{CxN}, CENTER_{CxN}, HEART_{CxN},

¹Although these patterns can be headed by a dynamic preposition (*to*, *into*, *through*, etc.), only those headed by the most frequent static prepositions (*in* and *at*) are considered.

²Unless specified otherwise, all examples are from the Corpus of Historical American English (Davies 2010). The descriptors consist of the year and the genre.

and $MIDST_{c_{xn}}$. The consistent higher-order paradigm that they are assumed to be part of is a multi-level construction network headed by a more schematic construction, namely the Internal Location construction (henceforth the IL construction). Although there is no set list of criteria for ‘constructionhood’,³ the patterns will nevertheless be recognized to count as constructions if they are productive, schematic, and impose a specific construal upon the trajector/landmark relation, based on a systematic inspection of their most distinctive landmark collocates in the COHA.

My second goal is to show that, like all construction networks, the IL construction network is dynamic and subject to internal reorganization and optimization. To keep track of the shifting distributions of $MIDDLE_{c_{xn}}$, $CENTER_{c_{xn}}$, $HEART_{c_{xn}}$, and $MIDST_{c_{xn}}$ over time, their collocational preferences will be compared across four periods in the COHA (Davies 2010): 1810s–1860s, 1870s–1910s, 1920s–1970s, and 1980s–2000s (the periodization will be justified in Section 3). The collocates will be mapped onto a reference semantic vector space using a predictive distributional semantic model (*word2vec*’s SGNS). Frequency-based contour plots will be added onto this reference space for each period and each subschema. The resulting dynamic visualizations will help detect cases of schematization and show how the network optimizes the distribution of its subschematic nodes to cover all the relevant aspects of internal location.

This paper does not address other markers of internal location, some of which fit the *Prep NP_{IL} of NP_{Im}* constructional template (*in the core/crux of*), whereas others fulfill similar functions but display a different morphosyntax, such as the simple prepositions *amid*, *amidst*, *among*, and *amongst*. Regarding the first kind of markers, they were excluded from a quantitative treatment because they are too rare in the COHA ($N_{core} = 134$, $N_{crux} = 13$). Regarding the second kind of markers, they are assumed to part of a distinct sub-network which, arguably, is linked to the functional stratum of the IL construction.⁴ Future work is therefore needed to understand how this sub-network connects to the more schematic IL construction network. This paper does not attempt either to model the respective contributions of the subschemas to the reinforcement of the mother node, which Hilpert (2015) calls ‘the upward strengthening hypothesis’. Research is underway to test this hypothesis.

The paper is structured as follows. Section 2 reviews the terms of the debate with respect to constituency. The four prepositional patterns count as constructions because of a conflation of formal and functional factors. Section 3 presents the data and, for each subschema, compares frequency of use to productivity. Section 4 explains the methodology underlying the design of diachronic vector spaces, namely the combination of a distributional semantic model and frequency-based contour lines. Such maps show that the most productive nodes in the network, i.e. $MIDST_{c_{xn}}$ and $HEART_{c_{xn}}$, are also the most schematic. They have ended up sharing the task of locating trajectors within abstract locations, whereas $MIDDLE_{c_{xn}}$ and $CENTER_{c_{xn}}$ locate trajectors within concrete locations. Section 5 provides a qualitative assessment of the data, showing that the four subschemas are not strictly compositional and can no longer be analyzed under the sole perspective of spatial criteria. Section 6 summarizes the results and sketches the IL construction network. It concludes with a description of the dynamics at work in the vertical and horizontal dimensions of the network.

³However, see Hilpert (2016: 68–72) and Hilpert (2021) for discussion.

⁴Gréa (2017) includes the simple preposition *parmi* ‘among/amid/amidst’ in his study of *au sein/milieu/centre/cœur de*. Yet, he does not hypothesize the existence of a construction, and formal similarity between the units is irrelevant to his approach.

2 Complex prepositions as constructions

2.1 The debate around complex prepositions

Hoffmann (2005: 26) observes that complex prepositions are mentioned in 19th- and 20th-century grammars. Such units go by different names: 'phrasal prepositions' (Earle 1873), 'prepositional formulæ' (Mätzner 1873), 'compound prepositions', or 'group prepositions' (Sweet 1892). These grammarians recognize that some Prep1 NP Prep2 sequences function like prepositions. Yet, none goes as far as to grant these sequences full prepositional status. One reason given by Sweet (1892: 134-135) is the apparent mismatch between form and function: syntactically, Prep2 governs the following noun; functionally, the noun is governed by the whole group.

Quirk et al. (1985: 671) concede the following: "[i]n the strictest definition, a complex preposition is a sequence that is indivisible both in terms of syntax and in terms of meaning". However, they add that, in usage, whether complex prepositions count as units or free assemblies is a matter of gradience: "there is no absolute distinction between complex prepositions and constructions which can be varied, abbreviated, and extended according to the normal rules of syntax". Accordingly, Quirk et al. develop a scale of cohesiveness that comprises "nine indicators of syntactic separateness":

- (a) Prep2 can be varied;
- (b) the noun can be varied as between singular and plural;
- (c) the noun can be varied in respect to determiners;
- (d) Prep1 can be varied;
- (e) Prep2 + complement can be replaced by a possessive pronoun;
- (f) Prep2 + complement can be omitted;
- (g) Prep2 + complement can be replaced by a demonstrative;
- (h) the noun can be replaced by nouns of related meaning;
- (i) the noun can be freely premodified by adjectives.

The most cohesive sequences are those that behave exactly like simple prepositions, e.g. *in spite of*. The least cohesive sequences are those whose constituents behave independently, e.g. *on the shelf (by the door)*. In the same line of thought, Biber et al. (1999: 76) go as far as to say that the degrees of variability make it impossible to decide where to draw the line between free combinations and units.

Not all linguists agree with gradient constituency. Huddleston (1988: 126) characterizes Prep1 NP Prep2 sequences in terms of a "mismatch" between the lexicon and grammar due to lexicalization. For example, in *for the sake of the premier*, although the four words *for the sake of* belong together lexically, the immediate grammatical constituents are *for + the sake of the premier*. This is further evidenced by the possibility of the genitive alternant: *for the premier's sake*. Huddleston does not treat such sequences as complex prepositions because lexical chunking does not override grammatical parsing in his approach.

Huddleston & Pullum (2002) group Prep1 NP Prep2 sequences under the heading "Idiomatic and fossilised expressions headed by a preposition".⁵ Such sequences differ from free expressions because they are characterized by varying degrees of idiomaticity (i.e. non-compositionality) and fossilization. Unlike free expressions, some instances of Prep1 (Article) N1 Prep2 X do not allow the whole range of syntactic manipulations that are permitted with free expressions. Some

⁵More precisely, Huddleston & Pullum (2002: 618) describe the sequence as Prep1 (Article) N1 Prep2 X, where X corresponds to a noun phrase functioning as complement to either Prep1 or Prep2, depending on how the expression is parsed.

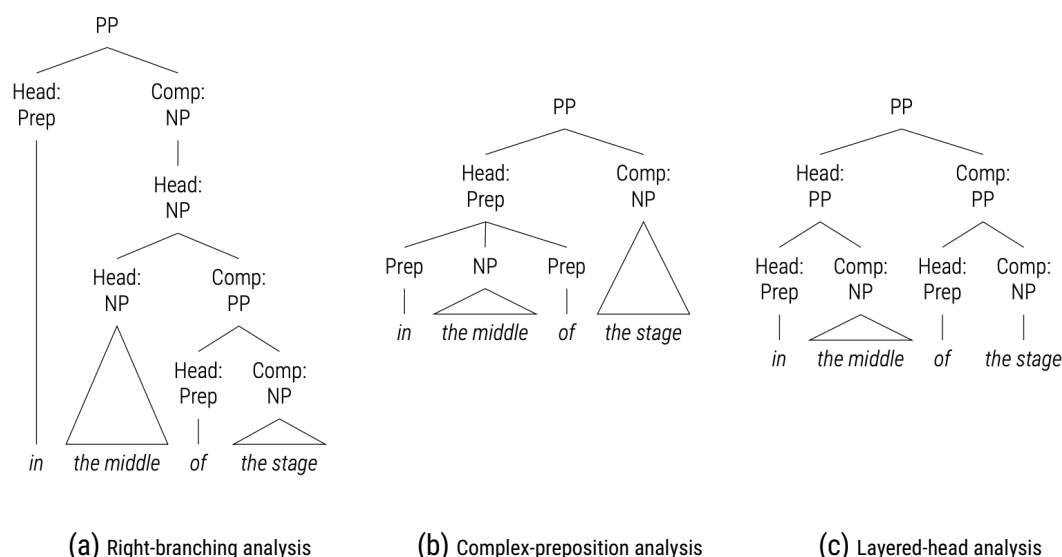


Figure 1: Three candidate syntactic structures

of these manipulations overlap with Quirk et al.'s nine indicators of syntactic separateness: occurrence without Prep2, omission of Prep2 + X, modification of N1, number change in N1, and determiner change. They propose additional manipulations: genitive alternation, coordination of N1, coordination of Prep2 + X, fronting of Prep2 + X. These constituency tests are meant to decide which syntactic structure corresponds to such expressions: (a) right-branching analysis, (b) complex preposition analysis, and (c) layered head analysis (Figure 1).⁶

In a right-branching analysis (Figure 1a), even though the NP *the stage* is part of the PP *of the stage* (down to the right of the tree), it is considered the complement of the head preposition *in*. This analysis is favored if the expression alternates with a genitive construction (e.g. *on the part of* → *on his part*). In a layered-head analysis (Figure 1c), the expression is divided into the head PP *in the middle* and the complement PP *of the stage*. This analysis is chosen if the fronting of Prep2 + relativised X is possible (*he was in league with her* → *the woman with whom he was in league*). According to Huddleston & Pullum, the complex-preposition analysis (Figure 1b) has “some initial intuitive appeal” but is blocked if one manipulation can break the string of contiguous words that an expression consists of, providing that the meaning is unchanged. Some expressions disallow all the syntactic manipulations listed above (e.g. *by dint of*, *in lieu of*, or *in view of*), but Huddleston & Pullum claim that this is not enough to warrant a complex-preposition analysis. They argue that these expressions belong to the same paradigm as expressions amenable to a right-branching or layered-head analysis. Their only specificity is their extreme degree of fossilization. In the same vein, Seppänen et al. (1994) posit four syntactic criteria that are specific to Prep2 and that supposedly challenge the constituent status of complex prepositions: fronting, coordination, ellipsis, and interpolation. Like Huddleston & Pullum, Seppänen et al. (1994: 11) concede that some Prep1 NP Prep2 expressions display a certain degree of syntactic “fixity” and idiomaticity. Yet, no matter how fixed and idiomatic an expression is recognized to be, the preservation of existing syntactic structure prevails in their approach as long as one manipulation is observed. Syntax is viewed as non-adaptive, radically separated from meaning, and therefore impervious to usage.

Purely formal approaches suffer from the absence of validation from usage. According to Hoffmann (2005), the constituency tests proposed by Huddleston & Pullum and Seppänen et al. are used too uncritically, and the validity of their constructed examples needs to be evaluated in the

⁶Adapted from Huddleston & Pullum (2002: 620)

context of samples of authentic language. Hoffmann concedes that some complex prepositions do not satisfy all the constituency tests. However, because even Seppänen et al. admit that some Prep1 NP Prep2 are more fixed than others, it would seem legitimate to acknowledge this gradient, for example by assigning a score based on how many constituency tests are passed. Seppänen et al. reject such a gradient on theoretical grounds: one counter-example is enough to deprive an expression of its unit status. Using the 100M-word British National Corpus, Hoffmann finds that each of the four constituency tests proposed by Seppänen et al. yields rare structural variants. He also finds that the constituency tests admit variants that do not challenge the unit status of some Prep1 NP Prep2 expressions and that such variants are far more frequent in the corpus than those that challenge constituency. In the light of corpus data, constituency is therefore not an all-or-nothing affair.

More importantly, deep-parsing analyses like the above involve underlying levels of syntax that are unlikely to be accessible to all language users (Dąbrowska 2012, 2014). In fact, speakers commonly rely on low-level generalizations to chunk expressions into exemplars that extend across artificially established constituent boundaries (Pijpops & Van de Velde 2016). This suggests that speakers commonly work with abstractions that emerge in a bottom-up fashion from the concrete examples they encounter, regardless of deep structure. In the context of complex prepositions, Beckner & Bybee (2009) show that chunking and categorization impact constituency because such domain-general processes have semantic effects and change incrementally over time. For example, the sequence *in spite of* is gradually forming into a unit because it is used consistently and repeatedly in contexts that suggest that its constituents are strongly associated. More precisely, even though *in spite of* is not affected by much phonetic change, *spite* behaves less and less like a prototypical noun and ceases to take determiners or modifiers as the pattern takes on new meanings (such as the expression of concession). The gradual loss of analyzability and categoriality is a consequence of the combined effects of frequency of use and semantic shift. What this means is that, over time, general syntactic blueprints may be overridden by item-specific routines due to the pressure of usage. Following the same logic, such pressures are likely to shape the internal structure of a given construction network. The IL construction is no exception, as the next sections will show.

2.2 The IL construction

Considering the large body of work on prepositions, relatively few papers have taken a constructional stance. One reason may be that the cognitive strategy that underlies complex prepositions is seemingly explicit and that their form is fully analyzable. This can be explained with reference to the origin of CxG, which emerged in reaction against theories that posit a sharp distinction between grammar rules and the lexicon on the one hand, and form and meaning on the other hand. As a result, CxG pioneers looked for non-canonical, idiomatic patterns such as *let alone* (Fillmore et al. 1988), the *way*-construction (Goldberg 1995), *what's X doing Y* (Kay & Fillmore 1999), or *the X-er, the Y-er* (Kay & Fillmore 1999) to show that, although some phenomena occupy the middle ground in the lexicon-grammar continuum, they shed light on central linguistic aspects of language. With fast-growing evidence that full accounts and broad generalizations are obtained from the observation of constructions in usage, it is now widely accepted that "it's constructions all the way down" (Goldberg 2003: 223) and that CxG is equipped to capture the totality of linguistic knowledge. More canonical and less idiomatic patterns have thereby received increasing attention in the CxG community despite their analyzability in terms of general syntactic mechanisms (e.g. Goldberg & van der Auwera 2012; Hilpert 2016).

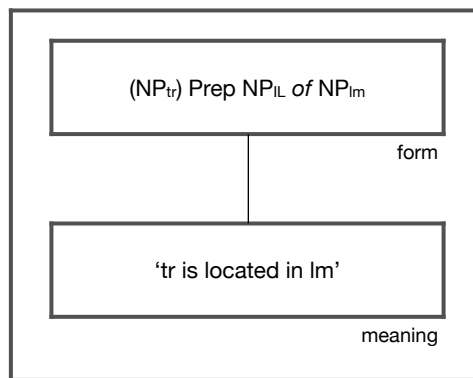


Figure 2: the IL construction

Construction grammar is a family of related approaches, with commonalities and differences. In Berkeley Construction Grammar, the definition is rather straightforward. As laid out by Kay (2013), only general and maximally productive patterns count as constructions (e.g. *let alone, what's X doing Y*). In Cognitive Construction Grammar, the approach that is adopted here, the definition has broadened since its initial formulation. Initially, a construction C is “a form-meaning pair $\langle F_i, S_i \rangle$ such that some aspect of F_i or some aspect of S_i is not strictly predictable from C's component parts or from other previously established constructions” (Goldberg 1995: 4). *De facto*, this excludes conventional patterns that are frequent enough to be granted a place in the inventory of constructions but that are not idiosyncratic. Such patterns are included in the revised definition (Goldberg 2006: 5).⁷ Although some patterns are very general and predictable, they are not necessarily fully productive in actual usage because some functional constraints apply.

Accordingly, the *Prep NP_{IL} of NP_{lm}* pattern can be viewed as a complex symbol that pairs a form with a meaning (Figure 2). The form is partly schematic. It consists of two semi-open slots (the prepositions *in* or *at*, and the NP denoting internal location, here *midst*, *middle*, *center*, and *heart*) and the fixed preposition *of*. According to Langacker (2010), prepositions are conceptually complex as a result of their intermediate status in regard to the lexicon-grammar continuum. Indeed, prepositions have in common with adjectives and adverbs that they profile a non-processual relationship. What distinguishes prepositions (simple and complex) is that they have two focal participants (a trajector and a landmark) whereas adjectives and adverbs have only one, namely a trajector (Langacker 2012: 115–116). Although they are not part of the structural core of the pattern, the trajector and the landmark appear in Figure 2 because both are aspects of the frame that are cognitively relevant to speakers when they use the construction.

The IL construction does not occur in a vacuum but is part of a higher-order constructional paradigm. The schema *Prep NP_{lm}* locates a trajector vis-à-vis a landmark and is unspecified as to the type of location. As such, it hosts a wide range of prepositional constructions (*inside/outside/near/in/etc. NP_{lm}*). Inside this general schema, the IL construction is sister to a wide variety of formally similar schemas, each inviting a distinct construal. For example, it is formally close to the marginal location construction (*Prep the edge/brim/outskirts/top/apex/bottom/foot of NP_{lm}*), which expresses another kind of location.

The IL construction is formally and functionally consistent. The initial preposition (*in/at*) specifies a region in space within which the trajector can be found by specifying the dimension of the

⁷More recently, the concept of construction has expanded to be more in keeping with how memory, learning, and categorization work: “constructions are understood to be emergent clusters of lossy memory traces that are aligned within our high- (hyper!) dimensional conceptual space on the basis of shared form, function, and contextual dimensions” (Goldberg 2019: 7).

landmark. Typically, *in* profiles the interior of the landmark, which is seen as a container. The preposition *at* describes the landmark as a point (Tyler & Evans 2003: 179). The NP that follows profiles an internal location with respect to the landmark. In (1), (2), and (4), *middle*, *center*, and *midst* could be said to refer to a part that is approximately equidistant from the foregrounded edges of the landmark, namely the stage, the ring, and the river banks, respectively. Yet, as we shall see later, the kind of internal location denoted by NPs_{IL} is not always geometric. Indeed, the conceptualization associated with the construction is more complex than it seems. This is particularly evident with *heart*. In (3), *the heart of Norwalk* specifies a region that epitomizes Norwalk but that is not necessarily in its geographical center. Finally, the preposition *of* mediates the location of the trajector vis-à-vis the landmark. Entities that serve as landmarks break down into three kinds (Langacker 2010: §36): (a) entities that are naturally characterized by spatial expanse such as enclosures, bounded areas, and geographic regions, (b) material objects that lend themselves to a locative construal, and (c) entities that are not normally construed as locations but that are construed as locative landmarks by virtue of figurative extension. This classification will prove relevant when we analyze the landmark collocates in Section 4.

3 Frequency distributions and productivity

The offline version of the 406M-word Corpus of Historical American English (Davies 2010) was used. Despite being one of the most commonly used large-scale resources in the study of the diachrony of English, several drawbacks are recognized to affect this version: inconsistent lemmas, malformed tokens, and incorrect POS tags (Alatrash et al. 2020). Another problem is the substantial variation in size between decades (from 1.2 million words in the 1810s to 29.5 million words in the 2000s). The corpus was updated in 2021 so as to address these issues. The 1810s decade was dropped and an extra decade was added (2010s). Duplicates were removed, and texts and annotations were corrected automatically. Nevertheless, the introduction of a new genre from the 1930s onwards (TV/movies) and the addition of texts to the most recent decades decreased the relative weight of the first five decades even more. Size gap remains an issue. Even though the dataset that this paper is based on was compiled prior to the 2021 update, it was not impacted significantly by the structural drawbacks of the ‘old’ corpus. The data were carefully inspected, corrected, and cleaned. Duplicates and false hits were removed manually. The issue caused by the uneven distribution of word tokens is addressed below.

Using a custom-made script for R (R Core Team 2021), all instances of the IL construction were extracted from the corpus.⁸ The script looped over each of the 116,614 COHA files searching for the following sequence: *in* or *at* + definite article + NP_{IL} (*heart*, *center*, *centre*, *midst*, or *middle*) + the preposition *of* + NP_{lm}. Landmark NPs were retrieved using a regular expression that is flexible enough to accommodate compounds, nouns preceded by adjectives, and nouns that do not immediately follow *of*. Because “prepositions are indifferent as to the nature of their trajector” (Langacker 2012: 117), trajector NPs were ignored. The occurrences were manually filtered so as to exclude cases where the NP following the initial preposition does not denote internal location and where the landmark NP is not a locating element. Such unwanted occurrences were frequent with *heart*, which commonly denotes the organ or the seat of emotions, as in (5).

- (5) With all his singularities, there was **in the heart of Uncle Tim** a depth of religious sincerity (...) (1843-*fic-MayflowerSketches*)

⁸The script is part of the folder `1.extracting` data in the companion files. To access these files, see the data availability statement.

The dataset was divided into four consecutive periods: 1810s–1860s (period 1), 1870s–1910s (period 2), 1920s–1970s (period 3), and 1980s–2000s (period 4). Admittedly, these periods do not have the same number of decades. The periodization was designed to address imbalance. Period 1 consists of six decades whose token counts are significantly smaller than the others. 1860s being the first decade to feature newspaper data, it was integrated to period 1 to minimize genre imbalance. Period 4 consists of three decades that are significantly larger (tokenwise) than the previous decades. To prevent this period from being overrepresented, it was reduced to three decades. The remaining decades were divided into relatively equal-sized periods (2 and 3).

15,635 tokens of the IL construction were retrieved. Figure 3 shows variation in token frequency per decade, normalized by the corpus size of each decade. The steepest increase in usage is observed for $MIDDLE_{cXn}$, followed by $CENTER_{cXn}$ and $HEART_{cXn}$. After an initial period of increase reaching its peak around the 1860s, the usage of $MIDST_{cXn}$ drops until the end of the 2000s period, up to the point where its token frequency is close to that of $HEART_{cXn}$.

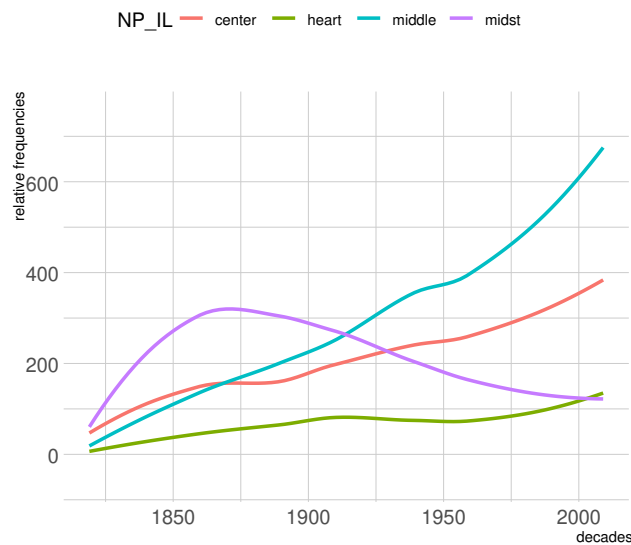


Figure 3: Relative token frequencies per decade for the four *Prep NP_{IL}* of *NP_{Im}* constructions (with locally weighted scatterplot smoothing)

One question to be addressed is whether these trends in usage can be translated into trends in productivity. One common candidate for the capture of realized productivity is type frequency (V), understood as the number of unique constructions found in the corpus. Here, this amounts to finding how many NP_{Im} types a subschema can host.

Although one might be tempted to rely on relative type frequency, this is unlikely to work because types are not distributed uniformly in a corpus and, the larger the corpus, the harder innovations are to find. One workaround adopted by Perek (2018: 9–10) is to (a) drop the texts from the 1810s and 1820s, which are poorly balanced in terms of genre and consist of only about 1.2 and 6.9 million words, and (b) compile samples for each decade of the corpus by randomly selecting texts until the largest common sample size is reached (i.e. 13.1 million words in the 1830s). This kind of subsampling assumes that the type frequency of a construction is readily comparable from one decade to another for equal sub-corpus sizes. However, given that the token frequency of the construction changes, and given that type frequency scales with token frequency in a non-proportional way, one should first estimate this scaling for each decade (Feltgen 2020).

The fact remains that indexing a productivity measure on V does not discriminate between established forms and new forms, unlike another common metric, inspired by quantitative works

in morphology (Baayen 1989; Baayen & Lieber 1991; Baayen 1993): V_1 , i.e. the number of hapax legomena of a given morphological category. V_1 captures potential productivity. It correlates with the number of neologisms in a given category, which in turn correlates with the productivity of the rule at work. In the context of our construction, with a stable part (*Prep NP_{IL} of*) and one slot to be filled (*NP_{lm}*), productivity was measured at the level of that single open slot.

Like V , V_1 scores cannot be compared directly, as types and hapax legomena become much harder to find in larger samples. They can only be compared fairly at the largest common sample size (Gaeta & Ricca 2006). To keep track of type frequency and hapax legomena developments across the COHA for the construction while avoiding the abovementioned pitfalls, V and V_1 were plotted for each subschema and each period in the form of vocabulary growth curves (VGCs) (Baayen 1992; Evert & Baroni 2007).

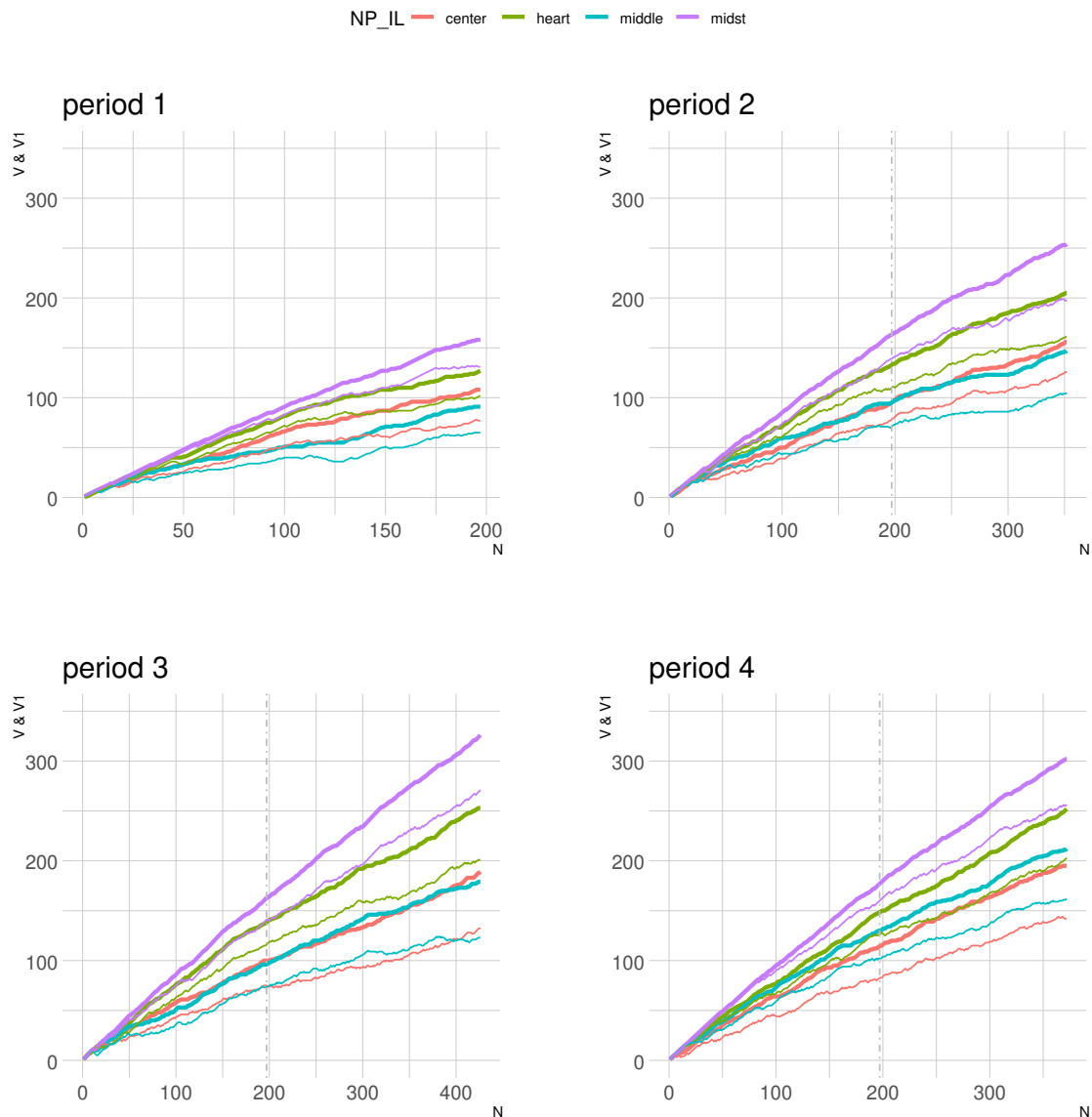


Figure 4: Vocabulary growth curves across the four periods (bold curves: V ; thin curves: V_1)

In Figure 4, VGCs compare V and V_1 for each period and each subschema at the largest common sample size ($N_{heart} = 197$ in period 1), denoted by the dashed vertical line in periods 2, 3, and 4. The x -axis charts the progress through the tokens of each subconstruction, while the y -axis

shows how many types (thick curves) and hapax legomena (thin curves) have been accumulated. The steeper the curve, the more productive the subschema. At first, each curve rises steeply as most tokens define new types and hapax legomena. As more tokens are scanned, fewer types and hapax legomena are found, and the curve flattens slightly.

Productivity is not a matter of how many times a construction is attested. Although $MIDDLE_{cxn}$ is the most frequent construction in the COHA ($N_{middle} = 5821$), followed by $MIDST_{cxn}$ ($N_{midst} = 4243$), $CENTER_{cxn}$ ($N_{center} = 4224$), and $HEART_{cxn}$ ($N_{heart} = 1347$), the two most productive subschemas are $MIDST_{cxn}$ and $HEART_{cxn}$, as evidenced by the topmost positions of their curves and the fact that these have the steepest slopes. The productivity levels of $MIDDLE_{cxn}$ and $CENTER_{cxn}$ are lower. Even though $MIDST_{cxn}$ and $HEART_{cxn}$ are the least used subschemas (token-wise), they attract the highest diversity of NP_{Im} types. Productivity is a sign that the constructional paradigm under study is dynamic and that some division of labor is very likely to take place among its members. Whether this translates into an increase in schematicity remains to be seen.

4 Collocational shifts, schematicity, and division of labor

This section details the distributional profile of $MIDDLE_{cxn}$, $CENTER_{cxn}$, $HEART_{cxn}$, and $MIDST_{cxn}$ by focusing on their landmark collocates. If we consider that a construction has lexical slots to be filled, one sign of schematicity can be found in the increasing number of types a construction hosts in its available slots, i.e. host-class expansion (Himmelman 2004). Indeed, the broader the meaning of a construction, the fewer the semantic constraints at work and, in theory, the more types the slots can host. Yet, if a construction does host more types from one period to the next, this will not count as schematization unless these types convey new, more abstract meanings. The first goal of a distributional analysis is therefore to see if and how the evolution of collocational preferences indicates a shift towards more abstract semantic domains. The second goal is to reveal if a specific division of labor has emerged among the four subschemas.

4.1 Distributional semantic models

Distributional semantic models (henceforth DSMs) are computational implementations of the distributional hypothesis: words that occur in similar contexts tend to have similar meanings (Harris 1954; Firth 1957; Miller & Charles 1991). They are used to produce semantic representations of words from co-occurrence matrices, i.e. tables of co-occurring words, with target words as rows, and their neighbors as columns. Originally, a co-occurrence matrix is populated with frequency counts (how many times the target word and its neighbors co-occur) and each row is an array of such frequencies, also known as a vector. Semantic similarities are apprehended in terms of proximities and distances between word vectors. These can be assessed visually by projecting the vectors onto a Euclidean space.

One structural aspect of DSMs that makes them particularly suited to the study of semantic shifts in a DCxG perspective is that they allow the linguist to hold a given distribution profile constant and track meaning shifts at regular intervals in a historical corpus (Sagi et al. 2011; Kulkarni et al. 2015; Hamilton et al. 2016). To justify a CxG reading of English modals, Hilpert (2016) builds a semantic vector space with the collocates of the most frequent verbs that occur with *may* in a 50-million word sample of the COCA (Davies 2008). The data are filtered and then arranged in a matrix in which the verb types are in the columns and their collocates in the rows. The co-occurrence frequencies are weighted with positive pointwise mutual information (PPMI). The matrix is converted into a cosine distance matrix, which is then transformed into a two-dimensional semantic vector

space with multidimensional scaling (MDS). Diachronic frequency information from the COHA is then projected onto the reference semantic vector space in the form of contour plots at regular intervals (1800s–1860s, 1870s–1920s, 1930s–1990s). Perek (2016, 2018) adopts a similar approach to assess the semantic shifts of the *hell*-construction and the *way*-construction.

Hilpert and Perek use count-based DSMs, i.e. models whose vectors are generated from co-occurrence counts. Such vectors are long (with as many dimensions as there are collocates) and sparse (most of their cells are zeros). This is likely to affect the quality of the vector representations, even after weighting and dimensionality reduction have been applied (Baroni et al. 2014). This paper departs from count-based models to the benefit of predictive DSMs (i.e. models generated with feedforward neural networks), in line with more recent works in DCxG (Budts & Peter Petré 2020; Fonteyn & Manjavacas 2021).

Predictive models are inspired by neural language models (Bengio et al. 2003; Collobert et al. 2011). Instead of counting how often a collocate c occurs near a target word w , predictive models estimate the probability of finding c near w . The resulting vectors are relatively low-dimensional (from 50 to 1000 dimensions, generally around 300) and dense (no cells with zeros).

The CBOW model of the `word2vec` toolkit (Mikolov, Chen, et al. 2013) predicts a word given its context. It has been shown to outperform count models on a variety of Natural Language Processing tasks such as semantic relatedness, synonymy detection, selectional preferences, and analogy (Baroni et al. 2014). Levy et al. (2015) warn that Baroni et al.'s comparison is unfair and observe that count models such as PPMI and singular value decomposition (SVD) perform equally well if fine-tuned with an ad-hoc combination of hyperparameters (context window, subsampling, deletion of rare words, negative sampling, context distribution smoothing, etc.).

Hamilton et al. (2016) show that Skip-Gram with Negative Sampling (SGNS), the alternative model of the `word2vec` toolkit (Mikolov, Yih, et al. 2013), outperforms PPMI and SVD in the discovery of new shifts and the visualization of changes. SGNS predicts a word's context given the word itself, a task that is complementary to the one addressed by CBOW.⁹ First, SGNS treats each instance of (w, c) , i.e. a target word w and a neighboring context word c , as a positive example. Second, it obtains negative samples by randomly sampling other words in the vocabulary, thus corrupting (w, c) . Third, it uses logistic regression to train a classifier on a binary prediction task ("is c likely to occur near w ?"), which amounts to deciding which of the positive example and the negative example is more likely. Finally, the weights learned during the classification task are kept and used as the word vectors.

It could be argued that `word2vec` suffers from the 'one vector per word' issue (Desagulier 2019) because it produces type-based distributional representations, i.e. an aggregation of all the contexts encountered by a single word form. In the case of homonymy, this is clearly a problem because the resulting vector conflates contexts that may have nothing to do with each other: e.g. *bat* as the stick used in baseball vs. the winged mammal. In the case of polysemy, some linguists might be wary of the quality of the resulting vectors and turn to token-based distributional representations instead. In theory, token-based DSMs such as BERT (Devlin et al. 2019) are optimal: they do provide as many representations as there are contexts, reflect semantic complexity, and detect functional-semantic change in grammatical constructions (Fonteyn 2021). In practice, however, some problems emerge. Because the base BERT model has been pre-trained on the BooksCorpus (800M words) and English Wikipedia (2,500M words), its vector representations are biased towards present-day English (Fonteyn 2020). Post-training BERT to increase its performance on

⁹One feature of SGNS that is of particular interest to usage-based linguists is that each word W_i is represented by two short, dense vectors: a word vector w_i and a context vector c_i . The final vector of a given word can either be the word vector ($W_i = w_i$) or the sum of the two ($W_i = w_i + c_i$). I chose the latter approach.

older forms of English is possible, but only some portions of the COHA can be used for this task. It is because fine-tuning BERT on the whole corpus comes at a huge computing cost.

Another aspect that makes `word2vec` a method still worth considering, despite undeniable progress in the field of token-based DSMs, is that it is not considered a 'black box'. It is possible to keep track of what the algorithm does at any stage.¹⁰ Conversely, most BERT distributions offer access to only the last two final hidden layers. When access is granted, there is still discussion as to what layer is relevant to the semanticist (Mun 2021).¹¹ Finally, one may consider that the aggregated approach to meaning representation offered by type-based DSMs captures the core meaning of any given word type (Erk & Padó 2010: 92). All things considered, and given the trade-off between computational cost and the semantic generalization requirement, `word2vec` was considered a reasonable alternative in the context of this paper given that due attention was paid to the hyperparameter setup. The consistency of the vector space in Figure 5 below suggests that a predictive type-based model such as `word2vec` has not said its last word.

I used a version of SGNS that is part of Levy et al.'s `hyperwords` script collection for Python.¹² This version allows the user to fine-tune hyperparameters, a possibility that is not readily available in the original `word2vec` distributions. To train SGNS on the whole COHA (1810s–2000s), the hyperparameters were set as follows:

- the original context distribution is smoothed by raising all context counts to the power of 0.75;¹³
- context window = ± 5 ;¹⁴
- negative samples = 15;¹⁵
- each vector has 300 dimensions;
- all words whose frequency is less than 5 in the COHA are discarded.

4.2 The reference semantic vector space

Based on the dataset described in Section 3, the most distinctive landmark collocates of the four subschemas across the whole COHA were selected with an association measure, namely log-likelihood ratio (LLR) (Dunning 1993). Only the landmark NPs whose LLR score was greater than 10 were kept. The word vectors of these distinctive collocates were retrieved and mapped onto a semantic vector space, as shown in Figure 5.

The rightmost part of the plot features nouns that denote spatial locations or material objects that are amenable to a locative construal. Towards the top center, in the transition zone between

¹⁰One anonymous reviewer rightly points out that not all neural network models are black boxes by default. In her diachronic analysis of the interplay between English modal auxiliaries and periphrastic *do*, Budts (2020) manages to keep track of what convolutional neural networks do throughout the model's build-up.

¹¹HuggingFace has a page dedicated to 'BERTology', i.e. papers that attempt to explain the inner workings of the BERT architecture: <https://huggingface.co/transformers/bertology.html>. Most users seem happy with BERT's performance without interrogating much how these are obtained.

¹²<https://github.com/williamleif/histwords/tree/master/sgns/hyperwords>.

¹³This increases the probability of rare noise words slightly and improves the quality of the vector representations.

¹⁴Levy & Goldberg (2014) show that window size influences the vector representations significantly. Shorter context windows (e.g. ± 2) tend to produce vector representations that foreground syntactic similarities, i.e. words that belong to the same parts of speech. Longer context windows ($\geq \pm 5$), on the other hand, tend to produce vector representations that foreground topical relations.

¹⁵SGNS uses more negative examples than positive examples and therefore produces better representations when negative samples are greater than one. By setting negative samples to 15, we have 15 negative examples in the negative training set for each positive example.

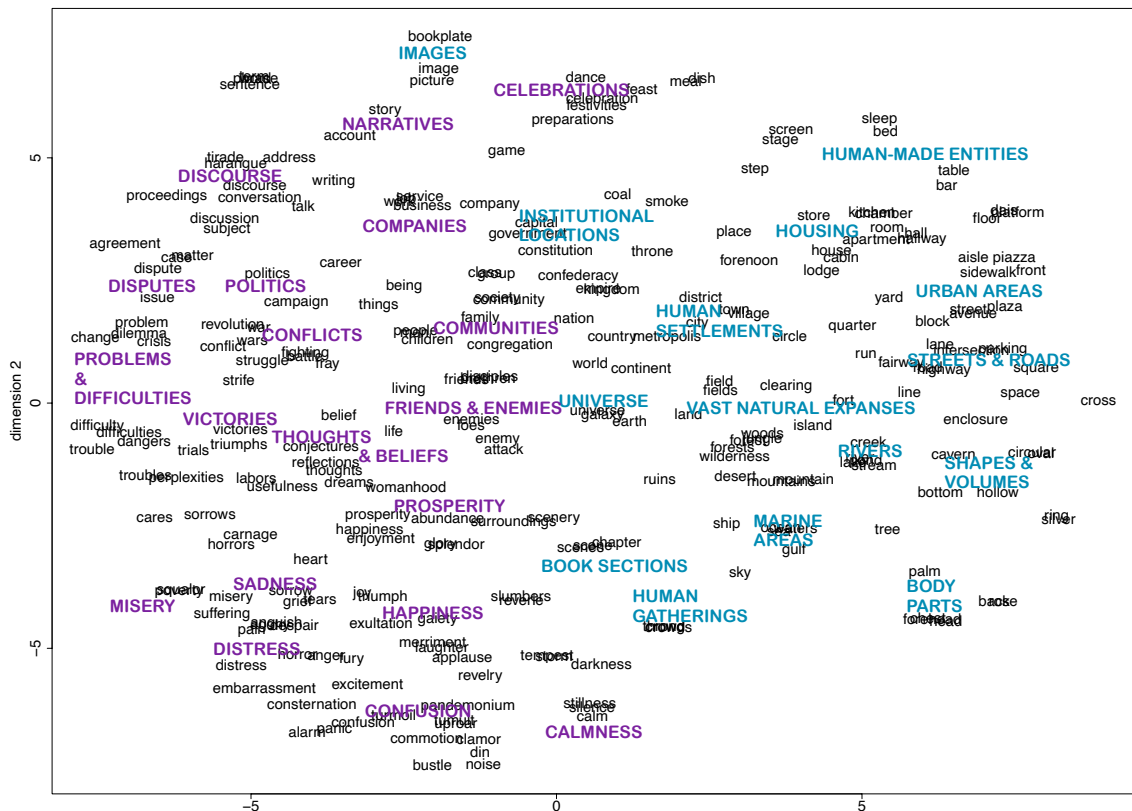


Figure 5: The annotated reference semantic vector space (in blue: concrete locations; in magenta: abstract/figurative locations)

spatial locations and abstract location, we find institutional and symbolic locations (*capital, government, kingdom*). Close to this group are collective nouns (*society, congregation*) and nouns denoting structured, homogeneous human communities, such as *enemies*. The left part of the plot features nouns that are not concrete locations *per se*, but construed as locative landmarks through figurative extension. These nouns denote either states (lower left part of the plot) or events (upper left part). Because the collocation scores of the words that appear in Figure 5 are calculated with respect to the whole period covered by the corpus, the resulting vector space is considered a reference point over which contours can be plotted for each subschema and each period. Given the configuration of the vector space, any translation from the right to the left is considered an increase in schematicity.

4.3 Contour lines

Contour lines connect data points of the same value. Their purpose is to indicate how densely semantic areas have been populated across the four consecutive periods. Contours are generally plotted over two-dimensional topographical maps to show elevation. Here, they represent densities of association between constructions and their most distinctive landmark collocates.¹⁶ The curves are indexed on log-transformed co-occurrence frequencies. The stronger the association

¹⁶Only the landmarks whose LLR scores indicate a significant attraction were kept (coll. strength > 1.3, $p < 0.05$).

between a group of words and a construction, the higher the density in the corresponding area, as indicated by an increased concentration of concentric contours.¹⁷

For reasons of legibility, the subschemas are examined in pairwise fashion: $MIDST_{cxn}$ and $HEART_{cxn}$ on the one hand, and $MIDDLE_{cxn}$ and $CENTER_{cxn}$ on the other. The pairs were determined by comparing the collocational preferences of the four subschemas in a Euclidean distance matrix. The collocational preferences were measured with periodized LLR scores. The matrix was transformed with multidimensional scaling so as to reduce the number of dimensions to two. K -means clustering was used to group the subschemas by pairs ($k = 2$). The above is visualized in Figure A.1. Two subschemas are close if the distributions of their landmark collocates overlap. A constant in the four plots is the proximity between $MIDDLE_{cxn}$ and $CENTER_{cxn}$. The proximity between $MIDST_{cxn}$ and $HEART_{cxn}$ is less obvious (they even belong to two distinct groups in period 3) but, as we will see below, their distributions become more similar over time.

4.4 Collocational preferences of $MIDST_{cxn}$ and $HEART_{cxn}$

Figure 6 displays the evolution of the collocational preferences of $MIDST_{cxn}$ and $HEART_{cxn}$ (for details, see Tables C.1 and C.2). We know from the previous section that these are the most productive subschemas. They are also the most schematic.

In period 1, the frequency peaks of $MIDST_{cxn}$ are concentrated towards the left part of the vector space, where nouns denoting figurative location (especially states) cluster. Only two kinds of spatial location are found to serve as landmarks with $MIDST_{cxn}$: wooded and marine areas. In period 2, the frequency peaks merge, and new collocate types are gained in the left part of the space. In parallel, $MIDST_{cxn}$ makes inroads into the right part of the space. This corresponds to the period when the expansion of the construction is at its maximum. In period 3, $MIDST_{cxn}$ recedes back towards abstract locations. This is the period when the construction has the fewest distinctive collocate types. In period 4, $MIDST_{cxn}$ spreads to similar areas as in period 2, but with fewer distinctive collocate types. Most of its peaks are located in the left part of the vector space. The right side of the graph is not completely deserted as the subschema co-occurs with NPs denoting marine and urban areas. Whether the host-class expansion witnessed between periods 1 and 2 translates into increased schematicity is dubious because of the direction of the shift, namely from abstract to concrete locations. Searching the EEBO corpus (Davies 2017) reveals that $MIDST_{cxn}$ co-occurs with NPs_{lm} denoting abstract locations well before the first period covered by the COHA, a sign that it has already reached a high degree of schematization by the time period 1 begins.¹⁸

The most striking trend concerns $HEART_{cxn}$, which expands towards NPs that denote more schematic locations between period 1 and period 4. In period 1, the frequency peaks of $HEART_{cxn}$ are found around geographic and geopolitical entities. In period 2, the peaks merge and include more similar collocates, as evidenced by wider contour lines. $HEART_{cxn}$ is also found sporadically in the left part of the plot, suggesting the start of a translation towards more abstract locations (e.g. *business, matter*). In period 3, $HEART_{cxn}$ remains grounded in concrete locations around the same 'epicenters'. It also sanctions new landmark types as it strengthens its position in the left part of the space. In particular, the density increases around conflicts and issues. In period 4,

¹⁷The contours were made with two-dimensional kernel density estimation. I used the `kde2d` function from the MASS package for R to estimate kernel density and generate a continuous approximation of the sample density for each group of log-likelihood scores. The base R `contour` function was used to plot the contours.

¹⁸Table B.1 shows that among the top 20 collocates of $MIDST_{cxn}$ in EEBO, two denote abstract locations: *troubles* and *torments*. Their frequencies increase from the early 17th century.

HEART_{CXN} reinforces its expansion around the peaks observed in the previous period. The largest peak density is now observed around issues (*matter, case, issue, concerns*).

As HEART_{CXN} undergoes increased schematization, its contour lines rarely impinge upon those of MIDST_{CXN}. The distribution can be considered complementary, although this division of labor allows for occasional overlap in terms of collocational preferences. The productivity levels of MIDST_{CXN} and HEART_{CXN} observed in Section 3 can be explained by the fact that, over time, these two subschemas co-occur with more semantically diverse landmark types than MIDDLE_{CXN} and CENTER_{CXN}. All in all, MIDST_{CXN} schematizes before period 1 and HEART_{CXN} undergoes schematization from period 2 onwards.

4.5 Collocational preferences of CENTER_{CXN} and MIDDLE_{CXN}

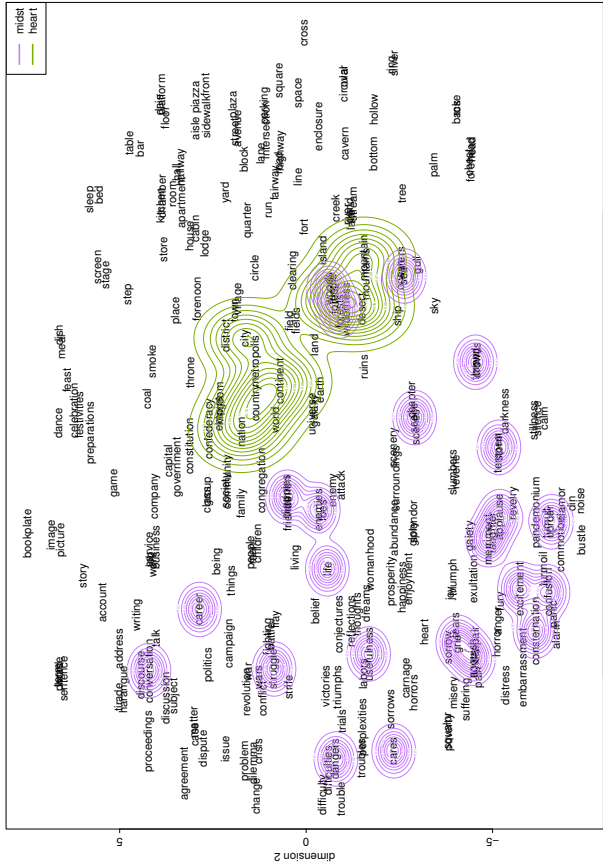
Figure 7 focuses on MIDDLE_{CXN} and CENTER_{CXN} (for details, see Tables C.3 and C.4). The occupation in the four panels is rather similar despite relative differences in terms of density in specific areas. The collocational profiles of MIDDLE_{CXN} and CENTER_{CXN} are characterized by relative temporal stability as both are firmly grounded in the right part of the vector space (i.e. concrete locations) from period 1 to period 4. Most of the lower left part, which is specific to MIDST_{CXN}, is left unoccupied. This indicates that the schematicity of these two subschemas is limited. The only incursions into abstract locations are found in the upper left part of the plot. Regarding CENTER_{CXN}, they are limited to a few landmarks whose LLR scores are not among the highest, e.g. *group* (periods 1–4), *company*, and *things* (period 4). MIDDLE_{CXN} attracts abstract landmarks from period 3 onwards: *conversation, sentence, phrase, war, work*. These landmarks tend to invite a temporal reading. For example, *Have I come in the middle of a conversation?* implies that the conversation began before the interruption. Although MIDDLE_{CXN} co-occurs punctually with abstract landmarks, its schematization is limited. Indeed, such uses are merely figurative projections of what goes on with concrete landmarks (such as *river* or *creek*), namely the interruption of an ongoing flow.

Compared to MIDST_{CXN} and HEART_{CXN}, the division of labor observed in Figure 7 is of another kind. The overlap between MIDDLE_{CXN} and CENTER_{CXN} implies that the distribution of their respective landmarks is mostly parallel. Assuming that a difference in form always spells a difference in meaning (Goldberg 1995: 67), we should expect each subschema to profile distinct aspects of the same landmarks. This remains to be confirmed in the next two sections.

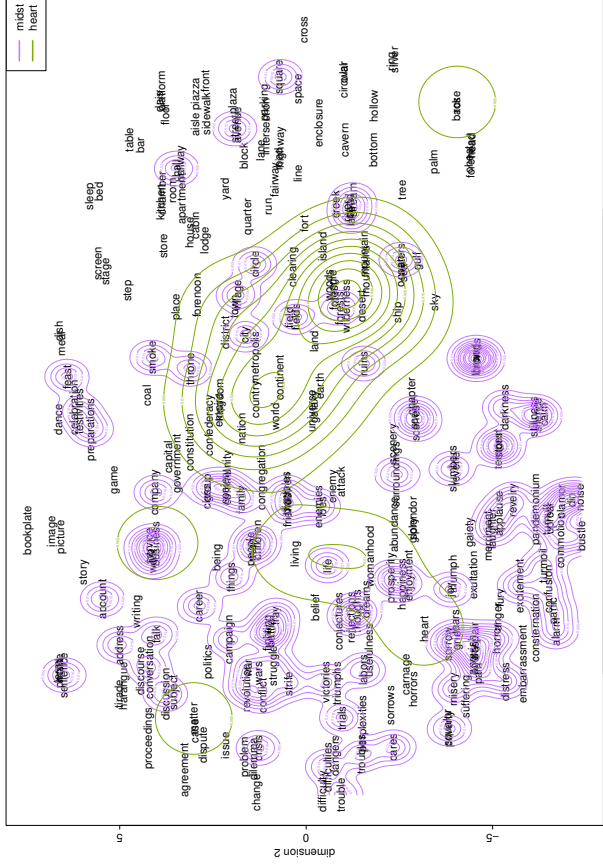
5 Functional shifts

Borillo (1998) analyzes French prepositions denoting internal location from the exclusive perspective of topological criteria. Gréa (2017) argues against this view on the grounds that this would imply that the NPs_{IL} are synonyms and therefore interchangeable.

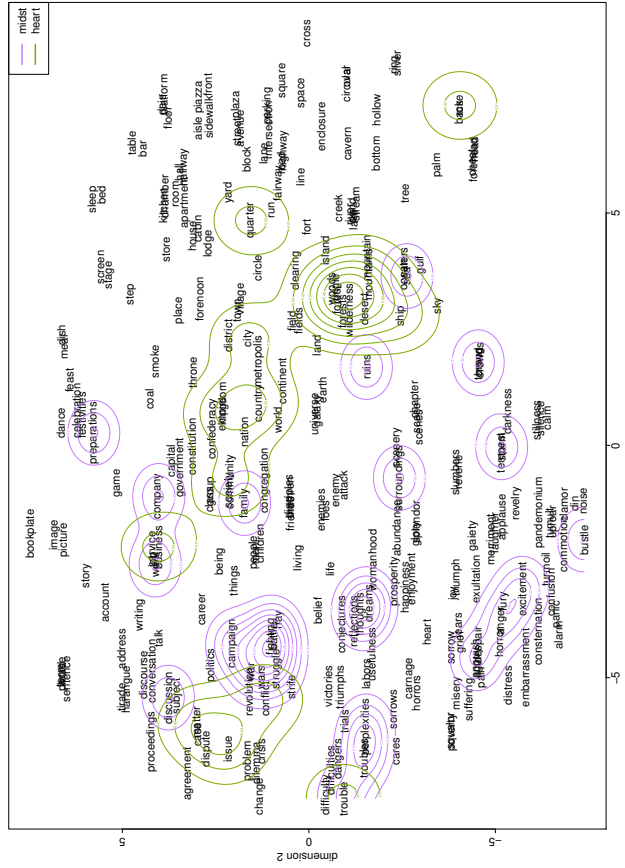
Indeed, from an exclusively spatio-physical perspective, all four subschemas match the configurations displayed in Figure 8a or Figure 8b, depending on whether the landmark is two- or three-dimensional. Gréa (2017: 101) describes this configuration in terms of a “coincidence” between the trajector and the landmark, which “translates into a superposition relation, in which the trajector is functionally separated from the landmark although located within it.” The only minor differences concern the relative position of the trajector in relation to the landmark. *Middle* profiles a point that is equally distant from the extremes of a bounded line or path. *Center* profiles a point around which a bounded entity, such as a circle, a sphere, a square, or a cube is drawn. Although they profile the central part of the landmark, *midst* and *heart* are not as specific as to the position of the trajector.



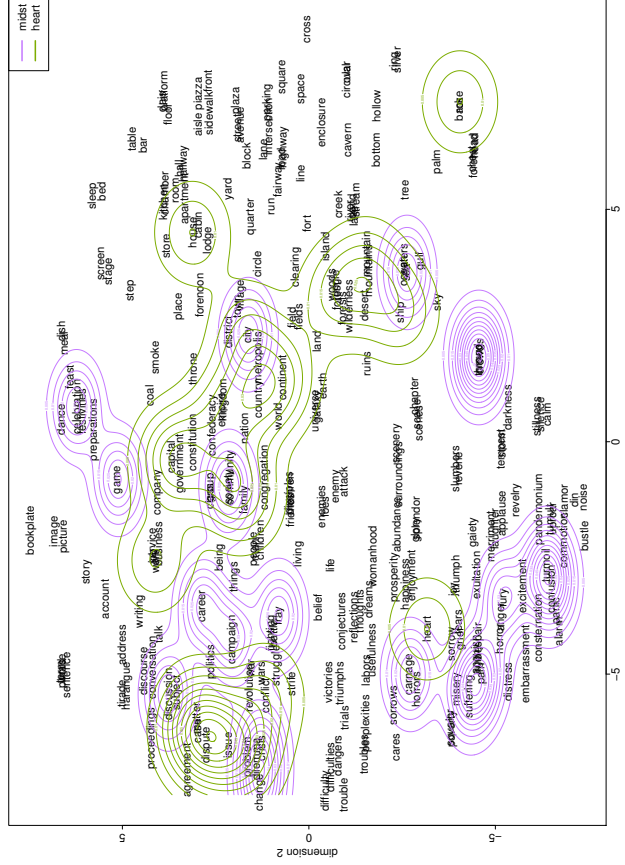
(a) Period 1



(b) Period 2

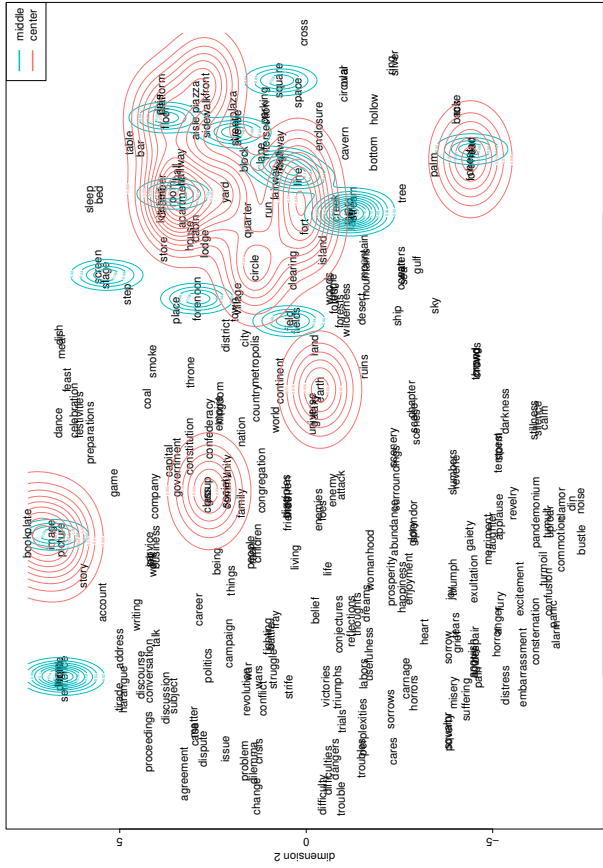


(c) Period 3

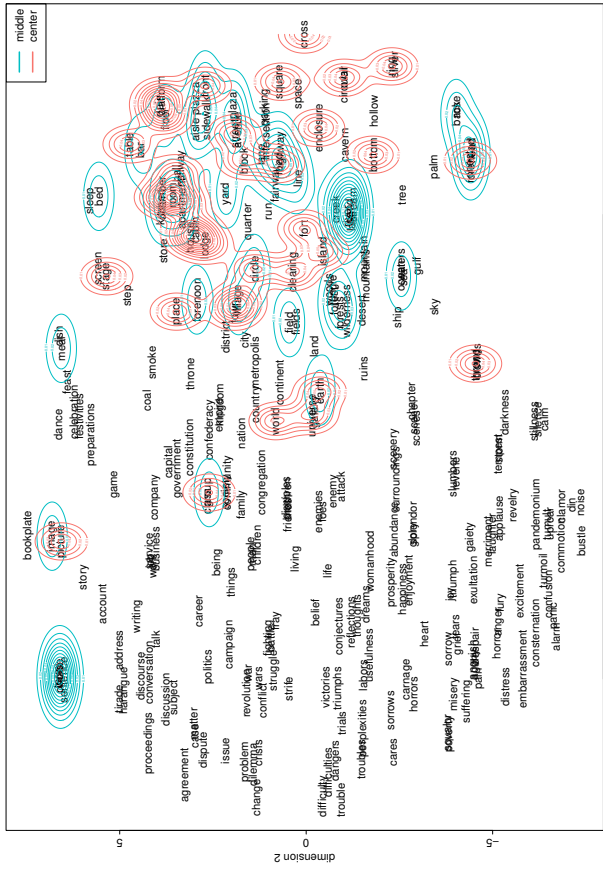


(d) Period 4

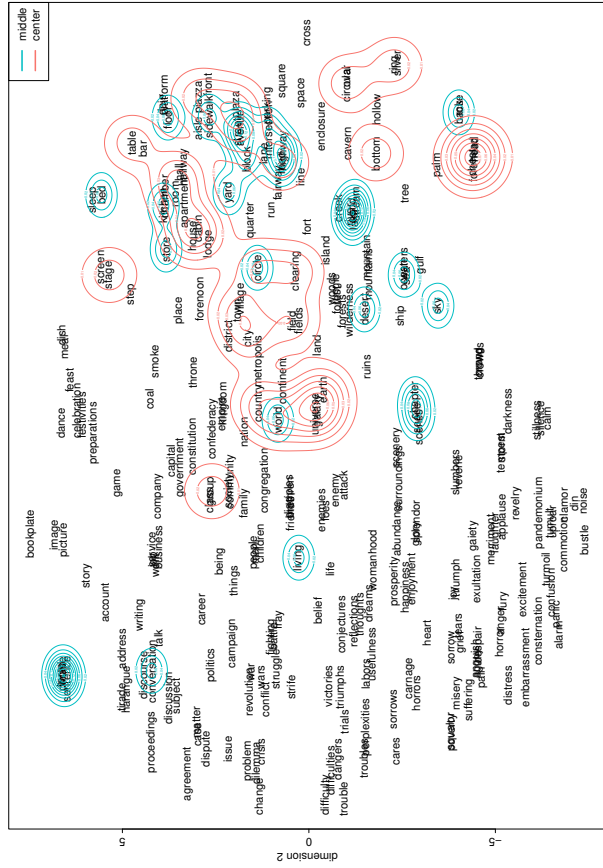
Figure 6: Distributional semantic plots of MIDST_{cxn} and HEART_{cxn}



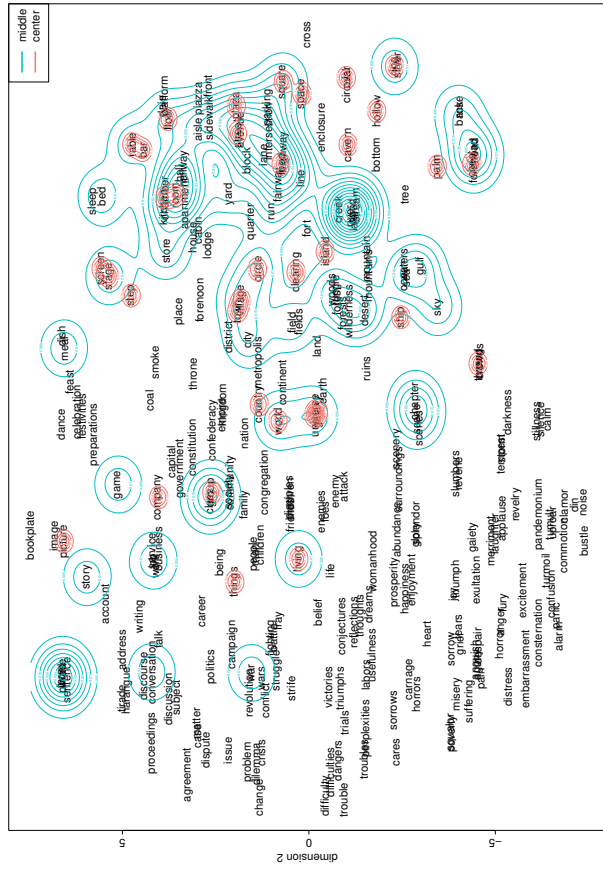
(a) Period 1



(b) Period 2



(c) Period 3



(d) Period 4

Figure 7: Distributional semantic plots of MIDDLE_{CXN} and CENTER_{CXN}

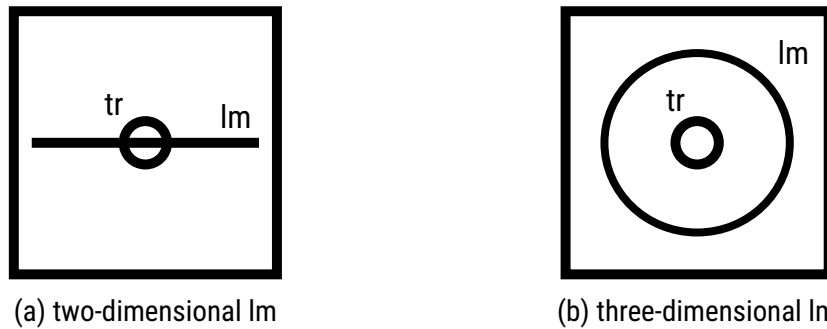


Figure 8: Schematic representation of a relation of coincidence between a trajector and a landmark

Gréa (2017) finds that each French preposition imposes its own construal based on landmark-specific features. This section summarizes the construals associated with their English counterparts. It shows that even if a subschema has not entered the path of schematicity, it contributes a meaning of its own that is distinct from the compositional, spatial readings depicted in Figure 8.

5.1 MIDST_{cxn} and HEART_{cxn}

MIDST_{cxn} invites a coincidence reading when the NP_{lm} is construed as locative, as in (6).

- (6) Howe was in all places, and **in the midst of every thing** [...]. (1824-FIC)

However, such an exclusively spatial construal is rare in the dataset and limited to the earlier periods. Consider (7)–(9), which focus on the NP_{lm} *forest*. Technically speaking, a forest is a bounded tract of land covered with trees. In most cases, MIDST_{cxn} foregrounds its spatial extension. The boundaries of the landmark are perceived as out of reach by the conceptualizer. This is marked explicitly by the adjectives *boundless* and *thickest* in (7) and (8), and implicit in (9).

- (7) [...] indeed, be supposed that a youth, reared **in the midst of boundless forests** [...] (1832-NF/ACAD)
 (8) They were **in the midst of the thickest forest**, [...] (1914-FIC)
 (9) He came upon [the clearing] **in the midst of a forest** [...] (2000-FIC)

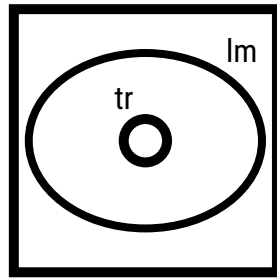
Among the landmark NPs that denote concrete locations, MIDST_{cxn} selects those whose vastness can be easily foregrounded, i.e. natural, urban, and social environments: *river, lake, sea, ocean, desert, room, street, city, crowd(s)*, etc. In context, the trajector contrasts with the vastness of the NP_{lm}. It appears isolated, estranged, overwhelmed, or threatened.

The above exemplifies what I call the estranged construal, whose structure is inherited from the three-dimensional coincidence reading (Figure 9a). The ellipse denotes the fact that the boundaries of the landmark are backgrounded, because out of reach of the trajector.

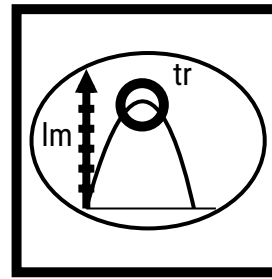
When the landmark collocates denote a figurative location, the estranged construal may still apply. In (10), the thoughts are conceptualized as a metaphorical expanse of confusion in which the experiencer is lost.

- (10) [...] I might get a whispered distress call from a young lady whom fate, in the person of the professor, had surprised **in the midst of other thoughts** [...]. (1917-MAG)

Intensive nouns denote entities that are associated with “intensive quantities” (van de Velde 1995: 129). These can increase or decrease and are not primarily related to space or time. This



(a) The estranged construal



(b) The intensive construal

Figure 9: Schematic representation of the estranged (left) and intensive (right) construals

construal is commonly conveyed by $MIDST_{cxn}$ in American English. The intensive construal applies when an intrinsic feature of an NP_{Im} is characterized by a magnitude and when the trajector profiles the apex of the scale. In Figure 9b, the landmark is denoted as a vertical axis in bold, which stands for a scale of magnitude and the circle at the apex of the curve denotes the trajector. In (11), the NP_{Im} *glory* is construed as a gradual process whose maximum level of praise or renown is reached when the fall happens.

- (11) Then I had fallen **in the midst of glory**, Nor ever liv'd to see this foul disgrace. (1821-FIC)

Most, if not all, of the NPs in the left part of the vector space have intrinsic features that can be intensified. They are therefore compatible with an intensive construal. The left part of the vector space in Figure 6 subdivides into nouns denoting states (lower left) and nouns denoting events (upper and upper left). Among the event nouns, we observe an increased preference for landmarks that refer to festivities (*preparations, dance, feast, meal*, etc.). Regarding these nouns, one might hesitate between a temporal reading and an intensive reading. One does not necessarily exclude the other. In (12a), the ceremony is underway and in full swing as the bombs fall from the sky. In (12b), the same contrast is at work between the festivities, whose intensity we assume is high, and the character's sadness.

- (12) a. [...] the North Vietnamese had gathered to celebrate. **In the midst of their celebration** a downpour of incendiaries and five-hundred-pounders had fallen out of the clouds. (2000-FIC)
 b. **In the midst of the festivities** Louise was discovered in tears (1898-FIC).

As far as states are concerned, the list of distinctive NP_{Im} types that enter $MIDST_{cxn}$ shortens between period 1 and period 4 and specializes in negative feelings and emotions. Given the etymology of *heart*, which designates the muscular organ and, by extension, the seat of feelings and emotions, we would have expected $HEART_{cxn}$ to perform this role.¹⁹ After period 2, the distinctive landmarks of $MIDST_{cxn}$ refer mostly to afflictions (*horrors, misery, suffering, despair*) and unrest (*fury, turmoil, confusion*). In (13), the NP_{Im} *his anguish* denotes a state that affects the trajector. $MIDST_{cxn}$ sanctions an intensive construal by profiling the apex of the psychological curve.

- (13) **In the midst of his anguish** he still found the presence of mind to say 'Sir'. (1973-FIC-Trevayne)

¹⁹*heart, n., int., and adv.* 2021. In *OED Online*. Oxford University Press. <https://www-oed-com.faraway.parisnante.fr/viewdictionaryentry/Entry/85068> (9 March, 2021).

Some instances are indeterminate between an estranged construal and an intensive construal. In (14), the landmark can be construed as both a hostile environment surrounding the trajector and a moment when the violence reaches its peak.

- (14) In this spot my mother, who would not quit his side even **in the midst of battle**, was most basely massacred. (1832-FIC)

In this respect, MIDST_{CXN} is very close to HEART_{CXN} which, at first glance, invites both readings. However, the data indicate that only the intensive construal is specific to HEART_{CXN}. Admittedly, in (15a), the boundaries of the landmark are perceived as maximally distant, which induces psychological pressure onto the trajector. However, this pressure is most likely conveyed by the context. In contrast, the remoteness of the landmark is presented as desirable in (15b).

- (15) a. There is no describing the melancholy aspect of such a settlement [...] **in the heart of an immense forest**, through which you have travelled for miles, [...]. (1845-FIC)
b. [...] it is her dream to live **in the heart of the country**... somewhere utterly remote [...]. (2001-FIC)

Each time, the construction profiles and intensifies the inner quality of the landmark: the vastness of the forest (a forest is, by definition, vast, as opposed to a grove or a wood), and the tranquility of the countryside.

By way of confirmation, let us focus on landmarks denoting geopolitical entities and urban environments, which are among the most distinctive collocates of HEART_{CXN} as early as period 1 (e.g. *city, country, nation*). Such NPs often imply human activities, whose intensity can vary along a scale. In (16a), the landmark *city* does not convey any intensity by itself. The role of the construction here is to invite an intensive reading by locating the trajector where the landmark is the busiest. This reading becomes manifest when we compare HEART_{CXN} to CENTER_{CXN}, as in (16b). This time, it is the geographical center that is profiled, as opposed to its outskirts.

- (16) a. [...] on that narrow avenue **in the heart of the city** is handled the enormous traffic between the twin cities [...]. (1892-MAG)
b. [...] we cross the Gran Avenida, and continue along the wide, acacia-lined Calle de Alma to the Puerta del Sol (Gate of the Sun), **in the center of the city**. (1931-MAG)

The intensive reading applies regardless of whether the NP_{Im} is bounded or not. When the landmark does not inherently involve a quality, HEART_{CXN} foregrounds derivable qualities via coercion. In (3), the trajector is found in the part of the landmark that is the most representative of Norwalk's cultural identity.

By the end of period 4, the highest collocate density for HEART_{CXN} is observed with NPs_{IL} denoting dispute. In this context, the construction is headed by the preposition *at* and occurs in a copulative pattern, as exemplified in (17).

- (17) a. **At the heart of the dispute** is the groundbreaking experiment at Walter Reed. (1970-MAG)
b. Two weeks of fighting in Lebanon have not resolved the issues **at the heart of the conflict**. (1973-NEWS)
c. **At the heart of the case** were complex accounting issues. (2002-NEWS)
d. **At the heart of the matter** is a question of legality. (2002-MAG)

HEART_{CXN} profiles the trajector as a specific participant of the event, namely the cause of the dispute. Although indirect, the connection with the intensive reading is maintained as the importance of the participant in the process is rated as very high.

5.2 CENTER_{CXN} and MIDDLE_{CXN}

We commonly understand a center as the point around which a shape is drawn.²⁰ The center is considered as equidistant from the edges of the shape. According to Gréa (2017: 104), *au centre de* 'in/at the center of' expresses more than mere geometric centrality: it conveys a relation of functional dependence between the trajector and the landmark. In American English, this relation is prevalent too with CENTER_{CXN}. As with HEART_{CXN}, the choice of the head preposition (*in* vs. *at*) plays a part in the construal of CENTER_{CXN}. With *at*, the trajector is the center, as in (18a). With *in*, as in (18b), the trajector coincides with the center of the landmark.

- (18) a. In ancient times it was thought that the earth was **at the center of the universe**. (1959-NF/ACAD)
 b. Humanism puts man **in the center of the universe**. (1950-NF/ACAD)

Regardless of what head preposition is chosen, the landmark is functionally dependent upon its trajector: in (18), the universe cannot work without its centers, namely the earth and man. In Figure (10a), functional dependence is denoted by the double bar linking the trajector and the landmark.²¹

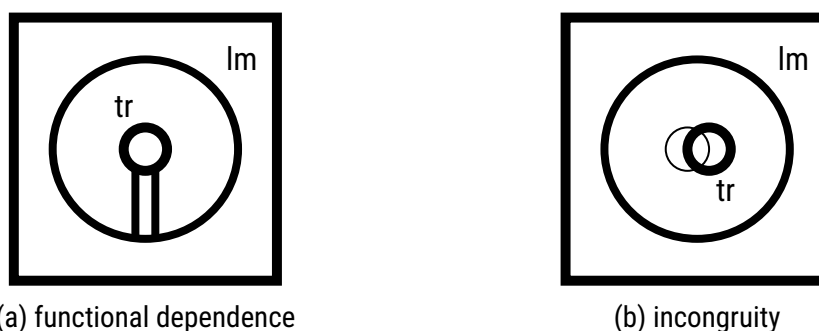


Figure 10: Schematic representation of a relation of functional dependence between a trajector and a landmark (left) and incongruous location (right)

Conceptually, MIDDLE_{CXN} is close to CENTER_{CXN} as it profiles a point that is equally distant from the extremes of a bounded line or path.²² In practice, this restrictive geometric reading is rare and limited to scientific writing, as in (19).

- (19) The prorenal canals lie **in the middle of the line of the head** [...]. (1897-ACAD)

The lack of functional dependence with MIDDLE_{CXN} has two consequences. First, the trajector and the landmark are merely juxtaposed, which results in a relation of coincidence, as illustrated in Figure 8. Second, the location of the trajector is imprecise, unexpected, or incongruous. Compare (20a) and (20b):

- (20) a. All eyes within were focused on a couple waltzing **in the center of the floor** to low music. (1922-FIC)
 b. "Don't leave it there **in the middle of the floor**," she said sharply. (1872-FIC)

²⁰*center, n.* 2021. In *OED Online*. Oxford University Press. <https://www-oed-com.faraway.parisnanterre.fr/viewdictionaryentry/Entry/29696> (9 March, 2021).

²¹After Gréa (2017: 105).

²²*middle, n.* 2021. In *OED Online*. Oxford University Press. <https://www-oed-com.faraway.parisnanterre.fr/viewdictionaryentry/Entry/118140> (9 March, 2021).

In (20a), the waltzing couple are given focal prominence where they are meant to be, namely a dancing floor. In contrast, MIDDLE_{CXN} does not impose such dependence in (20b). The trajector is not supposed to coincide with the landmark, and the coincidence between the two is incongruous. In Figure 10b, the regular circle denotes the trajector in its planned location, and the circle in bold denotes the trajector in its incongruous location.

Across all four periods, density peaks are consistently observed around NPs denoting natural water bodies and streams (*creek, river(s), lake, sea, ocean, waters*), urban passageways (*lane, intersection*), and rooms. Each time, the construction activates the coincidence construal and the context specifies its nature: simple juxtaposition, imprecise location, or incongruity, as in (21a), (21b), and (21c) respectively.

- (21) a. Some day a ferry-boat will take fire **in the middle of the river** when crowded with passengers. (1883-NEWS)
 b. I was further **in the middle of the river**, but he was still able to swim towards me [...]. (2018-FIC)
 c. He prohibited the Roman pedestrian's custom of reading newspapers **in the middle of the street**. (1949-MAG)

In the data, incongruous readings are common when the NP_{Im} refers to a road or a street. If a car is parked in the middle of the street, it is because it is parked improperly. If it is parked in the center of the street, it is because there is space to park (i.e. the parking space and the street are functionally dependent).

As early as period 1, MIDDLE_{CXN} also co-occurs distinctively with discourse units (*chapter, scene(s), discourse, conversation, sentence, and tirade*). When it does, it is almost exclusively in the context of an interruption, after verbs such as *break, cut off, or stop*, as in (22). *Center* is unattested with all these landmarks, except *scene* which, in this case, refers to an actual theater stage.

- (22) a. Hamish stopped **in the middle of his sentence**, and went to him and looked down. (1955-FIC)
 b. And **in the middle of all this tirade** Babs stops him with an imperious gesture [...]. (1920-FIC)

These landmarks do not have precise centers relative to which trajectors can be located. MIDDLE_{CXN} emphasizes that the trajector is where it should not be.

The combined expression of coincidence and imprecise location makes MIDDLE_{CXN} compatible with the expression of vague temporal location. In (23a), MIDDLE_{CXN} profiles a part of the landmark that is about halfway through the century. The *center* equivalent is possible, although unattested, but it would refer to a specific year exactly halfway through the century (1350). This level of precision is rarely needed outside of contexts involving scientific locations or measurements.

- (23) a. He wrote **in the middle of the fourteenth century** (1344-8) [...]. (1972-ACAD)
 b. ?He wrote **in the center of the fourteenth century**.

MIDDLE_{CXN} and CENTER_{CXN} operate mostly at the level of concrete locations, and the division of labor between them hinges on whether there is functional dependence between the trajector and the landmark. When there is, CENTER_{CXN} is preferred. Otherwise, MIDDLE_{CXN} is used.

Both *middle* and *midst* derive from Old English *midd* ‘middle’.²³ Accordingly, MIDDLE_{CXN} and MIDST_{CXN} invite very similar construals with landmarks denoting concrete locations, namely the expression of incongruous location:

- (24) Phil is alone out **in the middle of the field**. (1990-FIC)
(25) Her mother stopped **in the midst of a field** and nodded. (1992-FIC)

Because MIDST_{CXN} has become rare in these contexts, incongruous location is now specific to MIDDLE_{CXN}.

Although MIDST_{CXN}, HEART_{CXN}, CENTER_{CXN}, and MIDDLE_{CXN} have a spatial conceptual basis, all have evolved to the point when they cannot be reduced to a geometric reading. Each subschema frames the relationship between the trajector and the landmark in ways that are hardly ever fully compositional.

6 Sketching the IL construction network

The IL construction forms a multi-level network (Pijpops et al. 2021) in which several levels of generalizations are expected to coexist (Goldberg 2009). These generalizations are deployed in two dimensions: vertical and horizontal. The paragraphs below review how the empirical findings help characterize each dimension of the IL construction network.

6.1 The vertical dimension

Figure 11 depicts the IL construction at various levels along the vertical dimension of the network. Vertical links unite the lower-level instantiations to the higher-level schemas in a bottom-up fashion. As we go up the network, the level of lexical abstraction increases. On the basis of the distinctive associations between NPs_{IL} and landmarks, the micro level abstracts over constructs, which are of course too numerous to be represented here.²⁴ Although the figure represents only one item per subschema, the micro level is of course characterized by many types. Judging from the tables in Appendix C, some of these abstractions are recurrent and more entrenched than others, e.g. *in the midst of the confusion*, *in the heart of the city*, *in the middle of the road*, and *in the center of the room*. The next level up (subschematic level 2) abstracts over landmark NPs and distinguishes between preposition heads if applicable (*in* vs. *at*). The first subschematic level further abstracts over the landmark collocates and the preposition heads but keeps the distinction between NPs_{IL} active. Finally, the IL construction abstracts over the NPs_{IL}.

The chain of abstractions along the vertical axis and the resulting entrenchments at the nodal levels were operationalized by means of frequencies. In Section 3, type frequencies and hapax legomena allowed us to assess the combinatorial richness of MIDDLE_{CXN}, CENTER_{CXN}, HEART_{CXN}, and MIDST_{CXN} across four consecutive periods in the COHA. In Section 4, collocational affinities between the subschemas and their distinctive landmark NPs were compared across the same periods as a way of tracking semantic shifts.

The above paragraphs suggest that the constructicon is elaborated in a bottom-up fashion as a series of cumulative abstractions from the most concrete (constructs) to the most abstract level

²³In Old English, *in the middle of* consists of the preposition *on* ‘in’ followed by *midd* in the dative case, i.e. *middan*. In Late Modern English, the dative marking was replaced with the <s> genitive *myddist/mydiste/myddest* (*midst*, *n.*, *prep.*, and *adv* 2021). The [t] ending is epenthetic. I wish to thank Wilfrid Rotgé for pointing this out to me.

²⁴Because they are not mentally stored as such and therefore not part of the network proper, the constructs do not appear in boxes.

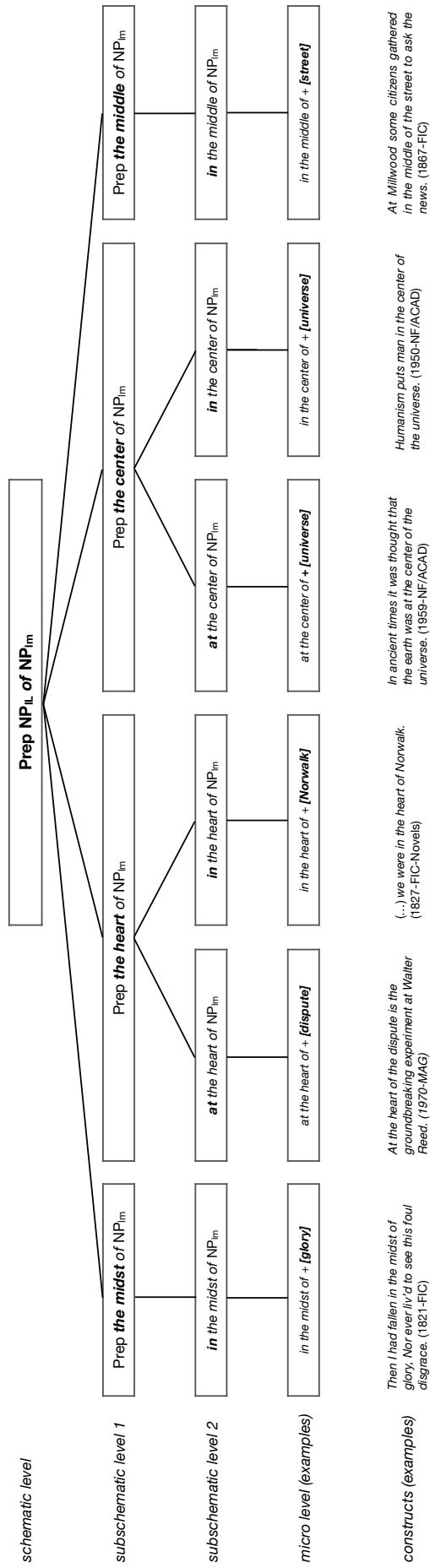


Figure 11: The IL construction network (only the formal component is represented)

(the construction). In other words, the vertical links have some upward orientation. Conversely, because a construction serves as a cognitive template for language production and comprehension, we should also consider that vertical links operate in a downwards fashion. In the context of the IL construction, the data suggest that the extension of $MIDST_{cXn}$ and $HEART_{cXn}$ beyond concrete locations became entrenched over time via the regular and consistent pairings of their formal strata with contexts featuring landmarks that were not locative *sensu stricto*. Once this functional extension was sufficiently entrenched, the new meanings (e.g. the estranged and the intensive readings) became available to speakers to express new relations between trajectors and landmarks. More precisely, they were activated from the subschematic template down to the constructs. Thus, we have good reasons to think that vertical links are bidirectional.

6.2 The horizontal dimension

On top of vertical links, horizontal connections are equally relevant to fully describe the internal dynamics of a construction network (Diessel 2019). Because we set out to characterize the divisions of labor that operate among the four subschemas, we focused on those that unite the nodes at the most immediate subschematic level in the IL construction. After building a semantic vector space with the most distinctive landmark collocates of each pattern, curves indexed on association scores were plotted for each of the four consecutive periods. The examination of how such collocation preferences shifted over time served the double purpose of spotting cases of ongoing schematization and identifying divisions of labor, two kinds of which were found: parallel (between $MIDDLE_{cXn}$ and $CENTER_{cXn}$), and complementary (between $MIDST_{cXn}$ and $HEART_{cXn}$). It was found that the first kind involved more collocational overlap than the second kind.

Recent discussions in DCxG invite us to assess these horizontal relations in terms of competition. De Smet et al. (2018) identify two competition models: “simple” and “extended”. The first model is a legacy of functional linguistics (e.g. Bolinger 1977). It allows no functional overlap (no synonymy) and form-function mappings ideally converge towards one-to-one relations (isomorphism). Consequently, when two functionally equivalent expressions compete, one is bound to replace the other. De Smet et al. consider this model inadequate because it ignores that functional overlap is common (Van de Velde 2014), it does not explain why and how functional overlap arises, and it fails to predict two expected consequences of the isomorphic ideal at the diachronic level, namely substitution and differentiation (Petré 2014). The second model is more elaborate: the division of labour between two competing expressions is shaped by language-internal motivations, e.g. how pragmatic constraints influence syntactic realizations (MacWhinney 2014; Rohdenburg 1996). When two functionally similar expressions compete, one is better suited than the other in some contexts, and the other is better suited in other contexts. The “extended competition” model explains existing divisions of labor but falls short of predicting emerging ones, especially cases of differentiation.

De Smet et al. (2018) propose a revised model based on attraction and differentiation. Analogical attraction is the process by which, when functionally similar constructions come to overlap, they tend to become more similar over time, by virtue of their anchoring in a broader constructional network. Differentiation can be seen as the situation when divisions of labor reorganize over time. Whereas “attraction is a normal response to situations of functional overlap” (De Smet et al. 2018: 204), differentiation is considered exceptional: “[differentiation] arises as a more or less accidental by-product of the relations in a bigger constructional network.” (De Smet et al. 2018: 223). Based on a diachronic study of the dative and benefactive alternations, Traugott (2020) argues otherwise: differentiation systematically arises from attraction.

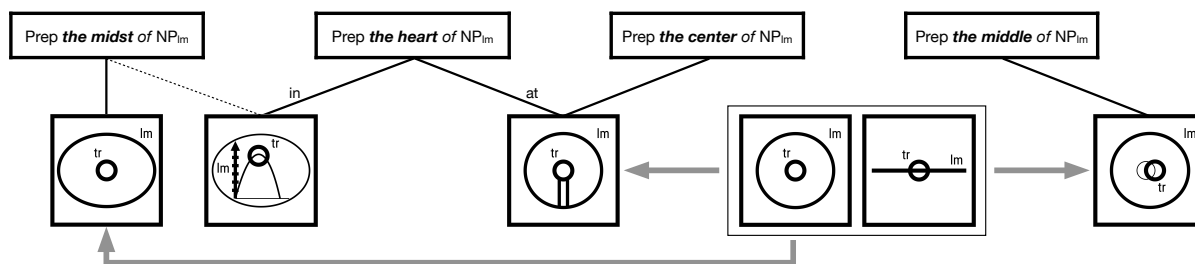


Figure 12: Form-function mappings in the IL construction network

Unlike the above works, the present paper has not investigated the evolution of syntactic changes, focusing instead on collocational preferences as a proxy to detect functional shifts (Section 4). Despite this methodological difference, the trends that emerge in Figures 6 and 7 echo some aspects of the model based on the attraction-differentiation dyad. From period 2 onwards, $HEART_{cXn}$ and $MIDST_{cXn}$ come to display increasing functional overlap: both are compatible with the intensive construal, which is sometimes hard to distinguish from the estranged construal. The leftwise shift of $HEART_{cXn}$ is a sign that it is attracted to $MIDST_{cXn}$, whose role as an attractor is facilitated by its high degree of entrenchment by the end of period 1. A reorganization of the constructional network is at play in periods 3 and 4, when the two subschemas seem to divide up the task of locating trajectors in abstract locations. In other words, once the analogical logic has taken hold, differentiation takes place. In this case, to paraphrase Traugott (2020), attraction and differentiation are indeed intertwined. As noted earlier, $MIDST_{cXn}$ makes inroads into the right part of the space in period 2, where $MIDDLE_{cXn}$ and $CENTER_{cXn}$ are firmly grounded. Because this incursion is only temporary, and because it happens when $MIDST_{cXn}$ starts losing ground to $MIDDLE_{cXn}$ and $CENTER_{cXn}$ (Figure 3), it is likely that the constructional network ultimately optimizes the expression of concrete internal location to the benefit of the latter two.

Despite local differences, $MIDDLE_{cXn}$ and $CENTER_{cXn}$ coexist in the right part of the semantic vector space across all periods. This functional stability suggests that the constructional network sanctions both subschemas at the same level when it comes to expressing concrete internal location. Judging from the contour lines in Figure 7, one might think that the subschemas are synonyms. Admittedly, both operate in the same broad functional domain. Yet, as seen in Section 5, they do not fully alternate: $CENTER_{cXn}$ is better suited to the expression of a relation of functional dependence between the trajector and the landmark, whereas $MIDDLE_{cXn}$ is more adapted to the expression of incongruous location. Once more, attraction and differentiation are like “two sides of the same coin” (Traugott 2020: 574).

Figure 12 focuses on the first subschematic level of Figure 11 and includes the functional poles identified in Section 5. Bold lines denote form-meaning pairings that have become central by the end of period 4. The dashed line denotes a pairing that has become secondary or obsolete. Grey arrows denote an etymological connection with the coincidence construal. Given the extent of meaning change, this reading is not distinctive of any construction anymore. Subschemas can be connected horizontally by virtue of (a) a functional pole that they share, or (b) a functional domain in common. $HEART_{cXn}$ is connected horizontally to $MIDST_{cXn}$ by virtue of a pairing in common with the intensive construal. $HEART_{cXn}$ and $CENTER_{cXn}$ are also connected due to their common pairing with the functional-dependency reading. $CENTER_{cXn}$ and $MIDDLE_{cXn}$ are connected horizontally via the domain in which they both operate: concrete locations.

Regardless of which model applies, competition is arguably not the most explanatory concept to capture the internal dynamics at work in the IL construction network. None of them appear to have lost ground over the period under consideration. Rather than have $MIDDLE_{cXn}$, $CENTER_{cXn}$,

HEART_{CxN}, and MIDST_{CxN} compete, the IL construction network has optimized their distribution so that all the relevant aspects of its semantic space are covered.

7 Conclusion

A DCxG approach avoids the aporias of preposition-centered debates on the constituent status of complex prepositions by focusing on usage. Collocational affinities between the prepositional patterns and their preferred landmarks show that, although analyzable in terms of general syntactic mechanisms, the four schemas subsumed by *Prep NP_{IL} of NP_{Im}* display regularities with respect to frequency of use, productivity, schematicity, and meaning.

Each subschema has evolved beyond the expression of spatial coincidence to frame the relation of internal location between the trajector and the landmark in its own way. With bounded landmarks, MIDST_{CxN} tends to construe the boundaries as out of reach, which results in a situation of estrangement for the trajector. With unbounded landmarks, MIDST_{CxN} intensifies properties that are often detrimental to the trajector. Diachronically, the subschema displays an increasing preference for the latter configuration. HEART_{CxN} has the most versatile distribution as its distinctive landmark collocates span the whole vector space. Most of the time, it imposes an intensive construal. Finally, CENTER_{CxN} and MIDDLE_{CxN} divide up the task of locating the trajector with respect to spatial landmarks. The former imposes a relation of functional dependence whereas the latter implies that the position of the trajector is incongruous *vis-à-vis* the landmark.

The network offers two ways of optimizing the expression of internal location by means of four subschematic constructions. One involves the complementary occupation of a given part of the functional space, with little overlap. The other implies a peaceful coexistence in the opposite part of the same space. Unlike optimization, competition is probably not the most likely relation between these nodes at the subschematic level. In fact, competition may not be the default relation between subschematic nodes, regardless of the construction network.

Acknowledgments

This paper has benefited from extensive and constructive comments by two anonymous reviewers. I am grateful for their input.

Data availability statement

All primary data and code used in this study are available via the Open Science Framework, and can be retrieved from <https://osf.io/x32jn/>

Appendix

Appendix A

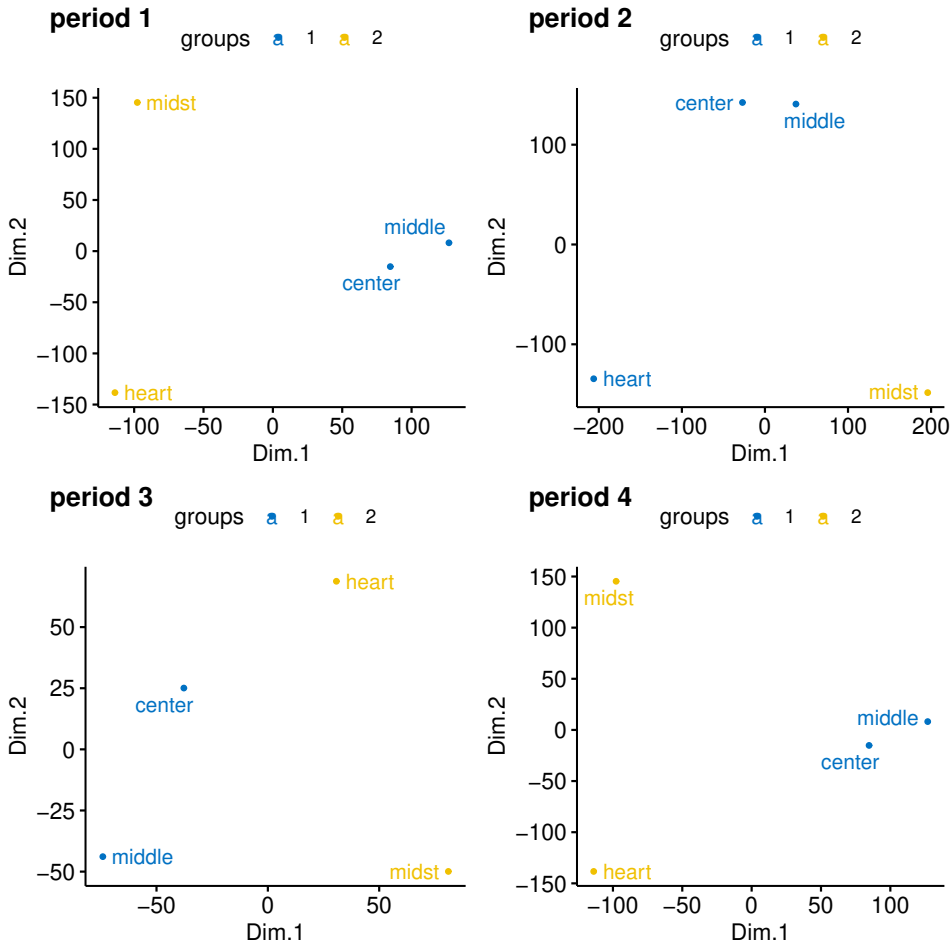


Figure A.1: MDS visualization of proximities and distances between MIDST_{CXN}, HEART_{CXN}, MIDDLE_{CXN}, and CENTER_{CXN}

Appendix B

Table B.1: Top 20 landmark collocates of MIDST_{CXN} in the EEBO corpus

NP _{lm}	1560s	1570s	1580s	1590s	1600s	1610s	1620s	1630s	1640s	1650s	1660s	1670s	1680s	1690s
<i>enemies</i>	1	1	1	2	12	12	11	34	34	64	28	41	57	23
<i>sea</i>	1	1	4	9	19	7	16	23	16	57	19	19	36	23
<i>church</i>	0	1	2	3	13	5	12	67	18	28	35	18	15	9
<i>people</i>	0	0	4	2	15	2	5	20	14	31	33	35	37	21
<i>winter</i>	0	1	1	1	9	12	8	22	9	42	29	22	24	32
<i>garden</i>	0	1	2	3	4	6	9	4	17	43	17	12	22	27
<i>flames</i>	0	0	0	1	1	5	3	4	15	22	35	32	20	21
<i>city</i>	0	0	0	2	4	6	1	2	9	24	19	31	37	14
<i>paradise</i>	0	1	1	1	3	5	5	7	11	25	22	15	30	21
<i>troubles</i>	1	2	5	1	0	7	8	10	12	20	15	11	20	18
<i>fire</i>	0	2	2	7	2	4	11	5	11	19	18	16	13	12
<i>throne</i>	0	0	0	0	2	9	2	1	8	29	14	9	30	17
<i>house</i>	1	1	1	3	4	9	10	10	11	26	13	12	11	5
<i>torments</i>	0	0	1	7	1	2	9	6	6	8	19	18	13	18
<i>heaven</i>	0	0	0	1	1	2	1	1	25	24	10	15	17	9
<i>land</i>	1	0	0	4	3	2	8	5	15	21	10	7	16	5
<i>wolves</i>	0	0	0	0	0	0	1	4	7	13	9	17	20	25
<i>earth</i>	0	0	0	2	2	6	7	7	12	25	5	3	15	11
<i>summer</i>	0	0	0	0	2	5	4	8	2	23	13	14	9	13
<i>afflictions</i>	0	3	2	1	5	2	3	4	11	27	10	4	7	11
<i>dangers</i>	0	0	1	0	2	4	4	4	11	17	6	9	16	16

Appendix C

Table C.1: Top distinctive landmarks of MIDST_{CXN} per period

PERIOD 1			PERIOD 2		
NP _{lm}	raw freq.	coll. strength	NP _{lm}	raw freq.	coll. strength
<i>crowd</i>	8	7.31	<i>confusion</i>	18	28.97
<i>grief</i>	4	6.15	<i>street</i>	2	20.2
<i>confusion</i>	3	4.61	<i>excitement</i>	9	17.9
<i>excitement</i>	3	4.61	<i>tumult</i>	8	15.91
<i>sea</i>	3	4.61	<i>crowd</i>	16	15.54
<i>storm</i>	3	4.61	<i>city</i>	6	15.52
<i>struggle</i>	3	4.61	<i>reflections</i>	7	13.92
<i>woods</i>	3	4.61	<i>talk</i>	7	13.92
<i>anguish</i>	2	3.07	<i>conflict</i>	6	11.92
<i>applause</i>	2	3.07	<i>laughter</i>	6	11.92
<i>brethren</i>	2	3.07	<i>performance</i>	6	11.92
<i>career</i>	2	3.07	<i>work</i>	12	11.63
<i>cares</i>	2	3.07	<i>square</i>	2	10.65
<i>consternation</i>	2	3.07	<i>struggle</i>	8	10.55
<i>conversation</i>	2	3.07	<i>campaign</i>	5	9.93

PERIOD 3			PERIOD 4		
NP _{lm}	raw freq.	coll. strength	NP _{lm}	raw freq.	coll. strength
<i>work</i>	9	22.87	<i>crisis</i>	6	21.69
<i>argument</i>	4	12.81	<i>carnage</i>	4	18.12
<i>campaign</i>	3	9.6	<i>confusion</i>	4	18.12
<i>excitement</i>	3	9.6	<i>fury</i>	3	13.59
<i>preparations</i>	3	9.6	<i>turmoil</i>	3	13.59
<i>uncertainties</i>	3	9.6	<i>campaign</i>	4	13.34
<i>struggle</i>	4	8.25	<i>recession</i>	5	12.73
<i>anger</i>	2	6.39	<i>change</i>	3	9.31
<i>anguish</i>	2	6.39	<i>society</i>	4	9.22
<i>bustle</i>	2	6.39	<i>bowels</i>	2	9.05
<i>company</i>	2	6.39	<i>crowds</i>	2	9.05
<i>currents</i>	2	6.39	<i>developments</i>	2	9.05
<i>debate</i>	2	6.39	<i>hills</i>	2	9.05
<i>delays</i>	2	6.39	<i>pain</i>	2	9.05
<i>dreams</i>	2	6.39	<i>period</i>	2	9.05

Table C.2: Top distinctive landmarks of HEART_{CXN} per period

PERIOD 1			PERIOD 2		
NP _{lm}	raw freq.	coll. strength	NP _{lm}	raw freq.	coll. strength
<i>continent</i>	3	15.39	<i>city</i>	29	77.56
<i>forest</i>	2	10.22	<i>mountains</i>	8	32.07
<i>mountain</i>	2	10.22	<i>business</i>	8	25.84
<i>nation</i>	2	10.22	<i>country</i>	8	23.64
<i>desert</i>	3	8.97	<i>kingdom</i>	4	19.03
<i>country</i>	3	7.54	<i>mountain</i>	5	15.81
<i>city</i>	3	5.59	<i>nation</i>	5	15.81
			<i>wilderness</i>	8	14.4
			<i>woods</i>	5	13.79
			<i>earth</i>	8	11.99
			<i>jungle</i>	4	11.78
			<i>continent</i>	4	10.05
			<i>matter</i>	3	9.96
			<i>town</i>	9	9.8
			<i>cordilleras</i>	2	9.5

PERIOD 3			PERIOD 4		
NP _{lm}	raw freq.	coll. strength	NP _{lm}	raw freq.	coll. strength
<i>city</i>	12	21.33	<i>city</i>	30	58.99
<i>forest</i>	5	14.92	<i>country</i>	13	25.93
<i>conflict</i>	3	13.69	<i>capital</i>	6	19.23
<i>issue</i>	3	13.69	<i>rose</i>	4	18.52
<i>quarter</i>	3	13.69	<i>matter</i>	5	17.97
<i>rose</i>	3	13.69	<i>case</i>	5	15.2
<i>wilderness</i>	4	13.49	<i>empire</i>	3	13.89
<i>business</i>	3	9.41	<i>issue</i>	3	13.89
<i>community</i>	3	9.41	<i>region</i>	3	13.89
<i>empire</i>	2	9.12	<i>government</i>	4	13.73
<i>ground</i>	2	9.12	<i>heart</i>	5	9.25
<i>matter</i>	2	9.12	<i>anxiety</i>	2	9.25
<i>mountains</i>	2	9.12	<i>approach</i>	2	9.25
<i>plant</i>	2	9.12	<i>concerns</i>	2	9.25
<i>jungle</i>	2	5.51	<i>mission</i>	2	9.25

Table C.3: Top distinctive landmarks of MIDDLE_{CXN} per period

PERIOD 1			PERIOD 2		
NP _{lm}	raw freq.	coll. strength	NP _{lm}	raw freq.	coll. strength
<i>road</i>	12	25.89	<i>road</i>	55	110.21
<i>room</i>	25	24.24	<i>floor</i>	67	101.91
<i>river</i>	6	16.02	<i>street</i>	31	50.91
<i>sentence</i>	6	16.02	<i>room</i>	129	44.1
<i>street</i>	7	13.29	<i>sentence</i>	24	42.33
<i>image</i>	4	10.64	<i>river</i>	10	18.51
<i>lake</i>	4	10.64	<i>word</i>	6	14.7
<i>floor</i>	9	8.87	<i>kitchen</i>	10	12.55
<i>forenoon</i>	2	5.3	<i>forenoon</i>	5	12.24
<i>head</i>	2	5.3	<i>lane</i>	5	12.24
<i>parlor</i>	2	5.3	<i>sidewalk</i>	5	12.24
<i>word</i>	2	5.3	<i>bar</i>	4	9.79
<i>stream</i>	4	4.22	<i>phrase</i>	4	9.79
<i>channel</i>	2	2.1	<i>back</i>	7	9
<i>field</i>	2	2.1	<i>lake</i>	9	8.79

PERIOD 3			PERIOD 4		
NP _{lm}	raw freq.	coll. strength	NP _{lm}	raw freq.	coll. strength
<i>floor</i>	46	24.65	<i>street</i>	80	97.11
<i>road</i>	25	21.43	<i>road</i>	79	77.96
<i>street</i>	20	17.09	<i>city</i>	9	33.78
<i>desert</i>	12	14.58	<i>floor</i>	46	26.28
<i>lake</i>	8	13.66	<i>desert</i>	21	24.07
<i>sentence</i>	15	12.77	<i>ocean</i>	15	22.05
<i>conversation</i>	7	11.95	<i>living</i>	26	17.39
<i>sidewalk</i>	6	10.23	<i>highway</i>	10	14.68
<i>word</i>	6	10.23	<i>village</i>	2	13.57
<i>world</i>	2	8.76	<i>hallway</i>	9	13.21
<i>bridge</i>	5	8.52	<i>river</i>	9	13.21
<i>river</i>	10	8.48	<i>conversation</i>	20	13
<i>ocean</i>	4	6.82	<i>sidewalk</i>	12	11.88
<i>song</i>	4	6.82	<i>intersection</i>	8	11.74
<i>block</i>	8	5.86	<i>parking</i>	8	11.74

Table C.4: Top distinctive landmarks of CENTER_{CXn} per period

PERIOD 1			PERIOD 2		
NP _{lm}	raw freq.	coll. strength	NP _{lm}	raw freq.	coll. strength
<i>apartment</i>	4	13.5	<i>room</i>	141	110.81
<i>bookplate</i>	3	10.1	<i>table</i>	30	35.63
<i>picture</i>	3	10.1	<i>circle</i>	16	19.7
<i>room</i>	15	8.29	<i>stage</i>	15	19.31
<i>earth</i>	2	6.72	<i>enclosure</i>	6	17.17
<i>foreground</i>	2	6.72	<i>village</i>	13	16.83
<i>fort</i>	2	6.72	<i>square</i>	15	16.16
<i>front</i>	2	6.72	<i>road</i>	3	15.78
<i>mass</i>	2	6.72	<i>lodge</i>	7	14.55
<i>pit</i>	2	6.72	<i>clearing</i>	7	11.59
<i>yard</i>	2	6.72	<i>earth</i>	12	9.51
<i>group</i>	4	5.15	<i>hall</i>	11	8.89
<i>forehead</i>	3	4.19	<i>bottom</i>	3	8.57
<i>line</i>	3	3.01	<i>cage</i>	3	8.57
<i>floor</i>	5	2.28	<i>ground</i>	3	8.57

PERIOD 3			PERIOD 4		
NP _{lm}	raw freq.	coll. strength	NP _{lm}	raw freq.	coll. strength
<i>room</i>	74	55.66	<i>room</i>	129	74
<i>stage</i>	11	11.49	<i>street</i>	2	43.42
<i>head</i>	4	10.88	<i>road</i>	6	27.64
<i>house</i>	4	10.88	<i>table</i>	38	23.79
<i>world</i>	11	10.09	<i>universe</i>	14	23.59
<i>cabin</i>	3	8.16	<i>circle</i>	14	15.83
<i>compartment</i>	3	8.16	<i>ring</i>	11	14.44
<i>earth</i>	3	8.16	<i>picture</i>	7	11.77
<i>lobby</i>	3	8.16	<i>chest</i>	19	11.26
<i>semicircle</i>	3	8.16	<i>group</i>	11	10.5
<i>campus</i>	4	6.47	<i>square</i>	11	10.5
<i>city</i>	13	6.34	<i>light</i>	4	9.76
<i>circle</i>	7	5.72	<i>step</i>	4	9.76
<i>bottom</i>	2	5.43	<i>galaxy</i>	6	9.61
<i>cave</i>	2	5.43	<i>palm</i>	6	9.61

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