Semantic State Superpositions and Their Treatment in Virtual Lexicographic Laboratory for Spanish Language Dictionary

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Abstract.The paper is devoted to ambiguities of Spanish language units: their formal modelling and treatment in the virtual lexicographic laboratory VLL DLE 23. The final goal is to find optimum solution for lexicographic treatment and research of ambiguities in the laboratory. As a theoretical base for developing ambiguity model, the theory of semantic states was selected. The ambiguity, i.e. the acquisition of different meanings by the unit at the same time in a given context, is represented in the model as a superposition of respective semantic states.Based on literature materials, the formal model of superpositions describing ambiguity formation mechanism in Spanish units was built. The model was further used to make out the interface intended for treating semantic state superpositions in VLL DLE 23.

Keywords: ambiguity, semantic state, superposition, virtual lexicographic laboratory, computer lexicography.

1 Introduction

One of the main problems of computer linguistics and lexicography isdevelopingmethods for language substance modelling. As an objectof modelling can be any unitof phonetic, morphological, lexical and other levels.A special aspectwe'd like to stay on here concerns ambiguitieswhich the lexical units (plain words, collocations) display in speech or text.Studyingambiguities hasbecome an object of research intheoretical [1, 2, 3, 4] and applied (computer) linguistics [5, 6, 7]. The main problems to be touched on by the researchers are: 1) the nature of ambiguity, including its position among other phenomena like homonymy and polysemy; 2) ambiguity classification; 3) ambiguity behavior in different discourses; 4) developing natural-language processing systems to deal with texts which contain ambiguities etc. The problem we'd like to deal with in our paper is ambiguities in the context of creating specialsystem (software) to maintain monolingual dictionaries in

digital environment. This systemis intended for lexicographers to process dictionary material and for scholars to conduct their different investigations based on the dictionary. Conducting lexicographic works and linguistic researches requireselaboration of a special software complex called virtual lexicographic laboratory[13] (herein after VLL). At present Ukrainian lingua-information fund develops a VLL for Spanish monolingual dictionary "Diccionario de la lengua española, 23ª edición" (herein after VLL DLE 23) and additional module to it for treatingand researching ambiguities of Spanish lexical units.

Prior to developing VLL DLE 23 it is important to get a strictly formalized microstructure of the dictionary in question using the theory of semantic states developed by Ukrainian Academic VolodymyrV. A. Shyrokov and his colleaguesand successfully proved on the materials of the Ukrainian language. The main idea laid in this theory is that any monolingual dictionary contains a set of possible semantic states which units can havein a language.When used in a context, collocation, sentence or text, the language unit is supposed to acquire one of semantic states from the set. The formalization of semantic state comes to building the model consisting of grammar (relation to a part of speech, grammar category) and lexical component (semantics) of state as well as additional parameters like homonymy index, context number etc. The whole set of semantic states for any lexical unit, registered in the dictionary, can be represented in the form of a chain. This chain is possible to be reduced to one element owing to the given context in which the unit functions. In this case we can assert that the unit has a "pure" semantic state. However there can be other contexts where it acquires two or more semantic states at the same time. In traditional linguistics such a phenomenon has different names like amphiboly [8], polysemy games [9], language game [10], lexical ambiguity [11, 12, 13] etc. In Shyrokov's interpretation this is a superposition of semantic states in other words, i.e. a chain of two or more elements. The semantic state and its superposition model are described in respective subsections. It should be noted the formal model of semantic state serves us as a basis for developing the database and user interface for VLL DLE 23.

Based on the above the goal of our research is to elaborate solutions concerning the user interface for lexicographic treatment of the superpositions in VLL DLE 23. To achieve the goal we are to: 1) study all possible superposition cases revealed in factual materials; 2) build up a formal model of superpositions, defining its parameters to be accessible through the interface; 3) outline the diagram showing interface with its main components.

1.1 Semantic State and its Formal Model

It's Russian mathematic A. M. Kolmogorov who was the first to introduce the notion of language unit state when attempting to give a formal definition to the case in the Russian language. But he hadn't published his linguistic works; theresults of his

[13] VLL (short for virtual lexicographic laboratory) is a digital environment where a dictionary exists as a language-information object designed to facilitate comprehensive informational description of lexical-grammar structures of a language or a set of languages [15].

research were published later by his disciple V. A. Uspenskiyin his paper [14]. Afterwards they were actually forgotten about.The second life to Kolmogorov and Uspenskiy‘s conception was given by V. A. Shyrokov in his works [16, 17] whereit got profound developmentas the theory of semantic states. According to this theory, semantic state represents a sum of grammar and lexical semantics and generalizes the notions of grammar and lexical meaning. As a basic statement we‘ll consider the existence of the correlation between a language unit and its state:

$$s: X \rightarrow (X), \tag{1}$$

Where X is a unit belonging to a certain class of language units, s is the correlation between X and a formal object $s(X)$, which is a content of the unit X. So, it is this object that will be named as semantic state. Let us assume decomposition of sematic state $s(X)$ into grammar and lexical components:

$$s(X) = g(X)l(X), \tag{2}$$

where $g(X)$ is grammar component of the state and $l(X)$ represents lexical meaning of the unit X. Decomposition (2) shows the dichotomy of language sign which is interpreted in traditional linguistics as a relation between form and content of language unit.

Let us analyzethe peculiarities of representing semantic states of Spanish language unit in DLE 23.The principles of their representation have been elaborated by the authors taking into account grammatical and lexical features of headwords: part-of-speech variation, dependence between lexical and grammaticalsemantics, special cases when lexical meaning has a limited use due to some grammar characteristics of a word etc.

For distinguishing grammatical and lexical componentsof semantic statesthe DLE 23 authors adopted the following designation system: 1) two vertical parallel lines (“‖”) to separate lexical meanings (definitions) corresponding to one grammatical meaning (part of speech, grammatical category); 2) black circle (“●”) to separate blocks of lexical meanings corresponding to different grammatical meanings; 3) white circle (“○”) to separate lexical meanings corresponding to some grammatical categories of a headword. The adjectives, adverbs and pronouns are marked as “adj.”, “adv.” and “pron.”, respectively. The nouns are identified with gender and number marks (“m.”, “f.”, “m. y f.”, “m. o f.”, “pl.”). Fig. 1 shows the example of a DLE 23 entry*cómico*.

cómico, ca. (Del lat. *comĭcus*, y este del gr. κωμικός *kōmikós*). adj. 1. Que divierte y hace reír. *Situación cómica*. ‖ 2. Perteneciente o relativo a la comedia. ‖ 3. Dicho de un actor: Que representa papeles **cómicos**. U. t. c. s. ‖ 4. Dicho de un autor antiguo: Que escribía comedias. U. t. c. s. ● m. y f. 5. **comediante** (‖ actor). ○ f. 6. *Pan.* **historieta** (‖ serie de dibujos). U. m. en pl. ‖ 7. *Pan.* **dibujos animados**. ■

Fig. 1. Entry of the headword cómico in DLE 23

The headword in consideration has three blocks of lexical meanings; the first is related to adjective (adj.), the second, to the noun of common gender (m. y f.) and the third, to the noun of feminine gender. The first block consists of four lexical meanings (1-4), the second, of one meaning (5) and the third, of two meanings (6-7). So, the sum of semantic states $S(X)$ can be formalized in the following way:

$$S(X) = \sum_{i,j} g_i(X) l_j(X), \quad (3)$$

Thus, grammatical states and respective lexical states of the language unit X = *cómico* are as follows:

1) g_1(*cómico*) = ~~–a~~dj.":l_1(*cómico*) = ~~–Q~~ue divierte y hace reír. *Situación cómica*", l_2(*cómico*) = ~~–P~~erteneciente o relativo a la comedia", l_3(*cómico*) = ~~–D~~icho de un actor: Que representa papeles cómicos. U. t. c. s.", l_4(*cómico*) =~~–D~~icho de un autor antiguo: Que escribía comedias. U. t. c. s."[14];

2) g_2(*cómico*) = ~~–m~~. y f.": l_5(*cómico*) =~~–~~**comediante** (|| actor)"[15];

3) g_3(*cómico*) = ~~–f.~~": l_6(*cómico*) = ~~–P~~*an.* **historieta** (|| serie de dibujos). U. m. en pl.", l_7(*cómico*) = ~~–P~~*an.* **dibujos animados**"[16].

Taking into account the relation between grammatical and lexical semantics, the formula (3) will get another element $I(i; j; x)$ displaying this relation:

$$S(X) = \sum_{i,j} g_i(X)(i; j; X) l_j(X) , \quad (4)$$

where i is grammatical meaning index of the headword X having semantic state $S_i(X)$; j is lexical meaning index corresponding to index i;$I(i; j; X)$ is the function providing relation between grammatical and lexical components of semantic state.

1.2 Language Unit Ambiguity and Semantic State Superpositions

The formula to display the whole set of a unit semantic states, is as follows:

$$S(X) = \alpha_1 s_1(X) + \alpha_2 s_2(X) + \cdots + \alpha_n s_n(X), \quad (5)$$

where$X$ is a language unit; $s_1(X)$, $s_2(X)$,…, $s_n(X)$ being partial semantic states the structure of which comprises grammatical and lexical components of the unit X;α_1, $\alpha_2$and$\alpha_n$being weighting factors the values of which can get different values depending on the context where the unit X is used. In other words, the recipient (lexicographer, reader or computer program) during context processing by his ~~–in~~telligence-communication apparatus"assigns respective values to these factors based on his subjective ideas aboutsemantic functioning of the unit X in the given context.The calculation of weighing factors is a subject of another research. But the important condition to be fulfilled is that the sum of their values $\alpha_1 + \ldots + \alpha_n$ should be equal to 1. The semantic state that has got maximum coefficient will be looked

[14] l_1(*cómico*) = ~~–E~~ntertaining and causing laughter. *Comic situation*", l_2(*cómico*) = ~~–R~~elating to a comedy", l_3(*cómico*) = ~~–A~~n actor playing comic parts. A. u. as a n. [also used as a noun]",l_4(*cómico*) = ~~–A~~n ancient author who wrote comedies. A. u. as an."

[15] l_5(*cómico*) = ~~–C~~omedian (|| actor)".

[16] l_6(*cómico*) = ~~–P~~*an.* Comics (|| comic strips).M. f. u.in pl." [more frequently used in plural].

upon as the most relevant. In this way the equation (5) applied to a certain context is supposed to be reduced to one element. Let us give some text fragments where Spanish word *banco* acquires different semantic states:

1. –Como no tenía nada que hacer, después de desayunar un jugo de naranja en una cafetería me dediqué a leer el periódico sentado en un *banco*, …"[17];
2. –Los *bancos* del mundo deciden bloquear cualquier transacción financiera proveniente de Haití"[18].

According to DLE 23, the word analyzed has a set of 10 semantic states which in the given contexts undergoes reduction to one element: in (1), to s_1(*banco*) = –Asiento, con respaldo osinél,enquepuedensentarsedosomáspersonas"[19] (a bench); in (2), to s_5(*banco*) = –Empresa dedicada a realizar operaciones financieras con el dinero procedente de sus accionistas y de los depósitos de sus clientes"[20] (a bank). The process of reduction is known in linguistics as word-sense disambiguation. The semantic states given above are considered to be –pure" since they don't contain grammatical and lexical componentsof other semantic states of the word *banco*. Consequently the recipient can identify them easily in these contexts.

However a language unit doesn't alwayshave –pure" semantic states as it was shown in the examples above. The cases of unit functioning in different sematic states at same time and in the same text (context) are attributedto the superposition of semantic states. In this situation we have an ambiguous word and the context analysis was unsuccessfulin identifyingthe sense it is used in. For example in the sentence –Su desgracia fue quebrarle la mano"[21] the word *mano* can be interpreted as –as a part of human body" (a hand) or –a pointer on a clock" (a hand), or –an act or right of playing first" (lead). Besides that, the pronoun *su* can denote –his", –her", –its" or –your".

Thus, the whole set of semantic states are reduced not to one but to the sum of two or more elements. Let us take a closer look at the phenomenon of semantic state superposition on the examples from Spanish literature and build up the formal model of semantic state superposition.

2 Semantic State Superpositions Occurrence in Speech

Ambiguity in texts can arise either naturally due to internal peculiarities of semantic nature of the word (1), or be made artificially by language speakers to express irony, achieve a comic effect etc. (2), simulate misunderstanding (3), veil the meaning of a word (4) or combine direct and figurative meanings in the same word (5):

1. –En tanto que don Quijote *pasaba* el libro, *pasaba* Sancho la maleta, sin dejar rincón en toda ella, ni en el cojín que no buscase, escudriñase e inquiriese, ni costura que no deshiciese, ni vedija de lana que no escarmenase, porque no se

[17] After having orange juice for breakfast at acafeteria, with nothing elseto do I set on a *bench* and devoted myself to reading a newspaper.

[18] The world *banks* decided to block any financial transactions from Haiti.

[19] A seat, with or without back, that can sit two or more persons on.

[20] An establishment engaged in financial operations with money incoming from its shareholders or deposited by its clients.

[21] He / She / You had amisfortune to break his / her / its hand / pointer / lead.

quedase nada por diligencia ni mal recado; tal golosina había despertado en él los hallados escudos, que *pasaban* de ciento"(I, 23, p. 284)[22];

2. –Salió de la carcel con tanta honra, que le acompañaron doscientos *cardenales*; salvo que a ningunallamaban eminencia"(Fco. de Quevedo, La vida del buscón llamado Pablos)[23];
3. –P: ¿Y si finalmente te quedarás para vestir *santos*? / R: Yo pués *los* vestiría con un Lacroix"(Tamara Falcó, Entrevista concedida a lecturas)[24];
4. –C*ruzados* hacen *cruzados* / *escudos* pintan *escudos*, / y tahúresmuy desnudos / con dados ganan condados"(Luis de Góngora, Dineros son calidad)[25];
5. –El carnaval logra *enmascararlo* todo. Salvo la belleza femenina" (Jnj –melibeo", en Flickr)[26].

Let us analyze the context (1). By using the verb *pasar* author meant that (a) Sancho *studied thoroughly* the content of the bag, (b) Don Quijote*looked through* the bookand (c) Sancho found *more than* hundred coins. So the superposition includes three semantic states (lower indexes of the states correspond to definition number in DLE 23): s_{22}(*pasar*) = –Leer o estudiar sin reflexión" (to look through smth.), s_{21}(*pasar*) = –Recorrer, leyendo o estudiando…" (to study thoroughly) and s_8(*pasar*) = –Exceder, aventajar, superar" (exceed, to be more than).

The context (3) contains a short fragment of the interview with a woman working as a fashion designer. In journalist's question (P) the word *santos* acquires its sematic state as a component of the Spanish collocation *vestir santos*and means–to be left on the shelf (of a woman)". He actually wants to find out what she will do when she passes the age in which she may have an opportunity to marry. But she (R) understood this phrase in its literal meaning: –which clothing styleshe would select for saints". She mighthave interpreted word *santos* in direct meaning and that's why her answer was –I would dress them [the saints] in Lacroix style".

As for the context (4), the word *cruzado* has been applied in two semantic states at the same time: s_3(*cruzado*) = –Dicho de un caballero: Que trae la cruz de una orden militar. U. t. c. s." (crusader) and s_7(*cruzado*) = –Monedade Castilla, de plata o de vellón, mandada acuñar por Enrique II, yque tenía una cruz en el anverso, en el caso de la de plata" (coin, money). The same situation happens to the word *escudo*: s_2(*escudo*) = –Superficie o espacio generalmente en forma de escudo, en que serepresentan los blasones de un Estado, población, familia, corporación, etc."

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[22] While Don Quixote examined the book, Sancho examined the valise, not leaving a corner in the whole of it or in the pad that he did not search, peer into, and explore, or seam that he did not rip, or tuft of wool that he did not pick to pieces, lest anything should escape for want of care and pains; so keen was the covetousness excited in him by the discovery of the crowns, which amounted to near a hundred [http://pd.sparknotes.com/lit/donquixote/section27.html].

[23] He was going out of prison with a great honor in the company of two hundred cardinals, though none of them was addressed as Eminence.

[24] Q: And what if you finally remain *to dress the saints* [left on the shelf, never get married] /A: Well, I would dress themin Lacroix style.

[25] *Money* makes *money* [*knights* make *knights*] / *gold pieces* paint *escutcheons* [*escutcheons* paint *escutcheons*] / and gamblers nude / with dice they win counties.

[26] The carnival can *mask* [*disguise*] everything, except for feminine beauty.

(escutcheon) and s_9(*escudo*) = –Unidad monetaria antigua de distintos países y épocas" (ancient monetary unit).

The phrase (5) evidences the superposition consisting of semantic states, one representing direct figurative meanings, respectively: s_1 = –Cubrir el rostro con máscara. U. t. c. prnl." (direct: to cover the face in a mask) and s_2 = –Encubrir o disimular algo. U. t. c. prnl." (figurative: conceal smth. from view). Consequently, the formal model of semantic state superposition in the contexts (1), (3), (4) and (5) is as follows:

$$S(X) = \sum_p s_p(X) , \tag{6}$$

where p is the index of a semantic state composing the superposition. The ambiguity shown in the context (2) is based on the homonymity of the word *cardenal*: $s_1^{[1]}$ = –Cada uno de los prelados que componen el colegio consultivo del papa y forman el cónclave para su elección" (a cardinal) and $s_1^{[2]}$ = –Mancha amoratada, negruzca o amarillenta de la piel a consecuencia de un golpe u otra causa" (a bruise). So the superposition of semantic states for the word analyzed will have the following model:

$$S(X) = \sum_{p,[k]} \alpha_p{}^{[k]} S_p{}^{[k]}(X), \tag{7}$$

where k is the index of a homonym used in meanings 1, 2… N. The formula above is also applicable to homography cases when different parts of speech coincide with each other by their grammatical form. For example, the popular shampoo in Argentina had slogan –para la caspa".When it was promoted by TV the viewers couldn't catch whether the word *para* was referred to the verb *parar* (3rd person singular in the indicative moodof present tense) or to the preposition *para* (for). The slogan in question could be interpreted ambiguously: the shampoo stops dandruff or the shampoo is intended for dandruff.

For the Spanish language is also natural to have grammatical ambiguity, in particular in nouns. With the same grammatical form the can function as an adjective in a sentence. This can also lead to ambiguous understanding of a word. For example: –Soy *cómico*, sí lo confieso, pero de corazón no malo y aún sincero cuando me lo propongo" (Chabaud Jaime, Divino pastor Góngora)[27].

The above sentence shows grammatical ambiguity of the word *cómico*. It can be either a noun or an adjective. It's worth noting that the main sign of the noun in the sentence is a definite (*el*, *la*) or indefinite (*un*, *una*) article. But it isn't observed in the context. That's why the phrase –Soy *cómico*" has two interpretations: –I'm a comedian" or –I'm funny".The superposition of semantic states of lexical and grammatical homonyms is formed in the way it is shown by the equation (7).

3 Lexicographic Treatment ofSuperpositions in VLL DLE 23

Within the scope of works on creating VLL DLE 23, we develop the interface intended for treating –pure" semantic states and their superpositions. If compare

[27] I'm *comic* [*a comedian*], I confess it from the bottom of my heart and I'm even sincere when I set my mind to it.

ordinary electronic dictionaries, including online dictionaries, VLL proposes software interface to perform:

1. *Access administration function*: user authorization and identification; addition and deletion of new users; managing access modes (only reading, reading and edition of dictionary material);
2. *Lexicographic works*: editing dictionary entries; creating dictionary on the basis of DLE 23; entry representation in any mode;
3. *Research works*: researching language levels covered by DLE 23 (grammar including word formation; vocabulary including semantics and pragmatics); researching the interaction of the language levels: grammar and semantics, word formation and semantics, semantics and pragmatics etc.

In the context of our research topic we propose a special module ―Superpositions" to be provided for VLL DLE 23 (fig. 2) and had the following interface elements:

1. The table enlisting all semantic states of a headword superpositions revealed in authentic texts (belles-lettres, journalism, advertising etc.), with the following columns:
   (a) ―Canonic form" where the initial form of the word having ambiguity is indicated;
   (b) ―Superposition" which contains the index of word superposition, for example: ―1+5", ―3+2" etc.; the figures indicating the numbers of semantic states represented in DLE. In case of homonyms their numbers to be given in square brackents;
2. Text field ―Context" to enter a text fragment where a word shows its ambiguity and, respectively, forms semantic state superposition;
3. The table containing the values of parameters constituting the equation (7):
   (a) ―State": semantic state index (corresponding to definition number in DLE) in the superposition;
   (b) ―Weight":the factor indicating the relevance of semantic state in superposition;
   (c) ―Homonym": if semantic state belongs to a homonym the index of the homonym (lexical or grammatical) should be indicated;
   (d) ―Part of speech" containing the relation of the word to the part of speech or grammatical category. The designation of parts of speech will be taken from DLE 23;
   (e) ―Definition" to insert a definition text from DLE 23. This parameter corresponds to lexical component of semantic state;
4. Text field ―Comment" to enter some notes containing the users' interpretations of word ambiguity (for example: language game or polysemy game etc.).

The window of the program module ―Superpositions" provided for VLL DLE 23 shows the example of treating ambiguous word *cardenal* and representing its semantic state superposition is shown on figure 2.All the tables and text fields are filled by a specialist (lexicographer and / or linguist) after thorough examination of the contexts extracted by him from different literature sources. On finding a context the user determines word ambiguity by looking through all the definitions of the word (semantic states) enlisted in VLL DLE 23. By the results of the context analysis the user defines the superposition of the word and fills it in the upper table in a form of the index combination. Further he fills details related to semantic states composing

the superposition. The weight factors are determined based on the user‘s own considerations or by using separate software.

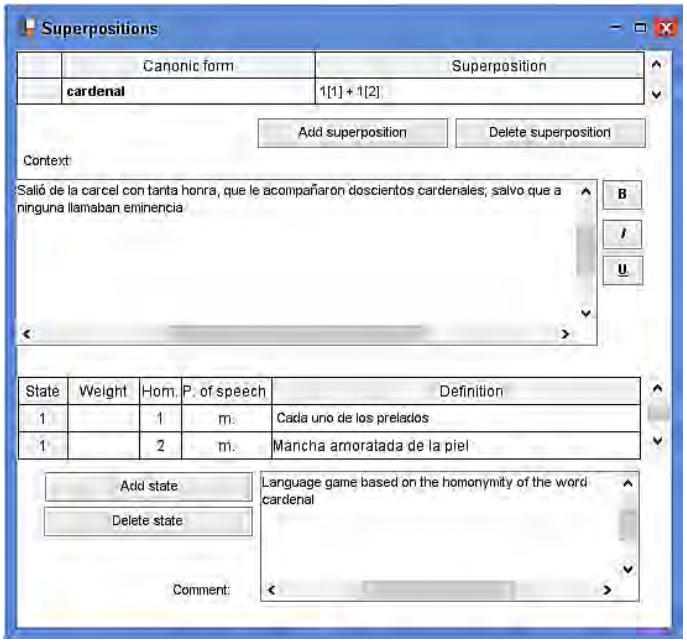

Fig. 2. Diagram of VLL DLE 23 interface for treating semantic state superpositions

4 Conclusions

1. Ambiguity is a property of a language unit to function in several semantic states at the same time in a context. Ambiguity can arise naturally (i.e. caused by the nature of a language) or can be caused deliberately by language speakers to create a particular effect.
2. The examples given above testify that any ambiguous Spanish unit can form semantic state superposition either on one or several language levels.
3. Using the theory of semantic states we built a formal model of superposition which represents the ambiguity of Spanish language unit. The parameters of the model (7) are going to be used for semantic state indexing, searching and displaying in respective form in VLL DLE 23.
4. In our opinion, the program module to be included in VLL DLE 23will facilitate conducting an ample range of linguistic researches, among them are logical-linguisticstudy of texts, analysis of speech acts including language games, semantic analysis etc. The module will be also planned to be used in linguo-didactic applications.

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