What You Don’t See is What You Get: Lexical Factorization of Verbs of Seeing

Master’s Thesis

Presented to

The Faculty of the Graduate School of Arts and Sciences
Brandeis University
Department of Computer Science
James Pustejovsky, Advisor

In Partial Fulfillment of the Requirements for the Degree

Master of Arts in Computational Linguistics

by
Todd Curcuru

August 2015
ABSTRACT

What You Don’t See is What You Get:
Lexical Factorization of Verbs of Seeing

A thesis presented to the Graduate Program in Computational Linguistics

Graduate School of Arts and Sciences
Brandeis University
Waltham, Massachusetts

By Todd Curcuru

In 1972 Aravind Joshi created an unpublished manuscript titled “Factorization of Verbs: An Analysis of Verbs of Seeing” that examined decomposing the semantic meaning of around 60 verbs of seeing into distinct factors that represented basic units of meaning. These factors could then be composed together to build up a frame that represented the meaning of a verb. In 2015 James Pustejovsky and Joshi published a paper “Lexical Factorization and Syntactic Behavior” that examined Joshi’s factorization framework in light of more recent distributional semantics, using Pointwise Mutual Information (PMI) to establish and explore the notion of Factor Expression Likelihood (FEL) – how likely a specific factor in a verb’s frame is to be expressed syntactically in a sentence. This work uses a corpus tool, Sketch Engine, and a large web corpus of English, enTenTen 2012, to examine Joshi’s factorizations from a distributional standpoint. I seek to find if and how individual factors are expressed syntactically through the
use of modifiers, and which patterns emerge that can be linked to the insertion or removal of certain factors. I then modify Joshi’s original factorizations in light of the data. This is done to motivate the creation of a metric for the FEL beyond just PMI – and since I have confirmed that specific factors do link to certain modifiers, it stands to reason that if one knows a verb’s factorization, one should be able to calculate how likely a modifier is to occur with that verb. This should also be extendable to calculate the likelihood of any syntactic realization of any factors of a verb’s factorization.
# Table of Contents

1. Introduction ........................................................................................................................................................................... 1

2. Methodology ........................................................................................................................................................................... 8

3. An Analysis of Verbs of Seeing by Factors .......................................................................................................................... 10

   3.1 See ..................................................................................................................................................................................... 10
   3.2 Look .................................................................................................................................................................................. 15
   3.3 Glance ................................................................................................................................................................................ 17
   3.4 Notice ............................................................................................................................................................................... 19
   3.5 Examine ........................................................................................................................................................................... 20
   3.6 Look for ............................................................................................................................................................................ 22
   3.7 Appear ............................................................................................................................................................................. 23
   3.8 Disappear ....................................................................................................................................................................... 25
   3.9 Expose ............................................................................................................................................................................... 29
   3.10 Hide ............................................................................................................................................................................... 31
   3.11 Blind ............................................................................................................................................................................... 32

4. Conclusions and Future Work .............................................................................................................................................. 36

References .................................................................................................................................................................................. 38
1. Introduction

In their 2015 paper “Lexical Factorization and Syntactic Behavior,” James Pustejovsky and Aravind Joshi examine lexical factorization for verbs related to seeing, extending work done by Joshi in an unpublished 1972 manuscript “Factorization of Verbs: An Analysis of Verbs of Seeing.” This work is concerned with establishing a verb class for verbs of seeing, and classifying verb lexemes into frames, composed of generalized factors that in some way accurately represent their meaning. They then explored how computational methods could use this factor based framework to elucidate and predict the selectional nature of predicates, as well as issues related to verb polysemy.

Joshi’s original contained around 60 verbs of seeing. Joshi restricted himself to only including verbs that relate to visual perception in the following ways – 1. The subject of a verb sees something or the object becomes visible to the subject; 2. The subject directs their sight, usually in order to see something; 3. The subject becomes visible; 4. Any of these types of predicates are “modulated” but other predicates, referred to as factors, such as causation, negation, temporality (duration and rate), etc.¹

With this definition Joshi examined the following verbs: appear, behold, blind, blur, conceal, cover, darken, descry, disclose, dazzle, display, disappear, discern, emerge, espy, examine, expose, exhibit, eye, fade, fade-in, fade-out, flash, flaunt, faze, glance, glare, glimpse,

¹(p. 22 Joshi 1972, p.4 Pustejovsky and Joshi 2015)
hide, inspect, look, mask, notice, obscure, observe, overlook, peek, peep, peer, reappear, regard, resemble, reveal, scan, scrutinize, secrete, screen, see, search, seek, show, sight, spot, stare, surface, survey, uncover, unmask, vanish, view, watch, witness.

And used the follow verbs as examples of not seeing verbs: point at, wave, signal, meet, be at, go to, detect, find, visualize, brighten, sparkle, glitter, glisten, shimmer, gleam, shine, flow, light, twinkle, illuminate, frown, wink, scowl, blink, glower. These tend to be verbs where an action occurs that could be perceived visually, or even an action where the subject specifically tries to gain the visual attention of some other object (e.g. point at, wave, signal), but these verbs do not specifically deal with the visual perception of some subject. The distinction is sometimes unclear, but we will use these examples as a basis for examining new words that should possibly be included in the set.

Many verbs included in the hierarchy have multiple senses, but only senses that relate to visual perception are included in the class. To give an example of a composed frame, take the simplest sense of see, whose meaning can be interpreted as “x perceives a thing by sight.”

(1) \( \text{See}_0(x,y) = \text{BY-MEANS} (\text{PERCEIVE}(X, \text{THING}(Y)), SIGHT) \)

Here we see the compositional nature of the frame – the most basic predicate, perceive has been composed with new factors to create a specific meaning: “x sees y.” This meaning can be modified further if composed with new factors, and in such a way new meaning can be “built up” from factor components. Pustejovsky and Joshi call (1) the kernel of the class of seeing verbs, being the most basic or prototypical verb in the class.

1 Kilgarriff et al. (2014): http://www.sketchengine.co.uk.

In effect, we could choose completely different factors to compose to arrive at essentially the same meaning. We could start with our kernel being $\text{SEE}(x,y)$, and compose all further factors using $\text{see}$ as a basis for meaning. But setting up $\text{perceive}$ as the basic unit of meaning allows for easy modification into other types of perception – such as hearing.

\[(2) \ \text{Hear}_0(x,y) = \text{BY-MEANS} (\text{PERCEIVE}(x, \text{THINGY}(x)), \text{SOUND})\]

Joshi (1972) uses verbs of hearing as a point of comparison for explanation and justification of his proposed frames, and using his current framework is illustrative of the compositional meaning, so no changes to the kernel have been made. However, in an effort to make more accurate frames, some changes to Joshi’s original factors will be weighed and considered.

Joshi’s original framework created a verb class with 11 categories, or subtypes. Verbs in the same subtype are given individual frames which are based around a main frame for that category, which I will call the kernel for that subtype. The subtypes are structured in a hierarchy, where the meaning of the relationships between subtypes is modeled by how their kernels differ. You can go from a subtype to another one level “higher” or “lower” with the addition or deletion of a factor from the kernel, which can also be thought of as an increase or decrease in the complexity of the verbs in that category, or the amount of information those verbs entail. For example, going up one level from the class kernel, $\text{see}$, as seen in (1), you have $\text{look}$:

\[(3) \ a. \ \text{INTEND}(x, \text{BY-MEANS}(\text{PERCEIVE}(x, \text{THING}(y)), \text{SIGHT})) \]

b. $\text{INTEND}(\text{see}_0(x,y))$
Here we can see the *intend* factor wraps the current frame for *see*._0_. This composition relays the meaning that in order to *look*, one must *intend to see*. Having the same variable *x* in the *intend* predicate as well as the *perceive* predicate tells us that *x* is the one who intends as well as the one who sees. In essence, “*x* intends for *x* to perceive *y* by sight.”

With that framework established, Pustejovsky and Joshi (2015) went on to look at how factors could relate to argument expression. They explain the concept of a *shadow argument* – an argument to a predicate whose meaning is understood semantically through the predicate but not syntactically through any other overt word or phrase. They used examples (4a-c) below to illustrate this idea.

(4) a. Mary buttered the bread.

b. !Mary buttered the bread with butter.

c. Mary buttered the bread with creamy, unsalted butter.

Because the verb *butter* carries the semantic meaning “spread with butter,” *with butter* is a shadow argument to the verb already. In our current work with frames, *with butter* would appear as a factor in the frame for *butter*. In (4b) we see that expressing the shadow argument overtly in the sentence results in a sentence that is semantically bizarre. But in (4c) we see that if the shadow argument is expressed overtly in a more specific manner, then this is perfectly licit. Pustejovsky and Joshi dubbed this *Shadow Argument Licensing* – a shadow argument to a verb can only be expressed syntactically by a phrase if that phrase is more informative than the shadow argument (i.e. a subtype or elaboration) (p.10 Pustejovsky and Joshi 2015).
Pustejovsky and Joshi then went on to propose the **Factorization Uniqueness Hypothesis**: Each semantic component (factor) contributing to the meaning of an utterance is uniquely expressed in composition. That is, if a factor, \( f_i \), is lexically encoded by a word, \( w \), then it cannot be independently expressed syntactically, unless it conveys new information; and if \( f_i \) is expressed syntactically by a phrase, \( X \), it may not be lexically encoded by any word not part of \( X \), unless \( X \) conveys new information beyond \( f_i \) (p. 13 Pustejovsky and Joshi 2015).

This has consequences for the factors that one would use in a frame such as those in Joshi’s verb class for verbs of seeing. If a verb contains a shadow factor, then that verb should not appear with that shadow factor expressed overtly. So when considering a possible factorization for a verb, if we look through a corpus and see that the verb appears repeatedly with a certain word, we know that word cannot be a factor of the verb directly. However, it could possibly be a subtype of a factor in our verb’s frame. And if we find a group of related words often appearing with our verb, it is good evidence that some generalization of that related group of words could be a factor of the verb.

Pustejovsky and Joshi begin to explore this idea with the concept of the Factor Expression Likelihood (FEL) – the likelihood that a certain factor of a verb will appear syntactically in a sentence with that verb. They use Pointwise Mutual Information (PMI) to explore relationship between *murder* and *kill*, and show that *intentionally* and *accidentally* are likely to occur with *kill* but not with *murder*. And this is because intention is already expressed semantically in the factorization of *murder*, and therefore we would expect modifiers of intentionality to have a low FEL with *murder*.
They then bring up an interesting discovery with *glance* and *look*, whose shorthand frames are reproduced below (p. 12 Pustejovsky and Joshi 2015):

\[
\begin{align*}
\text{(5) a. } & \text{Look}(x,y) = \text{INTEND}(x, \text{see}_0(x,y)) \\
\text{b. } & \text{Glance}(x,y) = \text{INTEND}(x, \text{MOMENTARY}(\text{see}_0(x,y)))
\end{align*}
\]

Here we see that *glance* is a subtype of *look* that is modified by the *momentary* factor. One looks for an indeterminate amount of time, but once glances only for a short duration. If this were just like *kill* and *murder*, we would expect to find that modifiers related to momentariness would appear with *look* but not *glance*, but instead we find the exact opposite. *Glance* appears especially with modifiers such as *briefly, occasionally, quickly* but *look* has no such special correlation. This shows us that *glance* has a shadow factor related to momentariness, but that such “momentariness” might be more an abstract notion of a short duration of time, than something explicit like the “butter” shadow argument of *butter*.

This also shows us that the relationship between *look* and *glance* is not the same relationship as between *kill* and *murder*, which ideally could be captured by their frames. The first thing to note is that the relationship change between the two pairs is different – the addition of *intention* is different from the addition of *momentariness*. It could be that momentariness has a naturally different FEL than intention, and so modifiers related to momentariness have a high probability of appearing when a verb has a shadow factor of momentariness. However, the difference could also be attributed to the fact that these two pairs of verbs have very different meanings. The kernel of *look* and *glance* is related to visual perception, which the kernel of *murder* and *kill* is some kind of physical action.
This question became the motivating factor behind the work which will comprise the rest of this paper. Given that a class of seeing verbs has already been established, with a clear hierarchy of the relationships between subtypes of verbs, where subtypes differ from their neighbors by only one factor, it should theoretically be possible to distinguish how the addition or subtraction of a single factor affects the distributional property of a verb. My goal is to examine Joshi’s class for verbs of seeing in relation to a large corpus of English to determine if those frames hold up well, and how they might be modified to more accurately represent the distributional nature of the verbs of seeing. I will also be looking for syntactic patterns that expression the factor relationships between subtypes of verbs.

In section 2, I will explain my methodology for examining these verbs, including PMI and the use of Sketch Engine. In section 3, I will present my analysis of the subtypes of verbs and their relationships to each other. In section 4, I will talk about extensions to this analysis and framework including clustering, factorization of modifiers, and further exploration that might prove fruitful in this framework.
2. Methodology

I will be using the online corpus tool Sketch Engine\(^1\) with the enTenTen\(^2\) English corpus, containing around 28 million unique words in almost 13 billion instances. This tool allows for searching of words, and will return a wealth of distributional information about that word. For verbs, it will include the highest correlated objects, subjects, modifiers, other verbs in and/or constructions, and much more. It can also compare two words of the same type in all of these categories directly, showing which objects, modifiers, etc. are more prone to occur with one word than the other. Finally I will be using the thesaurus tool, which calculates which words are distributionally closest to a given word.

All of these statistics can be sorted either by frequency or by Pointwise Mutual Information (PMI), except for the thesaurus tool which just returns a “relatedness” score between 0 and 1. PMI is a likelihood metric for determining how often two terms appear together versus how often they appear on their own. It is expressed as the log of the joint probability of two terms, divided by the product of the prior probability of each term. The log is used to make terms smaller and easier to compare.

\[
(2.1) \quad PMI(a, b) = \log \left( \frac{P(a,b)}{P(a)P(b)} \right)
\]

\(^1\) Kilgarriff et al. (2014): [http://www.sketchengine.co.uk](http://www.sketchengine.co.uk).

PMI represents a sort of relatedness between two words. Terms with a higher PMI have a higher correlation in the corpus. This is a good metric for our exploration, since we are looking for how changing a factor affects the modifiers and arguments of a verb, which occur close to the verb. However, this metric is not perfect, as very high frequency words will tend to have a low PMI with any word, and if such a word occurred with only verbs of a certain subtype vs. another, it might not show up in a top 25 ranked list of words of either subtype. Similarly, a very low frequency word can have an exaggeratedly high PMI with another term, simply because most of the times it showed up happened to be with that particular term. This problem can be somewhat alleviated with more data, but more data is not always available.

For convenience, I will be using the form of frames as proposed in the original Joshi manuscript, as opposed to the more type rich lexical factorizations shown in Pustejovsky and Joshi 2015. This is simply to more easily highlight the factors involved, even if it makes the polysemy less integrated into the framework.

I will also be using Joshi’s frames from his original manuscript without an in-depth explanation of the formation of those frames. For justifications and derivations of these frames, see his original 1972 manuscript. I will however point out where my frames differ from his.

One problem to be aware of is that searches in Sketch Engine are not sense disambiguated, so all senses of a verb are used to compute PMI statistics. So unfortunately the non-visual sense can influence the results, making any conclusions drawn less reliable. This can be alleviated somewhat by focusing on verbs in the subtype that have predominantly visual senses.
3. An Analysis of Verbs of Seeing by Factors

In Joshi’s 1972 manuscript, he created a class for verbs of seeing which includes verbs divided into 11 distinct subtypes. Words within each subtype are meant to be semantically closer in meaning that words between subtypes, as is evidenced in their similar factorizations. Many verbs have multiple senses, and some even have different senses in different subtypes. Senses with the exact same factorization can be considered synonymous.

3.1 See

The starting point for the whole class is given by the most basic verb of visual perception, see.

(1-see₁) By-means(Perceive(x, Thing(y)), Sight)

(3.1.1) I saw some delicious nachos.

(1-see₂) By-means(Perceive(x, Event(y)), Sight)

(3.1.2) I saw someone eat my nachos.

(1-see₃) By-means(Perceive(x, Fact(y)), Sight)

(3.1.3) The bird saw that someone had eaten my nachos.

Here we see the three basic types of objects of a visual perception – things or physical objects, events or actions, and facts. Not all verbs of seeing have senses for all three types of objects.
The next closest verb by means of thesaurus score to the visual senses of *see* is *view*, and it does not allow for the perception of facts.

(1-view$_1$) By-means(Perceive(x, Thing(y)), Sight)

(1-view$_2$) By-means(Perceive(x, Event(y)), Sight)

In Joshi’s original manuscript (p. 43), he marked the *Thing* predicate in *view$_1$* with an asterisk, and put a restriction that the object viewed must be “spread out in space,” such as a parade, procession, or a landscape. However, it seems the objects of *view* have changed over the years to include mostly video, photographic, or computer related objects – *video, profile, photo, image, page, content, gallery, clip, map, picture, movie, listing, pornography, list, presentation, document, file, film, slideshow, webpage, PDF, DVD*, etc. All are objects that either move on their own, or require movement of the eyes (i.e. scanning) to obtain some kind of information, either visual or textual. Correlated modifying phrases seem to support a notion of sight traversing distance, either by describing the origination of the sight using *from* with words like *afar, [an] angle, rear, distance, outside, Earth, roadside, front, side, top*, etc. There is also the use of tools that allow sight to travel long distances, or to modify sight to some benefit, using *through* and words like *prism, stereoscope, lens, microscope, eyepiece, telescope, binoculars, filter*, etc. It therefore might be beneficial to add movement of sight to the frame for *view*.

(1-view$_1^*$) By-means(Perceive(x, Thing(y)), Motive(Sight))

(1-view$_2^*$) By-means(Perceive(x, Event(y)), Motive(Sight))
Comparing to see, internet and video related words are exclusive to view, such as pornography, webcast, webinar, PDFs, DVDs, photogallery, webpages, PowerPoint, etc. In regard to origination using modifier phrases starting with from, see has a more widespread use of words, such as window, shore, street, viewpoint, air, summit, point, outside, balcony, deck, inside, where as view has a comparatively higher PMI with afar, front, angle, roadside, read, standpoint. This seems to support that seeing is more general, as one can start an act of seeing from more places than an act of viewing, and acts of viewing seem more correlated with places or orientations that would require movement of the sight. When comparing modifier phrases that start with through, however, see has a higher PMI with all words listed before than view, with the exception of prism. It seems like the use of instruments is more correlated with see than view, but only slightly. It could be that since see is more generic than view, it allows for more syntactic modification.

The next verb in the first category is the much rarer espy, which only had about 2.2 thousand appearances in the corpus compared to see with 15.7 million and view with 1.09 million.

\[(1\text{-espy}_1) \text{ By-means(Perceive}(x, \text{ Thing}(y)), \text{ Sight})\]

\[(1\text{-espy}_2) \text{ By-means(Perceive}(x, \text{ Event}(y)), \text{ Sight})\]

Since there were so few appearances of espy, Sketch Engine was not able to display any useful data regarding it. Both of these senses are attested in the manuscript (p. 41), but Joshi says that they should be the frame for see modulated by a manner predicate such as “distinct manner”
or “with effort.” He makes the same claim for the verb discern, which seems to primarily have the non-visual meaning of “come to understand,” with all the highest rated PMI objects in the corpus being abstract – vocation, truth, difference, nuance, subtlety, etc. But sentence (3.1.4) does suggest visual perception.

(3.1.4) I was able to discern the slight shape of nachos hiding in the darkness.

(1-discern) By-means(Perceive(x, Thing(y)), Sight)

But it might be more accurate to say discern is a verb of perception, and with sight happens to be one of the ways that one can discern something.

The verb witness allows for an event or fact as an object, but not something physical.

(1-witness₁) By-means(Perceive(x, Event(y)), Sight)

Leaving these frames as such would lead witness to be totally synonymous with see, but intuitively that feels like it should not be the case. Unlike see and view which have objects that are neutral, the objects for witness are transitory in nature; they all involve a change or transition – miracle, emergence, atrocity, incident, murder, transformation, spectacle, rise, decline, explosion, boom, devastation, surge, violence, resurgence, growth, birth, phenomenon, horror, upsurge, massacre, carnage, killing, destruction. When one witnesses an event, there is a sense of participation or presence during the event that see does not necessarily imply – saw the devastation can have a resultative meaning – one saw the result of the devastation. But
witnessed the devastation requires that one experience the event throughout. However, exactly how to model that requirement is unclear.

\[(1\text{-witness}_1^*) \ \text{By-means(Perceive}(x, \text{Transition}(y)), \text{Sight})]\]

The verb \textit{behold} in some ways behaves like \textit{discern} and some ways like \textit{witness}. By thesaurus score, these are the two verbs ranked highest with \textit{behold} behind the non-visual \textit{contemplate} and \textit{admire}.

\[(1\text{-behold}_1) \ \text{By-means(Perceive}(x, \text{Thing}(y)), \text{Sight})\]

\[(1\text{-behold}_2) \ \text{By-means(Perceive}(x, \text{Event}(y)), \text{Sight})\]

From both the objects and subjects collected by Sketch Engine, the Biblical nature of \textit{behold} can be seen – \textit{glory, Lamb, iniquity, handmaid, Him, ye, majesty, countenance, thee, Thee, Nephi, Satan, thou, Ezekiel, Enoch, Isaiah, etc.} This leads me to a new factor that relates to Biblical terms.

\[(1\text{-behold}_1^*) \ \text{Biblically(By-means(Perceive}(x, \text{Thing}(y)), \text{Sight}))\]

\[(1\text{-behold}_2^*) \ \text{Biblically(By-means(Perceive}(x, \text{Event}(y)), \text{Sight}))\]

For the factorization of \textit{resemble}, I introduce another two factors into Joshi’s framework – \textit{similar} and \textit{by-value}.

\[(1\text{-resemble}_1^*) \ \text{By-means(Perceive}(x, \text{By-value(Similar(Thing}^*(y), \text{Thing}^*(z)), v)), \text{Sight})\]
*Can be predicate of type Thing or Event

In a resemblance event, I take there to be 3 actors involved and a degree – the one who visually perceives the resemblance, an object, the object that is being resembled, and the degree of the resemblance. In sentences like (3.1.5a), the understood seer of the resemblance is the speaker.

(3.1.5) a. Those nachos resemble Mount Olympus.

b. I visually perceive that those nachos are similar to Mount Olympus by a certain amount.

Insertion of a factor is ideally supported by data, and this seems to be the case with resemble.

Modifiers tend to deal with the manner in which two things are similar or compare to one another – closely, remotely, vaguely, superficially, alike, somewhat, strongly, eerily, faintly, strikingly, loosely, uncannily, strangely, barely, etc.

3.2 Look

The second subtype of the verbs of seeing is typified by the kernel look. Compared to the previous category, verbs in this subtype also carry the meaning of intention.

(2-look) Intend(By-means(Perceive(x, Thing(y)), Sight))

Unfortunately, look is an especially sense diverse verb. It can combine with many particles or modifiers to form new senses – look like, look for, look up, look up to, etc. This means the data from obtained from Sketch Engine is rather muddy and not particularly helpful with identifying how the intention factor changes things from the first category. But it does contain what we can
view as a syntactic marker of intention – *at. Look*, and some of the other verbs that contain the *intention* factor do not take a direct object, but use *at* with an object instead.

However, an interesting problem arises at this point, which Joshi notes in his original manuscript (p. 41). For verbs of visual perception, *intention* and *duration* are often dependent on each other. If you intend to look at something, there also appears to be a duration associated with that event. The following verbs – *peer, observe, watch, eye, gaze, stare, regard, glare, gape* – all have a sense of duration, or non-momentariness. However, they do not appear highly correlated with modifiers of time, but mostly with modifiers of the manner in which one can look – *longingly, intently, silently, fixedly, vacantly, wistfully, adoringly, dreamily, blankly, thoughtfully, admiringly, curiously*, etc. These could be a good indication of the *intent* factor, as they appear fairly consistently across all these verbs. But unlike with *glimpse*, and to a lesser extent *glance* and *peek*, which are correlated with modifiers that relate to short durations of time – *briefly, fleetingly, momentarily*, the verbs with non-momentary durations do not express this syntactically. This seems to be similar to the case of *kill* and *murder*, where a shadow factor is not expressed overtly. Or one could take the view that adverbs like *intently, longingly, fixedly*, etc. also convey a meaning of non-momentariness.

In terms of factors, I can think of two ways to handle this. One would be to change the *Intend* factor to *Intend-Duration* to be a combination of intention and duration. This seems to follow the evidence fairly well, but it lacks generality, which could be problematic for extensions to this system. So for the time being I will keep *Intend* separate and add a *continuous or not(momentary)* factor, placing all these verbs in the next category.
3.3 Glance

This subtype contains the temporal modifications to the look kernel from the last section.

(3-glance) Intend(By-means(Momentary(Perceive(x, Thing(y))), Sight))

(3-peek) Intend(By-means(Momentary(Perceive(x, Thing(y))), Sight))

(3-glimpse) By-means(Momentary(Perceive(x, Thing(y))), Sight)

Just like with the non-momentary verbs, intention and momentariness seem to be blended together in manner of the modifiers for glance and peek – shyly, timidly, furtively, restlessly, uneasily, curiously, warily, surreptitiously, worriedly, etc. Also like those verbs, modifiers that relate to time almost are not correlated with them – only briefly appears with both. This is distinctly different for glimpse, which contains none of the manner modifiers that glance and peek have, with almost all modifiers relating to time or duration – fleetingly, briefly, momentarily, barely, occasionally, rarely, first, last, seldom, etc. It is for this reason that I have removed the Intend factor from glimpse, as it seems the Intend-Duration combination is not at play for it.

The non-momentary verbs of this group are as before:

(3-peer) Intend(By-means(Continuous(Perceive(x, Thing(y))), Sight))

(3-gaze) Intend(By-means(Continuous(Perceive(x, Thing(y))), Sight))

(3-stare) Intend(By-means(Continuous(Perceive(x, Thing(y))), Sight))

(3-gape) By-means(Continuous(Perceive(x, Thing(y))), Sight)
(3-glare) Neg-Violent(Intend(By-means(Continuous(Perceive(x, Thing(y))), Sight)))

(3-observe,₁) Intend(By-means(Continuous(Perceive(x, Thing(y))), Sight))
(3-observe,₂) Intend(By-means(Continuous(Perceive(x, Event(y))), Sight))

(3-watch,₁) Intend(By-means(Continuous(Perceive(x, Thing(y))), Sight))
(3-watch,₂) Intend(By-means(Continuous(Perceive(x, Event(y))), Sight))

(3-regard) Intend(By-means(Continuous(Perceive(x, Thing(y))), Sight))

(3-eye) Desirous(Intend(By-means(Continuous(Perceive(x, Thing(y))), Sight)))

One thing to note is that about half the verbs here take the particle at following them – peer, gaze, stare, gape, and glare. These join the three momentary verbs from above in this quality, suggesting that regard, observe, watch, and eye might belong to a separate subtype, since they can take direct objects. Also, watch and observe (and possibly eye and regard) can also take events as objects, so it is plausible that all these verbs would be a better fit with the 3.1 subtype.

Somewhat like glimpse above, gape lacks any of the intention-duration factors of the rest of the category. But it is also impoverished when it comes to data, so it is hard to draw steadfast conclusions. Of the modifiers not related to sexuality, stupidly, openly, silently may suggest a lack of intention. But unlike glimpse, there are no duration specific modifiers. It is
possible that *gaping* is an unintentional action, and the factors could be changed to *Not(Intend)*, but more data would be needed to verify it distributionally.

All the modifiers for *glare* are negative or violent – *balefully, menacingly, accusingly, hatefully, warningly, angrily, sullenly, malevolently, indignantly, defiantly, venomously, disapprovingly, evilly, coldly, suspiciously, fiercely, furiously*, etc. It might be better to have *Negative* be its own factor that can compose with *Violent*, or replace the *Neg-Violent* factor all together. Finding a good, generalized descriptor for a factor can be difficult.

The modifiers for *eye* seem to be related to desire – *enviously, hungrily, suspiciously, greedily, jealously, covetously*, etc. But some of the modifiers that appear with the rest of the verbs in the category do appear, unlike with *glare* – *longingly, curiously, furtively*.

### 3.4 Notice

The verbs in this category are all factive – they all have the same factorization as (1-see₃). Here we see a different sense of *observe* as seen in 3.3.

\[(4\text{-\it notice})\] \text{By-means(Perceive(x, Fact(y)), Sight)}

\[(4\text{-\it spot})\] \text{By-means(Perceive(x, Fact(y)), Sight)}

\[(4\text{-\it observe})\] \text{By-means(Perceive(x, Fact(y)), Sight)}

The modifiers for verbs in this category have three common threads – speed of completion, time of completion, and difficulty of completion of the noticing event. For speed we have *immediately, suddenly, quickly, instantly, first, last, suddenly, finally*. For time of completion we
have ever, lately, prior, before, never, soon, recently, early. For difficulty of completion we have hardly, barely, easily, scarcely, surely, definitely, effortlessly, absolutely. Unlike the verbs with intention, there are no modifiers that seem to combine intention and duration. Also, the modifiers related to difficulty of completion seem to suggest another sense for each of the verbs that related to achievement. One can imagine that when treasure hunting, spotting or noticing a clue could be considered an achievement.

\[(4\text{-notice}_2) \text{Achieve(By-means(Perceive(x, Fact(y)), Sight))}\]

\[(4\text{-spot}_2) \text{Achieve(By-means(Perceive(x, Fact(y)), Sight))}\]

\[(4\text{-observe}_2) \text{Achieve(By-means(Perceive(x, Fact(y)), Sight))}\]

3.5 Examine

This subtype of verbs builds off the kernel of 3.2 – look. These are all verbs where one looks to achieve a certain purpose. This is differentiated from verbs of the next section, where the purpose is there explicitly to find something.

\[(5\text{-examine}) \text{In-order-to(Intend(By-means(Perceive(x, Thing(y)), Sight)), Purpose)}\]

\[(5\text{-scrutinize}) \text{In-order-to(Intend(By-means(Perceive(x, Thing(y)), Sight)), Purpose)}\]

\[(5\text{-scan}) \text{In-order-to(Intend(By-means(Perceive(x, Thing(y)), Sight)), Purpose)}\]

\[(5\text{-survey}) \text{Repeatable(In-order-to(Intend(By-means(Perceive(x, Thing(y)), Sight)), Purpose))}\]

\[(5\text{-inspect}) \text{Repeatable(In-order-to(Intend(By-means(Perceive(x, Thing(y)), Sight)), Purpose))}\]
(5-track) In-order-to(Intend(By-means(Continuous(Perceive(x, Thing(y)), Sight))), Purpose)

(5-monitor)
Repeatable(In-order-to(Intend(By-means(Continuous(Perceive(x, Thing(y)), Sight))), Purpose))

The verbs in this category do seem to behave fairly uniformly with regards to their modifiers. The insertion of the *Purpose* factor leads to a use of modifiers describing the attention paid to the task, and all of the highest correlated ones are positive – critically, carefully, closely, thoroughly, systematically, meticulously, cautiously, rigorously, comprehensively, extensively, exhaustively.

I then noticed modifiers relating to the idea of repeatability, or a continued practice through multiple iterations – periodically, annually, routinely, regularly, yearly, repetitively, daily. This is separate from the continuous factor in *track* and *monitor*. These had modifiers related to a continuous duration – continuously, constantly, continually. The act of monitoring or tracking something requires constant attention, and monitoring someone is something you can do on a periodic basis.

This is different from the Intent-Duration verbs of 3.3 because here the continuity is overt, and not mixed with any kind of intention. With that being the case, it might likely be beneficial to distinguish between these two factorizations in some way, to represent their different syntactic behaviors.
3.6 Look for

This category builds off the previous category by specifying the *purpose* factor to specifically be to *find* something. *Look for* here is chosen as the kernel for the subtype because I was not able to obtain enough information for it from Sketch Engine, and so it gives the form listed in Pustejovky and Joshi as a basis, even though it should probably be modified in light of the findings for *search* and *seek*.

(6-Look for) In-order-to(Intend(By-means(Perceive(x, Thing(y)), Sight)), Find(x, Thing(y)))

(6-Search)
In-order-to(Intend(By-means(Continuous(Perceive(x, Thing(y)), Sight))), Find(x, Thing(y)))

(6-Seek)
In-order-to(Intend(By-means(Continuous(Perceive(x, Thing(y)), Sight))), Find(x, Thing(y)))

Changing the factor from *purpose* in the previous section has yielded a change in the type of modifiers for both *search* and *seek*. Many of the highest correlated modifiers are linked to emotion – *frantically, desperately, actively, eagerly, aggressively, earnestly, urgently, relentlessly*. However some of the modifiers from the last group appear here as well – *extensively, systematically, deliberately, diligently*. And the *continuous* modifiers from *monitor* and *track* return, with some more as well – *constantly, continually, continuously, endlessly, currently, presently, forever, still*. There are also a few modifiers related to achievement, but all in the negative – *unsuccessfully, fruitlessly, vainly*. 

22
It seems that having a specific purpose is related to a lot more emotionality and the realization of failure. It would be interesting to see how going from a generic purpose factor to a specific one affected the distributional behavior of verbs from a different class.

3.7 Appear

This subtype builds off the 3.1 kernel for see in a different direction, dealing with the notion of becoming possible to see or be seen. The kernel of this subtype, appear, will become the basis for the remaining categories.

(7-appear) \( \text{Become}(\text{Possible(By-means(Perceive(x, Thing(y)), Sight)))} \)

(7-emerge) \( \text{Become}(\text{Possible(By-means(Perceive(x, Thing(y)), Sight)))} \)

(1-surface) \( \text{Become}(\text{Possible(By-means(Perceive(x, Thing(y)), Sight)))} \)

The difference between see is the introduction of two new factors, become and possible. However, the likely emphasis in this subtype is the inchoative become, since possible is somewhat difficult to qualify exactly in the framework. The reason being that an act of seeing can include the notion that something is possible to be seen. If one sees something, then that something is by nature possible to be seen. So one can include possible in the factorization for see. But note that negation does not entail the opposite – just because one does not see something, that does not mean it is not possible to see that object, nor does it necessarily mean that the one who currently does not see the object is unable to see the object, that one just happen to not see the object at that time.
However, in this subtype and its derivatives, the subject of the action is performing a different role in regards to an act of seeing, and this likely necessitates the use of possible as a factor. For one to appear, one becomes possible to be seen by someone or something else. The inchoative become is essential to the meaning of appear, and there seems to be no way of defining it without including possibility, unlike with sight. The negation, not appear, can be glossed as not become possible to see, but unlike with see, there is no conflict with impossibility, as the negation factor not would be applied to the outermost layer of the factorization. In the next section we will see how not can be inserted inside the factorization to change the meaning of the predicate in a way other than just negation.

There are five main types of modifiers that correlate highly with verbs in this category – manner adverbs that describe an unexpected nature of how something can become possible to be seen – miraculously, mysteriously, magically, unexpectedly; modifiers related to frequency – frequently, regularly, sporadically, intermittently, sometimes, usually, often, again, occasionally, once, twice; modifiers related to ordinality – first, originally, initially, finally, newly, now, soon; modifiers related to rate – suddenly, slowly, abruptly, immediately, steadily, abruptly, spontaneously; and modifiers related to location – there, anywhere, everywhere, nowhere, below.

Compared to category 3.1 verbs like see and view, most of the modifier groups appear more correlated with the 3.7 verbs. The first group occurs only with verbs in 3.7, and this makes sense in light of their nature – they describe a lack or impossibility of knowledge into the inchoative nature of the event. If something appears miraculously then it was unexpected and
how it came to appear is likely unknown, at least at the time of the event. These seem like the most likely candidates for modifiers related to the factor become. Frequency, ordinality, rate, and location all occur with both categories of verbs, but the first three groups are more highly correlated with 3.7 verbs. 3.7 verbs also have modifiers that hint at the repeatable factor – sporadically, intermittently, regularly, and potentially other frequency modifiers. Something can appear and this disappear repeatedly – e.g. the sun on a cloudy day. However, the correlation does not appear to be as strong as it is for some of the 3.6 verbs, so whether we should include the repeatable factor in verbs of this category is something that would require more exploration to conclude.

(7-appear*) Repeatable(Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

3.8 Disappear

Building directly off the 3.7 kernel appear, we see how the inclusion of a negation factor not can give rise to antonyms disappear and vanish.

(8-disappear) Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(8-vanish) Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(8-reappear) Again(Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(8-resurface) Again(Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(8-blur) Become(Less(Possible(By-means(Perceive(x, Thing(y)), Sight))))
(8-darken) Become(Less(Possible(By-means(Perceive(x, Thing(y)), Sight))))
(8-fade) Gradual(Become(Less(Possible(By-means(Perceive(x, Thing(y)), Sight)))))
(8-fade-out) Gradual(Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight)))))
(8-fade-in) Gradual(Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

In this subtype, disappear, vanish, reappear, and resurface seem more closely related to verbs from 3.7, while blur, darken and fade have slightly different modifier correlations (with fade-in and fade-out being expressions suggested by Joshi to be included in the category, but were unsearchable in the same manner as normal verbs through Sketch Engine). The difference between the two groups is that the former again sees a high correlation of modifiers related to an unknown nature of the original of the inchoative process – mysteriously, magically, miraculously, inexplicably, unpredictably, while the latter does not. Because of this difference, there should be some distinction in the frames between the two groups, since become cannot be the reason for the difference if it is to be kept with blur, darken, fade and verbs in later categories (which seems to be an intrinsic part of the definition, and thus valuable). And since these words all link to an unknown nature of the appearing or disappearing event, and we do not also see highly correlated words that would suggest understanding or expectation of the origin, such as understandably, or normally, a factor of unknown seems to be worthwhile.

(7-appear*)
Repeatable(By-means(Become(Possible(By-means(Perceive(x, Thing(y)), Sight))), Unknown))

Inside this former group, vanish and disappear, and reappear and resurface form synonym pairs that can also be differentiated from each other by the modifiers with which they often appear.
One difference is that *reappear* and *resurface* contain the same modifiers as the 3.7 verbs that suggest repeatability – *periodically, continually, intermittently, sporadically, chronically* -- but *vanish, disappear*, and also *fade, blur, and darken* do not. There seems to be a connection between repeatability and visibility: all the verbs that deal with becoming visible are repeatable, while verbs that deal with becoming invisible are not, even though if something appears repeatedly it must also disappear repeatedly, and vice versa. This seems to be a case of taking two polarized opposite meanings (visible vs. invisible), and assigning attributes that apply to both of them only to the positive side. It would be interesting to see if this correlation happens to other pairs of meaning, and in which contexts. In terms of factorizations, a binary negation factor *not* could theoretically be placed at any level inside the frame, and it would be interesting to see if negating different subframes ever produced similar results. The only impetus to this study would be finding words in the language that corresponded to those exact factorization.

(8-reappear*)

Again(Repeatable(By-means(Become(Possible(By-means(Perceive(x, Thing(y)), Sight))), Unknown)))

Another difference between the two groups is that *disappear* and *vanish* have modifiers related to totality – *altogether, completely, virtually, forever, entirely, utterly*. These modifiers do not correlate highly with the other verbs of non-visibility, so it is likely a factor unique to these two in the set.

(8-disappear*)

To-extent(By-means(Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight))), Unknown), Total(e)))
Setting up the factorization in this way allows for different extents to be specified if left with a random variable $e$. Using the factor total as a predicate allows us to select only words that relate to totality. This could be accomplished more gracefully with typing as demonstrated in Pustejovsky and Joshi 2015 (p. 9).

Similar to the 3.7, all the verbs in this category are also highly correlated with modifiers of rate – suddenly, overnight, abruptly, quickly, rapidly, slowly, fast, instantly, spontaneously, promptly, gradually, progressively, steadily, eventually. Most verbs have both slow rates and fast rates, but faster rates seem to occur more often. Vanish also has more fast rates than the others, and has them more highly correlated, with gradually and slowly much more lowly correlated. Fade, on the other hand, is most highly correlated with gradually and slowly, but then the next highest correlates are fast, quickly, eventually, and rapidly. Darken is almost more highly correlated with gradually than fast rates. Because of this, Joshi’s original factor of gradual for fade is understandable, and should probably be in some way a default value, considering its higher correlation. But it would probably be better to indicate that these verbs are highly correlated with modifiers of rate in general, so we will use the random variable $r$ with the by-rate factor to indicate that.

(8-vanish*)
By-rate(To-extent(By-means(Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight)))),
Unknown), Total), Fast(r))

(8-resurface*)
By-rate(Again(Repeatable(By-means(Become(Possible(By-means(Perceive(x, Thing(y)), Sight)))),
Unknown))), r)
(8-fade*)
By-rate(Become(Less(Possible(By-means(Perceive(x, Thing(y)), Sight)))), Gradual(r))

3.9 Expose

The verbs of this category are related to the verbs of 3.7 by causality. In this group, an agent is causing an object to appear (often to an unspecified spectator).

(9-expose) Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(9-reveal) Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(9-uncover) Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(9-unearth) Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(9-unmask) Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(9-unveil) Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(9-disclose) Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(9-display) Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(9-present) Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(9-show) Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(9-exhibit) Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))

(9-demonstrate) Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight))))
Verbs in this group tend to correlate highly with very similar groups of adverbs, and are most easily distinguished from each other by which objects they tend to take. Unlike 3.7 and 3.8, verbs in this subtype do not tend to take modifiers related to rate, frequency, or ordinality more so than others. However, expose, exhibit, present, and demonstrate do tend to take modifiers related to repetition – constantly, repeatedly, regularly, chronically, consistently, annually. For all verbs in this category we tend to see modifiers related to intentionality – proudly, inadvertently, accidentally, knowingly, unwillingly, unknowingly, voluntarily. This is likely related to the causal nature of the acts – someone generally causes something intentionally or unintentionally. Thus the use of the cause factor in the factorizations, which could possibly be decomposed into intend to make, however the modifiers that appear here with cause are distinctly different from the ones that appeared before with intend, so it might be more desirable to leave the cause factor alone.

Another group of modifiers that separates this subtype from 3.7 and 3.8 is a group related to the extent to which the object is being caused to be visible – modifiers such as publicly, openly, prominently, internationally, nationally, widely, conspicuously, regionally, ubiquitously, everywhere. However, qualifying exactly what extent these modifiers are referring to is rather difficult – a high (or low for conspicuously) visibility is the key, but how to capture that as a factor is not clear to me. For now I will use universal as the extent.

(9-reveal*)

To-extent(Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight)))), Universal(e))
Looking at objects associated with these verbs helps us reveal that *disclose* is likely not a verb of visual perception, as nothing physical is ever disclosed. It seems that *reveal* is similar in that most things revealed are non-physical, but at least one can reveal one’s face from behind a mask, or reveal one’s hand of cards. *Disclose* seems to relate to *information*, and while types of information can be perceived visually, it is unclear to me if the act of disclosing causes a visual perception.

Similar, looking at objects of *expose*, and some of its other modifiers show it to have a negative association similar to *glare* – *corruption, lie, hypocrisy, weakness, flaw, rat, vulnerability, fraud, fallacy, scandal, wrongdoing, cruelly, dangerously, inferiorly, needlessly, ruthlessly, indecently, negligently, blatantly*. The modifiers are not quite the same, and *violent* might not be the best word to capture the commonality here. So I will leave it at *negative* to distinguish it from before, but this is a rather unsatisfactory factor. Perhaps composing *negative* and other factors could lead to a more appropriate way to capture these correlates.

(9-expose*)

\[
\text{Negative(To-extent(Cause(z, Become(Possible(By-means(Perceive(x, Thing(y)), Sight)))), Universal(e)))}
\]

### 3.10 Hide

Similar to how 3.9 extended 3.7 with causation, the verbs in this category are the causal forms of 3.8 - to *hide* something is to cause to make something disappear. Alternatively, 3.10 can be an extension of 3.9 as 3.8 was to 3.7 – an insertion of the *not* factor to create antonyms. Verbs in this category include *hide, mask, veil, secrete, conceal, obscure, disguise, bury, cloak, shroud,*
envelop, and camouflage. Most words of this category tended to have the lowest frequency counts of any so far (in the 10^4 range), and also tended to have either a similar distribution of modifiers, or no easily discernible patterns. For that reason I will only list one frame as a representative of the group.

\[(10\text{-hide}) \text{Cause}(z, \text{Become}(\text{Not}(\text{Possible}(\text{By-means}(\text{Perceive}(x, \text{Thing}(y)), \text{Sight})))))]\]

Modifiers related to cause and intentionality are similar to 3.9 – deliberately, intentionally, purposefully. Also, the extent to which something is hidden is often expressed, but in this case it is more often not an extreme, but a partial extent which is more frequent – partially, completely, partly, barely, somewhat, largely, wholly, utterly, fully, almost, nearly, extensively, thoroughly, entirely, slightly, scarcely, thinly, hardly. Thus the scale would have to do with wholeness or entirety.

\[(10\text{-hide*}) \text{To-extent}(\text{Cause}(z, \text{Become}(\text{Not}(\text{Possible}(\text{By-means}(\text{Perceive}(x, \text{Thing}(y)), \text{Sight}))))), \text{Entirety}(e))\]

3.11 Blind

The final category is a special take on the previous one. Someone is still causing something to be unseeable to someone, however in this case that is achieved by causing someone to not be able to see anything. Pustejovsky and Joshi lay out the factorization in two possibly ways:

\[(11\text{-blind}) \text{By-means}(\text{Cause}(z, \text{Become}(\text{Not}(\text{Possible}(\text{By-means}(\text{Perceive}(x, \text{Thing}(y)), \text{Sight}))))), \text{Action})\]
The problem with these is the focus is put on an action. Certainly one would blind another by means of an action, and that could be considered to be the difference between hide and blind—in order to blind someone, one would need to perform some action such as shining a bright light in one’s eyes. However, in order to hide something, one needs to put a blanket over it, or shove it under a bed. The difference is the argument structure—you hide something from someone, but you blind someone from something. To encapsulate this in the frame, we can change the factorization for blind slightly.

(11-blind*)
By-means(Cause(z, Momentary(Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight)))))), Action(z, x))

Now blinding is specifically an action that z does to x, as opposed to any action that would make x unable to perceive y. It might also be prudent to change hide to include Action(z, y) to specify that z is hiding y from x.

Returning to Sketch Engine, Joshi suggests that dazzle is a momentary action while blind is not. For my investigations, I also included mesmerize, entrance, fascinate, hypnotize, and spellbind as possible verbs of seeing synonymous or similar to dazzle, although it is unclear the extent to which they should be included. Momentarily and temporarily are the two highest correlated modifiers with blind, while momentarily is the highest correlated modifier with dazzle, and temporarily does not show up. Momentarily also occurs with spellbind, captivate,
and mesmerize, while fascinate has modifiers that suggest continuation – *endlessly, always, eternally, continually, perpetually*. Many verbs also show the verbs related to *cause* as seen in previous sections – *willfully, accidentally, purposely, deliberately*. And like vanish and disappear, all verbs except hypnotize display association with modifiers of totality – *permanently, utterly, totally, absolutely, wholly, completely*.

(11-blind*)

To-extent(By-means(Cause(z, Momentary(Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight))))))), Action(z, x), Total)

(11-dazzle*)

To-extent(By-means(Cause(z, Momentary(Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight))))))), Action(z, x), Total)

(11-mesmerize)

To-extent(By-means(Cause(z, Momentary(Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight))))))), Action(z, x), Total)

(11-spellbind)

To-extent(By-means(Cause(z, Momentary(Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight))))))), Action(z, x), Total)

(11-captivate)

To-extent(By-means(Cause(z, Momentary(Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight))))))), Action(z, x), Total)

(11-entrance)

To-extent(By-means(Cause(z, Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight)))))), Action(z, x), Total)
(11-fascinate)
To-extent(By-means(Cause(z, Continuous(Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight))))), Action(z, x)), Total)

(11-hypnotize)
By-means(Cause(z, Become(Not(Possible(By-means(Perceive(x, Thing(y)), Sight))))), Action(z, x))
4. Conclusions and Future Work

The goal of this work was to see if factors correlated with some kind of syntactic realization, to see if that would motivate further exploration for a Factor Expression Likelihood. Going through all of Joshi’s verbs of seeing category by category, examining the factors did lead to patterns emerging in the distributional environment of those verbs. I mostly only looked at adverb modifiers, but object, subjects, and prepositions also appeared to be correlated to factors.

Most of this was done by comparing verbs in one category with verbs in a category which only differed by one factor. But as I explored, I ended up finding lots of patterns and variations within categories, leading to the creation of new factors which were linked to the correlation of certain groups of modifiers in the corpus.

Succeeding in this endeavor was a proof of concept for the creation of a metric for FEL. Pointwise Mutual Information is a useful metric for determining how often two words occur together versus individually, but it would be ideal to have a calculation based on generalized factors – there should be fewer unique factors than unique words, potentially providing more data for a calculation based on factors. And since factors are word independent, seeing how their changes are manifested syntactically gives insight into how semantic meaning affects syntactic realization.
FEL can be used for word sense disambiguation – if one knows the factorizations for all the senses of a word, then one can compute the FEL for a phrase with each word sense, and the sense with the highest FEL would be your winner. It also potentially helps with attachment ambiguity – if one knows that a certain verb is not likely to take a certain preposition, then that preposition probably attaches to the noun instead.

In order to work toward a metric for FEL, a lot of work is probably necessary to be done. I used PMI to find highly correlated words to verbs, but my clustering of those words was all done intuitively, not computationally. It would be a great benefit to use automatic clustering techniques both for the verbs and modifiers used in this paper. Clustering the verbs of seeing automatically could give you some distributional insights not seen here that could help further refining the factorizations. Also, if one could use a sense disambiguated corpus, that would likely help immensely, as many of these verbs had multiple senses, which were all mixed together in the Sketch Engine results.

Clustering modifiers in different ways would also be rather useful too. It stands to reason that there can be overlap between groups of modifiers that correlate with different factors, e.g. the negative modifiers for glare and expose. It would be ideal to create factorizations for adverbs as well, so one could see how verb factors would select for different adverb factors. A verb with one factor might select for adverbs with factors x and y, so and adverb with xyz and an adverb with wyx might be selected for while wxz is blocked. Those kind of relationships could be very interesting to explore, especially with the power to cluster based around seeds of one’s choosing.
References


