Extending VerbNet's Verb-Specific Features to Enhance Selectional Preferences of Semantic Roles

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Abstract

This work proposes expanding the thematic role selectional preferences used in the lexical resource VerbNet as a way to increase the available semantic information in the resource, induce semantically-based subclasses for the more generic VerbNet classes, and create new links across classes. The addition of verb-specific features in the latest version of VerbNet provides a means for adding more specific selectional preferences based on the meaning of a class's individual member verbs. These features could refine both the instantiated class roles and the new implicit roles introduced in VerbNet version 4. We suggest 49 classes that would benefit from 111 verb-specific selectional preferences and explain how they would enhance VerbNet's semantic representations.

Keywords: semantic representations, VerbNet, thematic roles

1. Introduction

Deep learning has revolutionized natural language processing (NLP) in recent years, but problems with explanability and portability to low-resource languages or subject domains have led to the development of neurosymbolic methods. These new methods have made symbolic representations of meaning more relevant than ever for NLP. Lexical resources like VerbNet (Schuler, 2005), FrameNet (Baker et al., 1998) and PropBank (Kingsbury and Palmer, 2002) have a long history of contributing to NLP tasks that require rich semantic information, such as question answering, inferencing, and event and entity tracking. All three resources provide information on semantic roles, but VerbNet alone provides semantic representations for classes of verbs. These use Generative Lexicon subevent semantics (Pustejovsky, 1995, 2013) in a loosely neo-Davidsonian representation (Brown et al., 2019, 2022).

VerbNet's combination of syntactic and semantic regularities in the construction of its classes of verbs has resulted in some classes that are more syntactically than semantically coherent. Recent work (Kazeminejad et al., 2022) has added verb-specific features to the members of many VerbNet classes, allowing the formation of semantically coherent subclasses. We propose the addition of new verb-specific features that can both aid in that effort and enhance the semantic representations. These features would add more specific selectional preferences on the thematic roles based on the meaning of the individual member verbs (such as the Theme role in Build-26.1 class having the selectional preference FIBER for the verbs *knit* and *weave* but METAL for the verbs *hammer* and *forge*). These could refine both the traditional class roles and the implicit roles (e.g., V_Instrument) added to the semantic representations in VerbNet version 4. We suggest 49 specific classes that would benefit from 111 verb-specific selectional preferences and explain how they would enhance the semantic representations.

2. Background

VerbNet (Schuler, 2005; Schuler et al., 2009) is a large-scale English verb lexicon that uses similarities in verbs' syntactic and semantic behaviors to create hierarchical classes. Based on the classes created by Levin (1993), each class includes member verbs, general thematic roles that represent the arguments in the typical predicate-argument patterns of those verbs, and selectional restrictions on the class's thematic roles. The diathesis alternations that are the backbone of VerbNet's structure are listed in each class as syntactic patterns, and each syntactic pattern is accompanied by a semantic representation that incorporates the class's thematic roles (Bonial et al., 2011a,b).

The semantic representations list a series of semantic predicates, such as **has_location, desire** or **cause**, and an event variable **E**. The neo-Davidsonian representation uses the class's thematic roles as the arguments of the predicates and traces the progression of the event through subevent variables (Brown et al., 2022). The

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Escape-51 class, for example, has a syntactic frame with the semantic representation seen in (1).

(1) *He came from France to Colorado.*

Agent V Initial_Location Destination

has_location(e_1, Theme, Initial_Location)
motion(e_2, Theme, ?Trajectory)[1]
¬**has_location**(e_2, Theme, Initial_location)
has_location(e_3, Theme, Destination)

The semantic representations are general enough to fit with all member verbs in a class. For classes with semantically very similar verbs, the representations can be quite specific. For other classes, the member verbs are semantically diverse, with only general semantic features applying to all verbs. For example, the Entity-Specific_COS (change of state)-45.5 class includes verbs as diverse as *blossom, spoil,* and *tarnish.* It has one thematic role (i.e., Patient), the selection preference +concrete on that role, and a simple, generic semantic representation that highlights the change in the Patient from not being in a particular state to being in that state:

(2) *The roses bloomed.*

¬**has_state**(e_1, Patient, V_Final_State)
has_state(e_2, Patient, V_Final_State)

This example illustrates the two types of thematic roles in VerbNet: those instantiated as arguments (e.g., Patient) and those that are incorporated into the meaning of the verb (e.g., V_Final_State). The first type are the roles that have been widely used for semantic role labeling (Shi and Mihalcea, 2005; Giuglea and Moschitti, 2006; Palmer et al., 2011), such as Agent, Patient, and Location. Each class lists the roles that get instantiated in sentences using the class's verbs. VerbNet has 39 roles, related hierarchically (Bonial et al., 2011b).

The other type of role was introduced with new semantic representations and is used to describe roles that are semantically necessary but that never appear as arguments in sentences using the class's verbs (Brown et al., 2022). They instead are incorporated into the verb itself, as indicated by the initial V_ in the role name. The V_Final_State role in the example above is a one example. Most of these uninstantiated roles are based on roles in the set of usual, instantiated roles. For example, the V_Instrument role in the Wipe_Instr-10.6.2 class (example verbs: *iron, shovel, sponge* corresponds to the instantiated thematic role Instrument in the Carve-21.2 class (example verbs: *dice, grind, slit*. V_Final_State is unusual in that there is no Final_State role in any VerbNet class. However, V_Final_State is used frequently as an argument in the semantic representation of change of state classes.

Although the syntactic and semantic generalizations provided by VerbNet classes have proved useful for numerous NLP tasks over the years, the option of accessing more specific semantic features for individual verbs or subsets of verbs in a class was often suggested as desirable (Gao et al., 2016; Clark et al., 2018). Kazeminejad et al. (2022) describes an effort to do that through the addition of fine-grained semantic features to individual verbs in a class. These features usually provide values for an attribute that several of a class's verbs share. For example, the Run-51.3.2 class has verbs (e.g., *scurry* and *whiz*) with the attribute VELOCITY and the value +FAST. For classes that are already semantically coherent but quite large, such as Run-51.3.2, these features can tie together the many verbs into helpful subgroups, such as all the verbs that refer to types of walking. For very general classes, such as Other_COS (change of state)-45.5, the features add more semantically coherent subgroups of verbs.

3. Adding Verb-Specific Selectional Preferences

VerbNet's regular 39 thematic roles are used across all its classes with the same, consistent definitions. Within each class, however, the thematic role may be further specified with a selectional restriction that indicates the type of entity that usually fulfills that role (Table 1). As explained in Palmer et al. (2016), the selectional restrictions are to be interpreted not as strict constraints but as preferences. Because VerbNet's roles are organized into a hierarchy in which more specific roles inherit all the qualities of their parent roles, the selectional preferences can be seen as a further subordinate level of that hierarchy.

Although the VerbNet selectional preferences have been used for various purposes in the past, such as disambiguating prepositional phrase attachment (Bailey et al., 2015) and metaphor detection (Wilks et al., 2013), some have found that they needed to use information from other resources to reach the desired level of specificity (Wilks et al., 2013; Di Fabio et al., 2019). For example, the creators of Verb Atlas (Di Fabio et al., 2019) used VerbNet thematic roles for their resource but substi-

[1]The question mark indicates a role that is semantically entailed and used in other syntactic frames within the class but not instantiated in this syntactic frame.

tuted WordNet hypernym synsets for the VerbNet selectional preferences on those roles to expand the possible set of preferences.

The current set of selectional preferences (Table 1) contain types that vary widely in the extent of their usage. The type ANIMATE is used with roles in 147 classes, ORGANIZATION in 127 classes, and CONCRETE in 75. However, 61% of types are used in 5 or fewer classes. The ubiquity of the very general selectional preferences (e.g., CONCRETE) results from the same semantic diversity of the verbs in some classes that lead to very generic semantic representations. In a class like Entity-Specific_COS-45.5, the most you can say about the types of entities that fulfill the Patient role (and still be true for every verb in the class) is that they are CONCRETE. For other classes, like Calibratible_COS-45.6.1, the Patient cannot be further constrained at all using the current set of selectional preferences.

selectional restriction	**No. of classes**	**selectional restriction**	**No. of classes**
abstract	4	int_control	25
animal	3	location	32
animate	147	machine	14
biotic	1	nonrigid	1
body_part	14	organization	127
comestible	6	plural	2
communication	10	pointy	1
concrete	75	reflexive	3
currency	5	region	20
elongated	2	solid	7
eventive	1	sound	1
force	1	substance	2
garment	1	vehicle	3
human	3	vehicle_part	1

Table 1: VerbNet selection restrictions

We propose adding selectional preferences to individual verbs within a class using the established verb-specific feature element. In the class Entity-Specific_COS-45.5, for example, a mix of existing selectional preferences (e.g., HUMAN and BODYPART) and new ones (e.g., PLANT, METAL, and LIQUID) could be linked to individual verbs along with the role they restrict (see Table 2).

These additions would have several benefits:

- Increase the semantic information provided by VerbNet.
- Improve the semantic coherence of classes by creating subsets of verbs that share semantic features.
- Allow connections across classes for verbs in a particular semantic domain (e.g., verbs that pertain to food but that are housed in different classes, such as *bake* in the class Cooking-45.3, *eat* in the class Eat-39.1, and *spoonfeed* in the class Feeding-39.7, could be connected with a FOOD selectional preference for the Patient.
- Enhance the semantic representations when they are instantiated by particular verbs.

Class and Role	**Feature**	**Example verb**
Amuse; V_Emotion	positive feeling	cheer
	negative feeling	annoy
Calibratible_COS	+increase	rise
	+decrease	decline
	+fluctuate	swing
Remedy; Patient	**plant**	fertilize
	human	cremate
	animal	inseminate
	liquid	chlorinate
	air	humidify
Gobble; Patient	liquid	guzzle
	food	wolf

Table 2: Classes with existing verb-specific features that could act as selectional preferences (new proposed features in bold)

This final point was suggested in Brown et al. (2022). They suggested that the V_Direction role in the semantic representations for the Calibratible_COS-45.6.1 class could be refined by the verb-specific features when the representation is instantiated with items from text. For the sentence *The price of oil rose by 500% from $5 to $25.*, the arguments of the predicate **change_value** could be replaced with items from the text and with the verb-specific feature for *rise*, resulting in:

(3) **change_value**(e_2, INCREASE_V_DIRECTION, *500%*_Extent, *price*_Attribute, *oil*_Patient)

We suggest a slightly different format that uses a dot to combine the role and verb-specific feature, emphasizing the increased specificity of the role and the possibility of seeing it as a subtype of original role. Thus, the role in (3) would read V_DIRECTION.INCREASE. This format would also work well with the standard roles in VerbNet. When the specific verb is known, the representation can add the verb-specific feature to appropriate arguments in the representation. To apply this to one of the food-related verbs, the representation in the Gobble-39.3 class would change the generic Patient role to Patient.food when *gobble* is known to be the verb:

(4) *Cynthia gobbled the pizza.*
has_location(e_1, Patient.food, ?Source)
do(e_2, Agent)
body_process($\ddot{e}_3$, Agent)
motion($\ddot{e}_3$, Patient.food, ?Trajectory)
contain(e_4, Agent, Patient.food)
cause(e_2, e_3)

4. Method

We used a manual methodology to ensure highly reliable results. We started by considering classes that contain either of two VerbNet elements. One was existing verb-specific features, which often implicitly reference one of the thematic roles (e.g., the existing features INCREASE, DECREASE and FLUCTUATE in the Calibratible_COS-45.6.1 class. The only required task for those classes was to make that connection explicit. Most classes with role-related features, however, also seemed incomplete, such as Remedy-45.7, to which we suggest adding four additional features to restrict the Patient role (Table 2).

The other element that proved fruitful for identifying possible new features was the implicit role variation marked with V_. These roles by definition already point out that more specificity about the role could be found in the verb itself. Often a single attribute of the role was indentifiable in the verbs with a handful of values. For example, the Vehicle-51.4.1 class, which has such denominal verbs as *boat, bus,* and *jet*, uses a V_Vehicle role in its semantic representations. The verbs already have one of three features: MEDIUM_GROUND, MEDIUM_AIR, and MEDIUM_WATER. Additional features that refine the V_Vehicle role could be added, such as MOTOR VEHICLE, WATERCRAFT, and AIRCRAFT. These provide a middle level of specificity between V_Vehicle and the specific craft described by the verb itself, and they enable the creation of subsets of verbs based on vehicle type.

5. Proposed Features

We have identified 49 classes that could be enhanced with 111 selectional preferences as verb-specific features (see Appendix). The most common role that could be enriched with verb-specific selectional preferences is Theme, followed closely by Patient. Using the already verb-specific implicit roles that begin with V_ resulted in identifying several classes that would benefit from additional verb-specific features, such as Other_COS-45.45.4 and Remedy-45.7. Occasionally when one class was identified as eligible for new selectional preferences through its V_role (e.g., Sound_emission), it suggested a related class with no V_role (e.g., Substance_emission). A sample of classes and their proposed verb-specific selectional preferences are given in Table 3.

Class and Role	**Feature**	**Example verb**
Escape-51; Traject.	upward	rise
	downward	fall
	toward	approach
	away	recede
Calve-28.1; Patient	canine	pup
	feline	kitten
	bovine	calve
Create-26.4; Result	written_text	author
	music	compose
	dance	choreograph
	image	silkscreen
	artifact	fabricate
Preparing; V_fin._st.	cooked	bake
	fermented	brew
	mixed	mix
	burning	kindle

Table 3: Classes and verb-specific features that could act as selectional preferences

6. Future Work

We would like to validate our proposed features with a survey of English-language speakers, possibly on a crowd-sourced platform. Another possibility for validation or discovering new selectional preferences would be using Corpus Pattern Analysis (Hanks, 2013).

Semi-automating the process of discovering new selectional preferences would save time and money and could possibly be done by using LLMs. To test this idea, we queried Chat-GPT (3.5) on most of the verbs in the Entity-Specific_COS-45.5 class using the following query: "Can you group the following verbs according to the type of entities involved: flower, moult, rot, rust, germinate, oxidize, stagnate, sprout, wither, wilt, tarnish, swell, superate, tarnish, bud, atrophy, fester, crust, blossom, blister, spoil, erode, ebb? It created two groups, one with *germinate, sprout, wither, wilt, bud,* and *blossom* as verbs that involve plant life, and another with most of the other words as verbs that involve inanimate objects. Some verbs it ignored. These groupings are not perfect, but they do suggest some reasonable selectional preferences for the Patient role. GPT-4 would no doubt do a better job.

We would also like to test the utility of these features in a task like entity tracking. Kazeminejad et al. (2021) showed that VerbNet semantic representations improved performace on this task, suggesting that there might be further improvement with richer, verb-specific role preferences.

7. Conclusion

In this work, we have proposed the addition of verb-specific selectional preferences for certain VerbNet roles. The existing VerbNet element of verb-specific features on class member verbs provides a seamless way of incorporating this new information. We have argued that these new features would improve the semantic coherence of classes by creating subsets of verbs that share semantic features, allow connections across classes for verbs in a particular semantic domain, and enhance the semantic representations when they are instantiated by particular verbs.

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10. Language Resource References

11. Appendix: Verb-Specific Selectional Preferences

Instrument.knife
Instrument.liquid
Instrument.noose
Instrument.poison
Material.fiber
Material.food
Material.metal
Material.wood
Patient.air
Patient.animal
Patient.animate
Patient.body_part
Patient.dance
Patient.eyebrows
Patient.eyelashes
Patient.feet
Patient.fingers
Patient.fire
Patient.food
Patient.forehead
Patient.hand
Patient.head
Patient.human
Patient.lips
Patient.liquid
Patient.metal
Patient.neck
Patient.plant
Patient.solid
Patient.teeth
Result.artifact
Result.image
Result.music
Result.written_text
Theme.aircraft
Theme.blood
Theme.body_part
Theme.decoration
Theme.excrement
Theme.fire
Theme.gas
Theme.image
Theme.label
Theme.liquid
Theme.motor_vehicle
Theme.numbers
Theme.pest
Theme.plant
Theme.plant_part
Theme.saliva
Theme.solid

Theme.surface_substance
Theme.sweat
Theme.urine
Theme.vocal_music
Theme.vomit
Theme.watercraft
Theme.words
Trajectory.away_from
Trajectory.downward
Trajectory.toward
Trajectory.upward
Destination.food
Destination.animal
Destination.clothing
Destination.furniture
V_Direction.decrease
V_Direction.fluctuate
V_Direction.increase
V_Emotion.negative_feeling
V_Emotion.positive_feeling
V_final_state.burning
V_final_state.cooked
V_final_state.fermented
V_final_state.in_pieces
V_final_state.mixed
V_final_state.pale_skin
V_final_state.straightened
V_final_state.unconscious
V_final_state.asleep
V_final_state.compressed
V_form.compressed
V_form.cut
V_form.elevation_gain
V_form.elevation_loss
V_form.pieces
V_form.surface_substance_removed
V_form.turn
V_Instrument.ears
V_Instrument.eyes
V_Instrument.nose
V_manner.bragging
V_manner.ceremonial
V_manner.complaining
V_manner.physical
V_manner.possibly_verbal
V_manner.verbal
V_Patient.bovine
V_Patient.canine
V_Patient.feline
V_sound.continuous
V_sound.punctual
V_sound.sharp
V_sound.soft
V_sound.vibrate
V_Theme.plant
V_Theme.seafood
V_vehicle.aircraft
V_vehicle.motor_vehicle
V_vehicle.sled
V_vehicle.watercraft