

On Hidden Semantic Relations between Nouns in WordNet

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Abstract

The paper presents an effort on transferability of noun – verb and noun – adjective derivative and semantic relations to noun – noun relations. The approach relies on information from semantic classes and existing inter-POS derivative and (morpho)semantic relations between noun and verb, and noun and adjective synsets. We have added semantic relations between nouns in WordNet that are indirectly linked via verbs and adjectives. Observations on the combination between the relations and semantic classes of nouns they link, may facilitate further efforts in assigning semantic properties to nouns pointing to their abilities to participate in predicate-argument structures.

1 Introduction¹

The present work² aims at revealing hidden (indirect) semantic relations between nouns in WordNet by using information that is already available from the inter-POS derivative and (morpho)semantic relations between noun – verb, and noun – adjective synsets, and the semantic class of lexical concepts expressed by the members of a noun–noun pair.

The main relation among words in WordNet is synonymy (or near-synonymy; synonyms are defined as words which denote the same concept and are interchangeable in many (but not all) contexts). The synonyms (called 'literals') are

grouped into unordered sets (synsets) which are linked via the so-called 'conceptual relations'. Most relations between synsets connect words of the same part-of-speech (POS). Noun synsets are linked via hypernymy / hyponymy (superordinate) relation, and meronymy (part-whole) relation. Verb synsets are arranged into hierarchies via hypernymy / hyponymy relation. Adjectives are organised in terms of antonymy and similarity, and relational adjectives (pertainyms) are linked to the nouns they are derived from. Adverbs are linked to each other via similarity and antonymy relations.

Thus, WordNet consists of four sub-nets, with few cross-POS relations – the so-called '(morpho)semantic' relations between semantically similar words that share a stem with the same meaning (e.g., *writer* is an **Agent** of *write*, see (Fellbaum et al., 2009)); pertainym relations: noun – adjective (e.g., *pope* – *papal*); adjective – adverb (e.g., *bad* – *badly*); derivative relations: noun – verb (e.g., *write* – *writer*); adjective – verb (e.g., *writing* – *write*); noun – adjective (e.g., *pope* – *papal*).

Lexical concepts expressed by the synsets are further semantically classified by assigning the so-called 'semantic primitives' (or 'semantic primes' or 'semantic classes') to each synset ((Fellbaum et al., 2009); (Miller et al., 1993)). Noun and verb synsets are subjected to elaborate semantic classifications – nouns are organised into 25 semantic classes such as *noun.person*, *noun.animal*, *noun.plant*, *noun.process*, *noun.act*, *noun.location*, etc., and verbs – into 15 classes – *verb.stative*, *verb.communication*, *verb.cognition*, *verb.perception*, etc. Only three labels are applied to the adjective synsets – *adj.all* (mainly) for descriptive adjectives, *adj.pert* for pertainyms, and *adj.ppl* for adjectival participles, but there are efforts on more detailed classifications of adjectives in wordnets for other languages (the

¹For the requirements of the academic system, Tsvetana Dimitrova takes responsibility for sections 2 and 3, and Valentina Stefanova – for 1 and 4.

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WordNet for German (GermaNet), see (Hamp and Feldeg, 1997); WordNet for Russian (RussNet), see (Azarova and Sinopalnikova, 2004); the Polish WordNet (plWordNet), see (Maziarz et al., 1997); and the Bulgarian wordnet (BulNet), see (Stefanova and Dimitrova, 2017), (Dimitrova and Stefanova, 2018).

2 Nouns in WordNet

Nouns in WordNet are organised within the superordinate / subordinate (hypernymy / hyponymy) hierarchy. The hierarchical semantic organisation is limited in depth, and distinguishing features are added to create lexical inheritance system where each word inherits the distinguishing features (attributes (modification), parts (meronymy), functions (predication) from its superordinates ((Miller 1990, 1990)). An example would be {diarist:1} [10011486-n]³, which, as a hyponym of {writer:2} [10801291-n], is classified as *noun.person* and could be an **Agent** of the verb synsets {write:1} [00993014-v], {write:3} [01007027-v], *write:4* [01031966-v], and {write:5} [01691057-v] just like its hypernym.

Nouns are further related to verb synsets via derivative and/or (morpho)semantic relations – (morpho)semantic relations are applied to derivationally related noun – verb pairs, but not vice versa – not every derivationally related pair is (morpho)semantically linked, and to adjectives – via derivative and pertainym relations (pertainym relations are usually applied to *adj.pert* adjectives, and nouns and adjectives are derivationally linked but not every derivationally linked pair noun – adjective is in pertainym relation).

Some nouns linked via a verb have an explicit link through hypernym/hyponym relation: (1) they can be two hyponyms of the same hypernym, e.g., the nouns {exhibition:1} [eng-30-00522145-n] and {exposure:3} [eng-30-00522537-n] are derivationally linked via the verb {expose:9; exhibit:3} [eng-30-02140033-v], and are co-hyponyms of the noun synset {presentation:1; demonstration:1}

³Throughout the paper, the numbers of the literals follow those applied in the database used by the viewer Hydra available at: <http://dcl.bas.bg/bulnet/>. We do not give all literals and definitions due to space limitation but only ids of synsets acc. to PWN 3.0 – in square brackets, with POS marked at the end. There may be changes to semantic classes and (morpho)semantic relations between the PWN and the version on <http://dcl.bas.bg/bulnet/>, for detail see (Leseva et al., 2015).

[eng-30-00521562-n]; (2) One can be a hyponym of the other, as with {relish:2; flavour:2} [eng-30-05715864-n] which is a hyponym of {taste:9; taste sensation:1; taste perception:1} [eng-30-05715283-n], and the two are derivationally and morphosemantically (as **Event**) related to {taste:6; savor:4; savour:4} [eng-30-02194286-v]).

In the next section 2., we will discuss the relations between these nouns by taking into account the semantic class of the nouns and the 'linking verb', and the (morpho)semantic relations between the two (if available).

3 Nouns linked via verb synsets

In WordNet, verb and noun synsets are related via derivative and (morpho)semantic relations that link semantically similar verbs and nouns that share a stem with the same meaning. Verbs impose selectional restrictions on the entities selected for their argument positions, particularly on characteristics of the nouns taking specific semantic roles. For example, the **Agent** of cognitive verbs is expected to be animate and human (but not animal) while that of consumption verbs is animate but can be both human and animal. Selectional restrictions also apply to complements – for example, motion verbs may have as their **Instrument** nouns referring to vehicles and artifacts while their **Location** or **Direction** complement can be location, object or artifact.

Previous studies have further differentiated nouns which are linked via (morpho)semantic relations to different verb classes. (Paiva et al., 2014) and (Real and Rademaker, 2015) offer extension of the classification of deverbal nominals in Portuguese drawing upon work on Portuguese nominalisations (Real, 2014) where eight possible classes of eventive nominalisation have been proposed: action of, result of, physical result of, iteration of the act of, resulting state from, abstract result of, locative, collectivisation of.

In previous work on the Bulgarian wordnet, (morpho)semantic relations **Agent** and **Undergoer** were subdivided by taking into account the information about: verb and noun semantic classes, sentence frames encoding predicate-argument structure of the simple sentences that verbs can form, and noun suffixes, to formulate additional (morpho)semantic relations, such as **Experiencer**, **Actor**, **Recipient** ((Dimitrova, 2018)). (Leseva et al., 2018) have proposed subcategorisation

of nouns by taking into account information from WordNet, VerbNet, and FrameNet, which resulted in formulating subcategories such as: **Agent_communicator**, **Agent_effector**, **Agent_experiencer**, **Agent_undergoer**, **Artifact_undergoer**, etc.

Our proposal on introducing noun – noun semantic relations is based on the assumption that selectional restrictions are imposed not only by verbs but also by nouns derived from verbs such as nominalisations (e.g., *writing*), agentive nouns (e.g., *writer*), resultative nouns (e.g., *written*), etc. They are related to the source verb (e.g., *write*) not only via (morpho)semantic but also via derivative relations. We additionally take into account the relations between the semantic classes of the nouns linked through derivative relations via verb synsets.

Some – but not all – derivationally linked nouns are linked also via (morpho)semantic relations, as in (1) where {writing:2} and {writer:1} are **Event** and **Agent**, respectively, of {write:7}. Other derivationally related nouns, however, such as {pen:3} below, are only derivationally (but not (morpho)semantically) linked:

Ex.

{write:7; compose:3; pen:1} [01698271-v] *verb.creation* 'produce a literary work'

has_Event: {writing:2; authorship:2; penning:1} [00929718-n] *noun.act*

has_Agent: {writer:1; author:3} [10794014-n] *noun.person*

derivative: {pen:3} [03906997-n] *noun.artifact*

We assume that in many cases, the (morpho)semantic relations between the nouns may reflect the (morpho)semantic relations between the respective nouns and the verb, i.e., {writing:2} is an event nominal which has an **Agent** {writer:1}. This assumption, however sketchy, can be tentatively extended to other derivationally related nouns; thus, we can add a semantic relation **Instrument** to {pen:3}, which can be additionally related as an **Instrument** for {writing:2; penning:1} and an **Instrument** of {writer:1}:

Ex.:

{writing:2; authorship:2; penning:1} *noun.act*

has_Agent: {writer:1; author:3} *noun.person*

has_Instrument: {pen:3} *noun.artifact*

{writer:1; author:3} *noun.person*

has_Instrument: {pen:3} *noun.artifact*

Some noun synsets have been already linked via hypernym/hyponym relations, f.ex. {squandering:1} **is_hyponym_of** {waste:5; wastefulness:1}, and {wastrel:1; waster:2} *is_hyponym_of* {prodigal:2; profligate:3; squanderer:1}, and all of them are linked to the verb {consume:4; squander:1; waste:6}. Thus, the relation between them is overtly exposed though it can be categorised further.

In the following section, we propose a set of semantic relations that can be applied to the noun – noun pairs⁴

3.1 Noun – noun relations through verbs

As already stated, noun synsets that are derivationally related to a verb synset, can be linked through semantic relations that mirror (or are inherited from) the (morpho)semantic relations between noun and verb synsets on the basis of the assumption that a deverbal noun may inherit the argument structure of the source verb. Some noun – verb relations in WordNet are derivative only, but (morpho)semantic ones can be additionally formulated (see (Stoyanova et al., 2013).

Nouns of all semantic classes can be derivationally related to verbs, as in: cook: cooking (*noun.act*) is done by using a cooker (*noun.artifact*) as an **Instrument** by a cook (*noun.person*) as an **Agent**; toast: toasting (*noun.act*) is done by using a toaster (*noun.artifact*) as an **Instrument** to produce a toast (*noun.food*) as a **Result**. Further, a cook (*noun.person*) uses a cooker (*noun.artifact*) as an **Instrument** for cooking (*noun.act*); a toaster (*noun.artifact*) produces a toast (*noun.food*) as a **Result** when toasting (*noun.act*); etc. We have formulated a number of noun – noun relations, some of which such as Agent, Instrument, Result, Property, Location, mirror or are inherited from noun – verb (morpho)semantic relations; in some cases the type of relation was changed (Event can become Result) or additionally specified as with Resulting_State. There are also newly formulated relations such as Actor, Causator, Patient, Possessor, Experiencer, Cause, Time, etc. Relations are inverse, asymmetric and intransitive, e.g., **is_Agent_of** / **has_Agent**; **is_Subevent_of** / **has_Subevent**, etc.

The new relations assigned to nouns, may allow us to further assign semantic subclasses (re-

⁴The set is to be extended further but for now we cover only the main relations.

flecting their properties) to the nouns at hand. Thus, if a noun classified as *noun.person* is related via **Experiencer** relation, we may assume that it lacks properties like agentivity and control. Moreover, these properties would restrict the noun's properties that enable its participation in certain predicate-argument structures (if a noun is classified as *noun.object* or *noun.artifact* and is linked to other noun(s) via a **Location** relation, we may assume that it may also participate in **Location** relations with other verbs selecting a **Location** relation.

3.1.1 Noun – noun relations: an overview

We have manually assigned⁵ the semantic relations to 2,303 noun – noun pairs.

Persons

A noun labeled as *noun.person* can express a variety of relations to verbs and deverbal nouns such as Agent, Causator, Experiencer, Recipient, etc. Other semantic classes here are *noun.group* and *noun.animal*.

The **Agent** relation (513)⁶ is inherited from noun – verb relations and links nouns mostly classified as *noun.person* related via verbs of semantic classes such as *verb.creation*, *verb.motion*, *verb.change*, *verb.competition*. Nouns classified as *noun.person* have conscious and active referents, while the other noun in the pair refers to explicitly active predicates such as *noun.act*, *noun.event*, *noun.process*, *noun.communication*.

Ex.: {etcher:1} [10064977-n] **is_Agent_of** {etching:1} [00938791-n].

The **Actor** relation (174) links a noun which cannot be considered an active participant in the situation but refers to an entity who has abilities to perform the action referred to by the other noun (*noun.animals* linked to verbs via **Agent** relation are marked as **Actors**). Ex.: {inhabitant:1} [09620078-n] **is_Actor_of** {inhabitation:1} [01054545-n].

In the **Causator** relation (34), the other noun refers to a resultative phenomenon such as *noun.event*, *noun.phenomenon*, *noun.motive*, etc.

Ex.: {bell ringer:3; ringer:4} [10714851-n] **is_Causator_of** {ring:12; ringing:3} [07391863-n].

⁵For the resource, see: <https://dcl.bas.bg/semantichni-mrezhi/>, with any further additions and changes.

⁶Due to space limitation, only the total number of relations added is given in brackets here.

Three relations are labeled according to a semantic role differentiated on the basis of the verb class, (morpho)semantic relations and the class of the other noun in a pair. The **Experiencer** relation (98) holds between a *noun.person* and a noun classified mostly as **noun.feeling** or *noun.state* via *verb.emotion*, *verb.perception*, *verb.body*.

Ex.: {lover:1} [09622302-n] **is_Experiencer_of** {love:8} [07543288-n]

Nouns that are linked via **Patient** relation (85) are related to the verb via an **Undergoer** relation and can be *noun.person* or *noun.animal*, and the other noun in the pair is *noun.feeling*, *noun.possession*, *noun.cognition*, etc.

Ex.: {beloved:2; love:9} [09849598-n] **is_Patient_of** {love:8} [07543288-n].

The **Recipient** relation (17) holds between a noun related to the verb via an **Agent** relation, and a noun labeled as *noun.food*, *noun.competition*, *noun.possession*, *noun.communication*, *noun.artifact*, etc., as in: {luncher:1} [10277132-n] **is_Recipient_of** {lunch:3; luncheon:1} [07575076-n].

The **Possessor** relation (17) involves a noun labeled *noun.attribute*, and more rarely a *noun.possession*, as in: {economiser:1} [10044470-n] **is_Possessor_of** {economy:2} [05644727-n].

In a previous effort ((Dimitrova, 2018)), (morpho)semantic relations **Agent** and **Undergoer** were subdivided to formulate additional (morpho)semantic relations between nouns and verbs such as **Experiencer**, **Actor**, **Recipient** to be applied to the Bulgarian wordnet. In there, the relation **Experiencer** surpasses the relation **Agent** with two verb classes – *verb.perception* and *verb.emotion*. However, observations on the data about noun – noun relations show that if a *noun.person* is related to *noun.feeling* and *noun.state*, it is most likely to be **Experiencer** (53) or **Causator** (21) especially if linked via *verb.emotion* and *verb.body*. If a *noun.person* is linked to *noun.state*, it can be also **Patient**, **Possessor**, and **Actor** (e.g., {suspect:6} [10681383-n] **is_Patient_of** {suspicion:4} [13982839-n].

The **Agent** relation, however, still holds between *noun.person* and *noun.act* disregarding the class of the verb: a *noun.person* which is linked to a *noun.act* via *verb.cognition* is most likely to be **Agent** as referring to a person in professional function.

A noun labeled as *noun.person* is most likely a **Possessor** or a **Recipient** in relation to *noun.possession* (esp. when linked via *verb.possession*).

Thus, one may assume that if a *noun.person* is related to other nouns of classes such as *noun.feeling* and *noun.state* via Experiencer relation, it may lack properties such as agentivity and control (a sleeper may snore (just like a snorer) but cannot read or drive a car).

In addition, there are nouns classified as *noun.group* which are linked via **Agent** or **Patient** relation, as in: {mover:1; moving company:1} [08478482-n] **is Agent of** {move:16} [01850315-v]. Here, we may assume that the group and/or its members have properties characteristic of a person.

Artifacts

A *noun.artifact* refers to non-animate nouns and is linked with **Instrument** (166) relation to nouns of all other classes but mostly predicative ones, as in:

Ex.: {printer:2} [-04004767-n] **is Instrument of** {printing:4; printing process:1} [06677302-n] {machinist:1; mechanic:3} [10279018-n] **has Instrument** {machine:4} [03699975-n]

The *noun.artifact* is usually linked to the verb synset via *Instrument* or *Means* (morpho)semantic relations.

noun.artifact can be also Result of a *noun.act*, as in:

excavation:3 [03302121-n] **is Result of** *excavation:2; digging:1* [00941974-n]

Another relation that can link a *noun.artifact* and a *noun.act* is **Theme** (306) as in:

{piece:9} [03932203-n] **is Theme of** {patching:1} [00267349-n]

The **Theme** relation often links non-animate nouns related to the verb via an **Undergoer** relation (and *Uses*) which was subdivided into **Theme** and **Patient** depending on the characteristics of the noun's referent (a non-animate noun such as *noun.food*, *noun.plant*, etc. would be *Theme*, while animate and human nouns would be *Patient*), as in:

Ex.: {draft:12; tipple:2} [07883980-n] **is Theme of** {tippler:1; social drinker:1} [10712690-n]

{plant:1; flora:1} [00017222-n] **is Theme of** {planting:1} [00919513-n]

Most noun – noun pairs linked via **Instrument**

relation contain a noun classified as *noun.artifact* – these nouns are related to verbs via **Instrument** and **Vehicle** (morpho)semantic relations. Nouns classified as *noun.substance* are linked to verbs via **Material** and **Uses** relations. In these cases, a *noun.substance* refers to a man-made entity.

If a noun is classified as *noun.object* and is linked to *noun.act*, *noun.event* or *noun.state*, it may be **Theme** (21) and **Result** (25) but also **Location** (11) and **Uses** (9); if it is linked to *noun.act* and *noun.state* via the same verb, it is **Result** of *noun.act* and **Theme** of *noun.state*. One may also assume that *noun.artifact* can be argument of various predicates (a cooker can be an **Instrument** of cooking (but also, indirectly, of frying or boiling) but also a **Location** of putting, or a **Theme** of repair, or a **Result** of producing, etc.).

Events

A noun – noun relation that is mostly inherited from the noun – verb relation is **Result** (219) which holds between a noun labeled as *noun.artifact*, *noun.food*, *noun.object*, etc. (linked to the verb synset via the (morpho)semantic relation **Result**) and a *noun.act*.

Ex.: {toast:3} [07686873-n] **is Result of** {toasting:1} 00246552-n

The subcategorised relation **Resulting state** (89) holds between a noun classified as *noun.state* or *noun.feeling* and nouns of various classes such as *noun.state*, *noun.feeling*, *noun.event* via *verb.perception*, *verb.emotion*, *verb.change*, *verb.body* classes.

Ex.: {disturbance:7; upset:17} [14403282-n] **is Resulting state of** {upset:4} [00554850-n]

The type of the relation can be changed, as in: {snap:23} [07394236-n] **is Result of** {snap:4} [00344699-n] (the noun – verb relation was **Event**).

A new relation that encodes the relation between two predicative nouns is **Subevent** (144) – it mostly holds between a noun referring to the act as such and a noun which may refer to the beginning, the end or any moment in-between the starting and ending point. This relation often holds between *noun.act* and *noun.event*, with the former referring to an event within the act, and between *noun.process* and *noun.act* assuming that a process consists of a series of acts. An example here is: {start:20} [07325190-n] **is Subevent of** {beginning:1; start:1} [00235435-n]. The as-

sumption that the lexical inheritance condition is valid here, would mean that any Subevent may have **Agent** or **Instrument** of the main event, e.g., if {barrage:2; bombardment:3} [00987863-n] **has Agent** *blaster:1; chargeman:1* [09859557-n], and **has Instrument** {shell:12} [04190464-n], its Subevent *blast:15* [07408171-n] would inherit these relations, and any of the verbal predicates related to the verb {blast:6; shell:4} [01135922-v] such as its hyponym {crump:2} [01136393-v] and its hypernym {bombard:3; bomb:1} [01131902-v], may select for arguments the nouns at hand (i.e., the person *blaster* as an **Agent**, the artifact *shell* as an **Instrument**, and the event *blast* as a **Subevent**).

Others

The relation **Location** (121) links nouns classified as *noun.location*, *noun.object*, and *noun.artifact* with *noun.process*, *noun.act*, *noun.state* via *verb.stative*, *verb.motion*, *verb.body* through **Location** and **Event** (morpho)semantic relations: {hatchery:1} [08581299-n] **is Location for** {hatch:8; hatching:2} [13491464-n]

Nouns labeled *noun.object* or *noun.artifact* can be linked not only to verbs but to other noun(s) via **Location** relation prompting an assumption that the noun classified as *noun.artifact* may also participate in **Location** relations with other verbs selecting a **Location** relation (a person can be hospitalised in a hospital as a **Location** but can also live or dance (however unusual it may seem) in a hospital as a **Location**).

The relation **Uses** (176) holds between nouns that refer to all non-human and non-predicative referents such as *noun.substance*, *noun.artifact*, including *noun.animal*, as in: {hawker:1} [10076604-n] **Uses** {hawk:3} [01605630-n]

The relation **Cause** (63) holds between a *noun.phenomenon* or *noun.motive* and a *noun.act*, *noun.process*, *noun.event*, etc., as in: {soaker:2} [11502102-n] **Causes** {drenching:1; soaking:2} [00277811-n]

The relation **Property** (52) links a noun classified as *noun.attribute* to a noun of any other class, as in: {invalid:5; shut-in:3} [10214230-n] **has Property** {disability:1; disablement:1} [14548343-n], and this property may be characteristic of many other nouns of the same class (a chief executive can has a disability).

The relation **Time** (29) holds between a *noun.time* and a *noun.act*, *noun.process*, etc., as in: {period

of play:1; play:52} [15256915-n] **is Time for** {playing:1} [00041188-n].

3.2 Case study

Here, we offer some observations on co-occurrence between the classes of nouns in a pair. We have manually assigned relations on noun – noun pairs linked via *verb.perception*, *verb.competition*, and *verb.consumption*. In Table 1, we give figures on *noun.persons*.

Noun.person are often Agents with *noun.act*,

| verb.perception | | |
|------------------|---------------|---|
| noun.class | noun.class | Rel [No] |
| person | act | Agent [45] |
| person | event | Causator [4] |
| person | communication | Agent [3], Actor [2] |
| person | feeling | Agent [3] |
| person | state | Experiencer [4] |
| person | cognition | Agent [4], Experiencer [5] |
| verb.consumption | | |
| person | act | Agent [29], Actor [7], Experiencer [1] |
| person | quantity | Agent [1] |
| person | cognition | Experiencer [1] |
| person | state | Experiencer [2], Actor [2] |
| person | feeling | Experiencer [2] |
| verb.competition | | |
| person | act | Agent [55], Actor [20], Recipient [2], Causator [1] |
| person | animal | Theme [4], Uses[2] |
| person | artifact | Uses [10], Theme [2], Instrument [4] |

Table 1: *Noun.person* linked via *verb.perception*, *verb.consumption*, and *verb.competition*.

and Experiencers with *noun.feeling* and *noun.state*, and they Uses (incl. as Instruments) *noun.artifacts*. Further, with *verb.perception* and *verb.competition*, *noun.event* is Subevent and Result of *noun.act*, while *noun.act* is Subevent of *noun.process*. With *verb.consumption*, *noun.events* (4) are much rarer.

Nouns labeled *noun.food* and *noun.artifact* are often Themes of *noun.act* when the two are linked via *verb.consumption*.

The Location relation links nouns classified as *noun.location* and *noun.artifact* with *noun.act*. (The (morpho)semantic relation Location is rarely found with the three verb classes.)

The observations on noun – noun relations may help us formulate some principles behind combinations between a semantic relation, a verb synset of a particular semantic class, and a set of noun synsets from other classes that are indirectly linked through a verb via derivative and morphosemantic relations. If we assume that the nouns linked to verbs are arguments to a predicate, the features associated with a particular concept in argument position, can be inferred also by observing other nouns linked to the same verb.

4 Nouns linked via adjective synsets

An adjective denotes a property that is permanently inherent for an entity it modifies or refers to and is attributed to it in its entirety. Therefore, an adjective can be defined as part-of-speech whose denotative function is realised through its connection to the noun. Adjectives and nouns in WordNet are linked to each other mostly via derivative relations. Descriptive adjectives (*adj.all*) are organised into clusters based on similarity of meaning (synonymy) and binary opposition (antonymy). Relational adjectives (*adj.pert*) are (derivationally) related and linked to the synset which contains their source noun (as a literal). Adjectival participles (*adj.ppl*) are related via participle relation to verbs they are derived from. Thus, adjectives are organized via a set of relations that encode their properties of attribution, antonymy, similarity, derivation; fuzzynymy and thematic category (in the EuroWordNet (Vossen, 2002).

However, from a derivational point of view, the distinction between descriptive and relational adjectives can be somewhat fuzzy, as descriptive adjectives can be also derived from nouns and refer to an attribute property of the defined entity (expressed by the noun). The property qualifies and characterises the entity expressed by the noun from which they are derived (e.g., *pitiful* - *pity*, etc.). Hence, an adjective may express one-sided relationship with the entity denoted by the motivating noun, though adjectives, which are derived from a noun, are motivated by it. In WordNet, an explicit noun – adjective relation with relational adjective (*adj.pert*) is pertainymy

– an antisymmetric (derivative) relation between a relative adjective and the noun from which it is derived. The basic meaning of the relational adjective is determined by the noun from which it is derived, and these adjectives may inherit relations from the noun (Koeva, 2014). Some descriptive adjectives in WordNet may not be linked via pertainymy relation but can be derivationally related to a source noun.

We have extracted noun synsets which are indirectly linked via adjectives – a noun is derivationally related to an adjective which, in its turn, is related via similarity relation to another adjective which is related to another noun. We applied the following scheme of extracted nouns:

Noun derivative Adjective similar_to Adjective derivative Noun.

An example is given below where a noun – noun relation is assumed between {north wind:1; northerly:4; norther:1} and {north:3}.

Ex.:

{north wind:1; norther:1} [11487950-n]
noun.phenomenon

derivative: {northerly:2; northern:1}
[01601069-a]

similar_to: {north:2}

has attribute: {north:3} 08561081-n
noun.location

{north wind:1; norther:1} **is_Related_to** {north:3}

Some of these noun – noun pairs contain literals that are derivationally related (literals have the same root of at least one of the literals in the synset) though the synsets are not explicitly related via derivative relation; with others, only the adjectives are derivationally linked. We have identified only 31 noun – noun pairs that have at least one literal that is derivationally related, as in the example below.

Ex.

{salinity:1} [04993604-n] *noun.attribute*

derivative: {saline:1} [01074458-a]

similar_to: {salty:1} [01073822-a]

derivative: {salt:7; table salt:1}
[07813107-n] *noun.food*

We have attempted to explore the dependence between the semantic classes of the nouns that are indirectly related via adjectives linked via similarity relation, to formulate noun – noun relations which were experimentally applied.

4.1 Noun – noun relations through adjectives

The majority of noun – noun pairs here contain literals that are not derivationally related – 1,193 pairs – but noun synsets are otherwise related through derivationally related adjectives, as exemplified below.

Ex.:

{ceremony:1} [01026897-n] *noun.act*

derivative: {ceremonial:1} [01042491-a]

similar_to: {formal:2} [01041916-a]

has_attribute: {formality:2; formality:1} [04911420-n] *noun.attribute*

We have formulated four noun – noun semantic relations mostly drawing upon classes and definitions of the nouns. Here, we exemplify the co-occurrence of noun semantic classes that are most often found in our data. For a cleaner representation of dependencies between semantic classes of nouns we will present them in separate groups acc. to the formulated relations.

Result is a relation referring to a consequence of performing any action, process, event. Here, nouns classified as *noun.act* can express Result of *noun.artifact* [3]⁷, *noun.attribute* [33], *noun.cognition* [4], *noun.feeling* [4], etc. For example, {empiricism:2} [00635699-n] *noun.act*, which is **derivative** of : {empirical:1; empiric:1} [00858917-a] – **similar_to:** {experiential:1; existential:1} [00859632-a], has non-explicit relation with {experience:6} [05758059-n] *noun.cognition*. Hence, we can link {empiricism:2} with the relation **is_Result_of** to {experience:6} and formulate dependence of the type: *act Result cognition*, which means that an action can be a Result or can lead to a certain result of knowledge.

Nouns labeled as *noun.event* can be Result of *noun.attributes* [11]. For example {discharge:17; outpouring:3; run:49} [07407777-n] *noun.event* **is_Result_of** {fluidity:2; fluidness:2; runniness:1} [04937043-n] *noun.attribute*.

Property is a relation that links nouns referring to concepts that are considered to be characteristic of another noun mostly classified as *noun.attribute* (but also *noun.state*, *noun.feeling*). Nouns labeled as *noun.animal* are characterised by properties classified as *noun.attribute* [9] which

are not obligatorily associated with the animal (body part). For example, {scale:5}⁸ [01902877-n] *noun.animal* **has_Property** {roughness:3} or *animal* **has_Property** of some *attribute*.

Nouns classified as *noun.attribute* are Properties of *noun.act* [13], *noun.artifact* [8], *noun.cognition* [31], *noun.communication* [7], *noun.person* [11], *noun.state* [33], *noun.feeling* [21]. For example, {neurotic:3} [10354898-n] *noun.person* **has_Property** {obsessiveness:1} [04626062-n] *noun.attribute*.

Nouns classified as *noun.body* has property of nouns labeled as *noun.attribute* [12], *noun.state* [3]. So {fuzz:1} [05261894-n] *noun.body* **has_Property** {hairiness:1} [04683453-n] *noun.attribute*

Noun.state is property of nouns classified as *noun.feeling* [3] and *noun.person* [14]. For example, {subservience:2; subservientness:1} [13952466-n] *noun.state* **is_Property_of** {slave:2} [10609325-n] *noun.person*.

Nouns labeled as *noun.plant* [7], *noun.quantity* [4], *noun.shape* [11] have properties marked as *noun.attribute* like in the case of the example {thorn:3; prickle:4} [13089631-n] *noun.plant* **has_Property** {sharpness:3; keenness:1} [04705324-n] *noun.attribute*

Nouns classified as *noun.person* is characterised by *noun.attribute* [37], *noun.cognition* [4] or *noun.state* [6], e.g.: {teenager:1} [09772029-n] *noun.person* **has_Property** {youthfulness:1} [04928416-n] *noun.attribute*.

Part_of is a relation which links nouns referring to concepts as constituent elements of other concepts. This is a relation linking a noun referring to an event or entity which are associated with another event or entity. In this case **Part_of** is more often related to abstract nouns such as event and entity than to nouns having separate components as in the examples: 'the finger is part of the hand'; 'this piece is part of the pie', where the meronymy relation is to be applied.

Nouns labeled as *noun.communication* can be Part of *noun.cognition* [4] or *noun.attribute* [30], as in: {irony:3} [07106246-n] *noun.communication* **is_Part_of** {incongruity:1; incongruousness:1} [04714847-n] *noun.attribute*.

⁷The number in brackets shows the occurrences of the noun pairs.

⁸Here, we give only noun – noun pairs due to limitation of space.

Related is a general relationship that shows that there is connectivity between different objects, phenomena, dimensions but it is more of a free association relation that has not been properly defined yet.

Nouns of semantic class *noun.cognition* are related to *noun.attribute* [47], *noun.person* [4], *noun.state* [5]. For example {insightfulness:1} [05621808-n] *noun.cognition* **is Related to** {perceptiveness:1} [04843875-n] *noun.attribute*.

Nouns labeled *noun.feeling* are related to nouns of classified as *noun.attribute* [8] or *noun.state* [9], as in: {uneasiness:3} [07507329-n] *noun.feeling* **is Related to** {discomfort:2} [14446652-n] *noun.state*.

Nouns classified as *noun.food* are related to nouns classified as *noun.attribute* [14], *noun.substance* [3], as in: {fizz:2} [07919310-n] *noun.food* **is Related to** {bubbliness:1; frothiness:1} [04733347-n] *noun.attribute*.

Nouns labeled as *noun.object* are related to concepts classified as *noun.attribute* [10]: {reef:5} [09406793-n] *noun.object* **is related to** {shallowness:2} [05135725-n] *noun.attribute*

Noun.substance and *noun.time* are related to *noun.attribute* [25, 12] or *noun.state* [3, 2]: {vapor:2} [15055633-n] *noun.substance* **is Related to** {cloudiness:3} [14524198-n] *noun.state*

Considering the observed results, some dependencies have been formulated, which for the moment copy the information from the semantic classes of the related nouns:

act_Result_attribute [31];
attribute_Property_state [33];
attribute_Property_cognition [31];
attribute_Property_act [13];
attribute_Property_feeling [21];
body_Property_attribute [12];
state_Property_person [14];
shape_Property_attribute [11];
person_Property_attribute [37];
cognition_Related_attribute [47];
substance_Related_attribute [25];
time_Related_state [12].

To sum up, nouns, which refer to an attribute may be a result of a certain act, as well as a property of or related to a particular shape, person, physical body, cognition or substance. Further, they may

have certain properties of state, cognition, act or feeling. Nouns for state are properties of a person, while nouns that indicate time may be related to a particular state. Some of these relations such as Property and Result can be traced back to noun – noun pairs linked via verbs, hence they may further deepen the lexical-semantic inter-relatedness.

5 Conclusion

The paper offers an approach to identification of semantic relations between nouns in WordNet that are indirectly linked via derivative relations through verbs and adjectives. In many cases, the derivationally related nouns preserve the semantics of the verb and the adjective, though there are some restrictions. We have formulated a basic set of semantic relations which mostly repeat the knowledge encoded on different levels of the network. Noun – noun relations also reflect certain restrictions on nouns that are related to verbs of certain classes. The new relations assigned to nouns, will not only increase the inter-relatedness and density of WordNet relations but would allow us to assign new semantic properties to nouns. The work will continue with extending both the number of related noun – noun pairs and the set of the semantic relations formulated.

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