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Describing Linguistic Vagueness of Evaluative Expressions Using Fuzzy Natural Logic and Linguistic Constraints

Adrià Torrens-Urrutia [1,*,†], Vilém Novák [2,†] and María Dolores Jiménez-López [1,†]

1 Research Group on Mathematical Linguistics (GRLMC), Universitat Rovira i Virgili, 43002 Tarragona, Spain; mariadolores.jimenez@urv.cat
2 Institute for Research and Applications of Fuzzy Modeling (IRAFM), University of Ostrava, 701 03 Ostrava, Czech Republic; vilem.novak@osu.cz
* Correspondence: adria.torrens@urv.cat
† These authors contributed equally to this work.

Abstract: In recent years, the study of evaluative linguistic expressions has crossed the field of theoretical linguistics and has aroused interest in very different research areas such as artificial intelligence, psychology or cognitive linguistics. The interest in this type of expressions may be due to its relevance in applications such as opinion mining or sentiment analysis. This paper brings together Fuzzy Natural Logic and Fuzzy Property Grammars to approach evaluative expressions. Our contribution includes the marriage of mathematical and linguistic methods for providing a formalism to deal with the linguistic vagueness of evaluative expressions by describing the syntax and semantics of these structures. We contribute to the study of evaluative linguistic expressions by proposing a formal characterization of them where the concepts of semantic prime, borderline evaluative expressions and markedness are defined and where the relation between the semantic constraints of evaluations and their sentiment can be established. A proof-of-concept of how to create a lexicon of evaluative expressions for future computational applications is presented. The results demonstrate that linguistic evaluative expressions are gradient, have sentiment, and that the evaluations work as a relation of hypernym and hyponym, the hypernym being a semantic prime. Our findings provide the basis for building an ontology of evaluative expressions for future computational applications.

Keywords: evaluative expressions; linguistic gradience; fuzzy grammar; linguistic constraints; grammaticality; sentiment analysis

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1. Introduction

This article focuses on evaluative linguistic expressions, i.e., expressions such as *small*, *medium*, *large*, *very deep*, *rather shallow*, *beautiful*, etc. Our main objective is to provide a formal characterization of this type of expressions by defining them in syntactic terms (determining their canonical and borderline structures) and by describing them semantically in order to account for their vagueness and characterizing their sentiment polarity. In this work, we propose a model with a single scale that allows grading and computing the semantic orientation of an evaluative expression by means of a fuzzy relationship between the semantics of these expressions and the concepts of '*positive–negative*'. With this model, we can calculate the semantic orientation of words.

Fuzzy Natural Logic (FNL) and its theory of evaluative linguistic expressions is a well-known mathematical theory [1–7]. This theory is based on Lakoff's hypothesis of universal meaning [8]. Lakoff argues that natural logic is a collection of terms and rules that come with natural language and that allow us to reason and argue in it. FNL tries to account for the basic principle by which people understand each other. This principle is universal and makes communication possible between people of different origins and cultures. An example of this universal representation of meaning is found when any speaker of any place and language and in any situation is able to understand an expression such as "*that person is far away*". Regardless of whether the meaning of "*far*" is "*800 km*" or "*5 km*", we understand that "*far*" means "a high value on a scale of *distance*", with regards to a specific context. A component of FNL is also the theory of intermediate quantifiers [9–11] that are expressions such as *most, many, a lot of, a few, several*, etc..

FNL has been successfully applied in time series analysis [12–14], or data mining [15]. We claim that it can be useful for a richer extraction of semantic meaning and for more accurate sentiment analysis. The main advantage of our formalism is that it provides a unified formal analysis for the semantics of all kinds of evaluative expressions.

However, Fuzzy Natural Logic is a hardly known theory in linguistics and is barely used for linguistic semantic analysis. Most of the recent works in linguistics that involve the study of the semantics of the evaluative language is found in the area of sentiment analysis [16].

Some of the works in linguistics integrating FNL as a fundamental part of their framework can be found in the modelling of a Fuzzy Property Grammar [17–20]. FNL is essential to define the basis of a fuzzy grammar with linguistic features in such work. Furthermore, FNL describes the grammar on a higher (abstract) level. In contrast, linguistic constraints describe the grammar on a local level (at the level of the sentence). The notion of linguistic constraint stands for a relation that puts together two or more linguistic elements, allowing Fuzzy Property Grammar to model vague, highly controversial phenomena for linguists at both levels. Some of the phenomena that a Fuzzy Property Grammar models using the theory of evaluative linguistic expressions are linguistic gradience in natural language, grammaticality, linguistic complexity, and linguistic universality.

This paper provides modifications and suggestions to expand the theory of evaluative expressions towards a linguistic theory as well as future Natural Language Processing (NLP) applications. We have implemented in FNL the notions of theoretical linguistics, linguistic constraints, and characterization of borderline semantic linguistic phenomena in natural language.

Our proposal can contribute to the lexicon-based models in sentiment analysis. The issue of extracting sentiment automatically has been approached in two different ways [21,22]: by using *Machine learning techniques* or by considering *Lexicon-based approaches*. The advantage of the machine learning approach is that with a labeled data set training, a classifier can be easily built with existing classifier tools [23]. The main drawback of these techniques is that, being trained with very specific data, it is difficult to apply the model to new contexts. In contrast, lexical-based methods are robust across domains without changing dictionaries. Furthermore, applying dictionaries to a new language is a less demanding task than labeling data in a new language for a classifier [23].

Lexicon-based techniques promote a good synergy between the computational and linguistic approach since they use the linguistic information contained in the text [23]. Moreover, these approaches have been highly regarded in the recent studies.

Some techniques based on the lexicon start from the following two assumptions [23]: (1) words have a "prior polarity", having a semantic orientation independent of the context; and (2) it is possible to express the semantic orientation with a numerical value. Another important issue to consider is the fact that the semantic orientation of words is affected by the linguistic context; for this reason, it is essential to take into account contextual valence shifters.

Lexicon-based techniques provide for each word classifications of its semantic orientation. To assign each word the value of '*positive*' or '*negative*', these classifications are based on Distribution Semantics (DSm) methods. These classifications are either discrete or gradual.

As shown in Table 1, both [24]'s SentiWordNet and [25] Macquire's Dictionary show only two classifications related to semantic sentiment: *p*ositive and *n*egative. On the contrary, the Subjectivity Dictionary proposed by [26,27] considers in addition to the values '*p*ositive' and '*n*egative' two additional elements for each of them: *s*trong and *w*eak. Despite a certain graduality shown by the dictionary of subjectivity, this approach still fails to capture the vague and gradient spectrum between '*p*ositive' and '*n*egative'. In contrast, Ref. [23] offers a richer and more formal model in its proposed Semantic Orientation Calculator (SO-CAL) that features a graded rating on a 10-point scale, from −5 to +5. Unlike previous models, Ref. [23] makes an effort to capture both the vague and gradient nature of semantically oriented word meaning and provides a numerical value for each evaluative item that allows for more detailed extraction of sentiment and of meaning.

Table 1. Sample of semantic orientation values for lexicon-based approaches from Taboada [23].

	SentiWordNet [24] Baccianella et al. (2010)	**Macquire Dictionary [25] Mohammad et al. (2009)**	**Subjectivity Dictionary [26] Wilson et al. (2005)**	**SO-CAL [23] Taboada (2016)**
good	Positive	Positive	Positive (weak)	*3*
excellent	Positive	Positive	Positive (strong)	5
masterpiece	Positive	Positive	Positive (strong)	5
bad	Negative	Negative	Negative (strong)	−3
terrible	Negative	Negative	Negative (strong)	−5
disaster	Negative	Negative	Negative (strong)	−4

Although the models presented in Table 1 generally offer good solutions for calculating the semantic orientation of words, in this paper, we want to propose a different model that uses a single scale for grading and computing the semantic orientation of words and its sentiment together with the description of their structure in a sentence with a fuzzy grammar, i.e., describing prototypical and borderline structures in which such words appear.

The remainder of this paper is organized as follows. Section 2 introduces the basics of Fuzzy Natural Logic. Section 3 presents Fuzzy Property Grammars as a constraint-based grammar that deals with linguistic vagueness. In Section 4, our proposal of a formal characterization of evaluative expressions is presented by defining the concept and by providing a syntactic and semantic explanation of evaluative expression. Section 5 describes a proof of concept to identify trichotomic expressions in Spanish and English from SO-CAL corpus. Section 6 presents some conclusions and future research lines.

2. Fuzzy Natural Logic: Formal Prerequisites

This section summarizes the basic concepts of Fuzzy Natural Logic. It is underpinned on six key concepts:

- *Fuzzy set*. A fuzzy set A in a universe U, is a function $A : U \longrightarrow L$ where $L = [0, 1]$ is a support of the standard Łukasiewicz MV-algebra $\langle [0, 1], \wedge, \vee, \otimes, \rightarrow, 0, 1\rangle$. The $\wedge, \vee$ are lattice operations (here equal to min and max), $\otimes, \rightarrow$ are Łukasiewicz conjunction and implication, respectively defined by

$$a \otimes b = \max\{0, a + b - 1\}, \qquad a \rightarrow b = \min\{1, 1 - a + b\}$$

  where $a, b \in [0, 1]$. The set of all fuzzy sets on U is denoted by $\mathcal{F}(U)$. If A is a fuzzy set then its *kernel* is a set $Ker(A) = \{u \mid A(u) = 1\}$.
- *Lakoff's hypothesis of universal meaning*. According to Lakoff [8], natural logic is a collection of terms and rules that comes with natural language and allows people to

reason and argue in it. This idea captures the basic principle of why people understand each other. This principle is universal in all languages and makes communication among people possible.

- *Evaluative linguistic expressions* are those expressions of natural language used by people to characterize features of objects or their parts [1,5,12] such as *length*, *beauty*, *size*, *complexity*, *economical value*, *kindness*, among others. The most elaborated evaluative expressions in FNL simple evaluative ones. They have the general form

$$\langle \textit{linguistic hedge} \rangle \langle \textit{TE-adjective} \rangle \tag{1}$$

  $\langle$*TE-adjective*$\rangle$ can be grouped to form a *fundamental evaluative trichotomy* consisting of two antonyms and a middle term, for example $\langle good, normal, bad \rangle$, $\langle beautiful, normal, ugly \rangle$, $\langle easy, average, complex \rangle$, etc. The triple of adjectives $\langle small, medium, big \rangle$ is taken as canonical. On the other hand, $\langle$*linguistic hedge*$\rangle$ makes more or less specific the meaning of the $\langle$TE-adjective$\rangle$. Usually it is represented by an intensifying adverb such as "*very*", "*roughly*", "*approximately*", "*significantly*", etc. This is a special expression representing a linguistic phenomenon called *hedging*. In some papers of FNL, $\langle$*linguistic hedge*$\rangle$ is found as $\langle$*linguistic modifier*$\rangle$.
- *Possible world*. It is a specific context in which a linguistic expression is used. In the case of evaluative expressions, it is characterized by a triple $w = \langle v_L, v_S, v_R \rangle$. Without loss of generality, it can be defined by three real numbers $v_L, v_S, v_R \in \mathbb{R}$ where $v_L < v_S < v_R$. These numbers represent an interval of reals $[v_L, v_S] \cup [v_S, v_R]$ where v_S is marked to emphasize position of "typically medium".
- *Intension*. The intension of a linguistic expression is a property denoted by a specific word or expression. It is independent on a concrete possible world (context) and does not change when the context is changed.
- *Extension*. The extension of a linguistic expression is the referent. It depends on the particular context and changes when the possible world changes. With the exception of few specific cases, the elements falling into an extension are delineated vaguely. In our theory, they are accompanied by degrees. For example, the expression "*very long distance*" has always a high degree in any context of distance (possible world). Thus, "*very long distance in Europe*" is "*1000 km*" when "*driving a car*", while it is "*5 km*" when "*walking on foot*". In such case, extensions are fuzzy sets in the intervals $[0, 1000]$ and $[0, 5]$.

Definition 1. *Let $\mathcal{A}$ be an expression of natural language. Then, its intension Int($\mathcal{A}$) is a function*

$$Int(\mathcal{A}) : W \to \mathcal{F}(V) \tag{2}$$

where W is a set of possible worlds, V is a set of some objects and $\mathcal{F}$ is a set of all fuzzy sets defined on V. The extension of $\mathcal{A}$ in a given possible world (context) $w \in W$ is a fuzzy set $Ext_w(\mathcal{A}) = Int(\mathcal{A})(w) \in \mathcal{F}(V)$.

In Figure 1 (from [6]), extensions of the expressions forming the fundamental evaluative trichotomy are depicted. Part (b) of the figure contains informal justification, how the shapes of extensions of evaluative expressions are constructed. Namely, in the given context $\langle v_L, v_S, v_R \rangle$, "small" values are those around the left bound v_L, while, e.g., "very small" or "extremely small" are part of the small ones. Similarly for "big", that are values around the right bound v_R. "Medium" values are values around the central point v_S (note that it can lay on an arbitrary place between v_L and v_R).

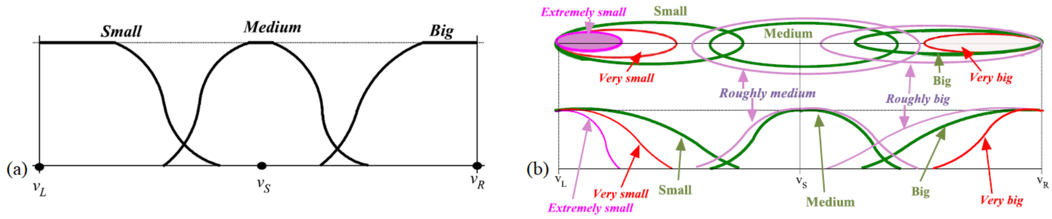

Figure 1. (**a**) Fuzzy sets modeling extensions of expressions that form the fundamental linguistic trichotomy; (**b**) Scheme of extensions of evaluative expressions with modifiers.

3. Fuzzy Property Grammar

Fuzzy Property Grammars combine the formalism of Fuzzy Natural Logic and linguistic constraints typically used in linguistics. The higher-order fuzzy logic as a formalism describes the grammar at a higher level (abstractly), enabling a mathematical formalization of the degrees of grammaticality. In comparison, linguistic constraints of a Property Grammar [28] allow us to describe vague phenomena on a local-sentence level. However, unlike a standard Property Grammar, FPGr characterizes the objects (constraints) as prototypical and borderline. Therefore, both assets are necessary to build a Fuzzy Property Grammar. In this section, the basic concepts of Fuzzy Property Grammars are presented.

A linguistic *constraint* is a relation that puts together two or more linguistic elements such as *linguistic categories*, or *parts-of-speech*. Formally, a linguistic constraint is an n-tuple $\langle A_1, ..., A_n \rangle$ where A_i are linguistic categories. We usually have $n = 2$. We consider the following linguistic categories:DET (determiner), ADJ (adjective), $NOUN$ (noun), $PROPN$ (proper noun), $VERB$ (verb), ADV (adverb), $CONJ$ (conjunction), $SCONJ$ (subordinate conjunction) and ADP (preposition).

To identify linguistic categories, it is necessary to either use a part-of-speech tagger or to identify them according to the constraints of a specific language. For example, Spanish and English would have their constraints to identify a $NOUN$ and an ADJ, which will not necessarily be shared with Chinese or Japanese. It could happen that natural languages would require an extension or a shortening of these part-of-speech. Because FPGr is closely related to the framework of Universal Dependencies (UD) [29,30], we recommend using the UD parser to identify each part of speech. UD recognises a maximum of 17 elements in a part-of-speech parsing. However, when working with FPGr in the syntactic domain, the model proposes to shorten from 17 part-of-speech to 9 (at maximum) to simplify the model and the analysis of the inputs from UD. The fact of how FPGr would identify part-of-speech with constraints UNIVERSALLY is not explored yet, since it is such a new model and mainly applied for the syntactic domain, mainly in Spanish and English. A further explanation of this can be found in Torrens–Urrutia in [19] (Chapter 7). One of the options to describe linguistic categories with constraints universally is to implement formal definitions of General Natural Syntax (GNS) from Manca and Jiménez-López [31] into FPGr.

The constraints provide a non-derivational definition of several linguistics. Linguistic constraints indicate the properties that an object (or objects) must satisfy. Thus, linguistic constraints define both the linguistic knowledge of a speaker, and the membership of a linguistic input towards a specific grammar in terms of constraint satisfaction. There are four types of constraints in Fuzzy Property Grammars:

- *General or universal constraints* that are valid for a universal grammar (any language).
- *Specific constraints* that are applicable to a specific grammar.
- *Prototypical constraints* that definitely belong to a specific grammar, i.e., their degree of membership is 1.
- *Borderline constraints* that belong to a specific language with some degree only (we usually measure it by a number from [0,1]).

The constraints that FPGr work with are the following (the A and B are understood as linguistic categories):

- *Linearity* of precedence order between two elements: A precedes B, in symbols $A \prec B$. Therefore, a violation is triggered when B precedes A. Example: *"The (DET) professor (NOUN)"*, $C_\alpha(DET \prec NOUN)$. C_α stands for satisfied constraint.
- *Co-occurrence* between two elements: A requires B, in symbols $A \Rightarrow B$. A violation is triggered if A occurs, but B does not. Example: *"The (DET) girl (NOUN) plays football"* $C_\alpha(NOUN \Rightarrow DET)$, but *"girl (NOUN) plays football"* $C_\beta(NOUN \Rightarrow DET)$. C_β stands for violated constraint.
- *Exclusion* between two elements: A and B never appear in co-occurrence in the specified construction, in symbols $A \otimes B$. That is, only A or only B occurs. Example: *"He (PRON) does yoga"*, $C_\alpha(PRON \otimes NOUN)$, but *"He (PRON) boy (NOUN) does yoga"* $C_\beta(PRON \otimes NOUN)$.
- *Uniqueness* means that neither a category nor a group of categories (constituents) can appear more than once in a given construction. For example, in a construction X, $Uniq = \{a, b, c, d\}$. A violation is triggered if one of these constituents is repeated in a construction. Example: *"The (DET) the (DET) kid that who used to be my friend"* $C_\beta($ in nominal construction: $Uniq = \{Det, Rel\})$.
- *Dependency*. An element A has a dependency$_i$ on an element B, in symbols $A \rightsquigarrow_i B$. Typical dependencies (but not exclusively) for $_i$ are $subj$ (subject), mod (modifier), obj (object), $spec$ (specifier), $verb$ (verb), $conj$ (conjunction). A violation is triggered if the specified dependency does not occur. Example: *"Andorra is a small (ADJ) country (NOUN)"*, $C_\alpha(ADJ \rightsquigarrow_{mod} NOUN)$, but *"Andorra is a small (ADJ) goodly (ADV)"*, C_β $(ADJ \rightsquigarrow_{mod} NOUN)$.
- *Obligation*. This property determines which elements are heads. It is expressed by the symbol $\Box$. This property tends to be avoided since FPGr pursues to define the relationship of part-of-speech without hierarchy or derivation, only at a local level. However, it is useful to define specific constructions to express the mandatory appearance of a category or linguistic feature.

Additionally, two key concepts for the formalization of Fuzzy Property Grammars are:

- *Linguistic Feature*. Features specifies when properties are going to be applied to a category. The typical feature to be represented is a linguistic function, such as the function of *subject*: $A_{[subj]}$. Features are always written and subindexed in a linguistic category, i.e., $NOUN_{[subj]}$.

Example 1. *A property for an English grammar such as* $N \prec V$ *might be inaccurate since the noun can both precede and be preceded by a verb. We can specify functions and other values for a category to provide proper linguistic information thanks to the features. Therefore, property grammars can specify that a noun as a subject precedes a verb:* $N_{[subj]} \prec V$. *Features reinforce properties as a tool that can describe linguistic information independently of a context and more precisely represent grammatical knowledge by taking into account linguistic variation. However, features can express any type of specification from any domain. For this paper, we are interested in semantic features, which will be expressed like the following* $A_{[sem:x]}$. *Such characterization is useful for words that even being defined with the same category trigger different meanings, i.e., I have a snake, (snake* $NOUN_{[sem:animal]}$*), John is a snake, (snake* $NOUN_{[sem:treacherous]}$*).*

- *xCategory*. An *xCategory* is a feature which specifies that a certain category is displaying a *syntactic fit* from another category, for example, an adjective with a *syntactic fit of a noun*. All the *xCategories* are marked with a x before a prototypical category, i.e., $xADJ$. For example, in Spanish, *el boxeador (NOUN) león (NOUN)* (*the lion boxer*), *león (NOUN)* is performing as an adjective; therefore, *el boxeador (NOUN) león* $(NOUN_{[xADJ]})$.

Definition 2. *A Fuzzy Property Grammar (FPGr) is a couple*

$$FPGr = \langle U, FGr \rangle \tag{3}$$

where U is a universe

$$U = Ph_\rho \times Mr_\mu \times X_\chi \times S_\delta \times L_\theta \times Pr_\zeta \times Ps_\kappa. \tag{4}$$

The subscripts $\rho, \ldots, \kappa$ denote types and the sets in (4) are sets of the following constraints:

- $Ph_\rho = \{ph_\rho \mid ph_\rho$ *is a phonological constraint*$\}$ *is the set of constraints that can be determined in phonology.*
- $Mr_\mu = \{mr_\mu \mid mr_\mu$ *is a morphological constraint*$\}$ *is the set of constraints that can be determined in morphology.*
- $X_\chi = \{x_\chi \mid x_\chi$ *is a syntactic constraint*$\}$ *is the set of constraints that characterize syntax.*
- $S_\delta = \{s_\delta \mid s_\delta$ *is a semantic constraint*$\}$ *is the set of constraints that characterize semantic phenomena.*
- $L_\theta = \{l_\theta \mid l_\theta$ *is a lexical constraint*$\}$ *is the set of constraints that occur on lexical level.*
- $Pr_\zeta = \{pr_\zeta \mid pr_\zeta$ *is a pragmatic constraint*$\}$ *is the set of constraints that characterize pragmatics.*
- $Ps_\kappa = \{ps_\kappa \mid ps_\kappa$ *is a prosodic constraint*$\}$ *is the set of constraints that can be determined in prosody.*

The second component is a function

$$FGr : U \longrightarrow [0, 1] \tag{5}$$

which can be obtained as a composition of functions $F_\rho : Ph_\rho \longrightarrow [0, 1], \ldots, F_\kappa : Ps_\kappa \longrightarrow [0, 1]$. Each of the latter functions characterizes the degree in which the corresponding element x belongs to each of the above linguistic domains (with regards to a specific grammar).

Technically speaking, $FPGr$ in (5) is a fuzzy set with the membership function computed as follows:

$$FGr(\langle x_\rho, x_\mu, \ldots, x_\kappa \rangle) = \min\{F_\rho(x_\rho), F_\mu, \ldots, F_\kappa(x_\kappa)\} \tag{6}$$

where $\langle x_\rho, x_\mu, \ldots, x_\kappa \rangle \in U$.

Let us now consider a set of constraints from an external linguistic input $D = \{d \mid d$ is a dialect constraint$\}$. Each $d \in D$ can be observed as an n-tuple $d = \langle d_\rho, d_\mu, \ldots, d_\kappa \rangle$. Then, the membership degree $FGr(d) \in [0, 1]$ is a degree of grammaticality of the given utterance that can be said in arbitrary dialect (of the given grammar).

FPGr operates taking into account the notion of *linguistic construction*, originally from [32,33]. A linguistic construction is understood as a *pair of structure and meaning*.

In FPGr, linguistic constructions in written language stands for a simplified version of a $FPGr$ because only three linguistic domains are relevant for it: the morphological domain (mr), the syntactical domain (x), the semantic domain (s), $< mr, x, s >$, the others are neglected: $FPGr =< \overline{U}, \overline{FGr} >$.

Definition 3. *A construction is:*

$$\overline{U} =< mr, x, s > \tag{7}$$

Examples of constraints in the linguistic domains in Equation (7):

- *The morphological domain* $< mr >$, which defines the part-of-speech and the constraints between lexemes and morphemes. For example, in English, the lexeme of an adjective $\prec$ (precedes) the morpheme *-ly*, and the morpheme *-ly* $\Rightarrow$ (requires) an adjective as a lexeme.

- *The syntactical domain* $< x >$, which defines the structure relations between categories in a linguistic construction or phrase. For example, in English, an adjective as a modifier $ADJ_{[mod]}$ of a noun $NOUN$ is dependent ($\rightsquigarrow$) of such a noun ($ADJ_{[mod]} \rightsquigarrow NOUN$).
- *The semantic domain* $< s >$, which defines the network-of-meanings of a language and its relation with the syntactical domain. This can be defined with semantic frames [34,35]. It is also responsible for explaining semantic phenomena as metaphorical meaning, metonymy, and semantic implausibility. For example, in English, $drinkable$ object (i.e., $water_{[sem:drinkable]}$) $\Rightarrow$ (requires) $recipient$ (i.e., $glass_{[sem:recipient]}$). A metonymy can be triggered with the follow $IF - THEN$ rule: If asking for something $drinkable$ without $recipient$ (i.e., "*may I have some water, please?*"), then $recipent$ is included as a feature in the frame of $drinkable$ object, i.e., $water_{[sem:drinkable,recipient]}$.

All the linguistic descriptions from now on are conducted following the framework of Fuzzy Property Grammars (FPGr). For a deeper insight of the theory, see [18–20].

4. Evaluative Linguistic Expressions with Linguistic Features

4.1. Linguistic Prerrequisites

Fuzzy Natural Logic must include the following linguistic concepts in the theory of evaluative expressions. Those concepts are essential to characterize prototypical and borderline evaluative words.

- *Referent*. A referent is a person or thing to which a linguistic expression refers. For example, in the sentence *Paul talks to me*, the referent of the word *Paul* is the particular person called *Paul* who is being spoken of, while the referent of the word *me* is the person uttering the sentence. In the case of the evaluative linguistic expressions, we will understand the *referent* as the entity which *is being evaluated*.
  The referent of the evaluation can be: (1) in the linguistic input, (2) close to the evaluative word, or (3) it can be absent in the linguistic input but present in the extra-linguistic context.
  Usually, in English and Spanish language, the referent will typically be the subject of the evaluative sentence ($X_{[subj]}$) if the referent and the evaluation are in a dependency relationship with a $VERB$. Otherwise, the syntactic head of the evaluative word will establish a modifier dependency with it. This syntactic head will usually be a $NOUN$ from the evaluation. For example, in *Paul runs fast*, the referent of the evaluation *runs fast* is *Paul*, not the $VERB$ *runs*. Therefore, the fact that the evaluative word has a dependency of *modifying* a $VERB$, $ADJ \rightsquigarrow_{mod} VERB$, does not imply that it will be the referent, even though $VERB$ is a higher element in the syntactic hierarchy. Sometimes, a referent can be co-referential. That is, the same referent appears twice in a sentence. For example, *Paul had his huge backpack with him*. In such case, *Paul* and *him* refers to the same person. But, following our definition, the referent of the evaluation is not *Paul*, but the *backpack* since it is the one receiving the evaluation.
  When the referent is in the linguistic input, the evaluative word and the referent will have a relationship of dependence. Such as in *Mark watches a bad show on TV*. In this case, the referent is *a show*, and the evaluative word is *bad*. On the other hand, typically, when the evaluation and the referent are connected with a dependency through a verb, the referent will usually be the subject. For example, *Cristina thinks that Claudia is smart enough to pass her degree*. The evaluation is *is smart enough*, and the referent is *Claudia*. Both constructions have a relationship of dependence, and they are connected because of the verb. However, further exploring to set a frequent pattern of dependency between referent and evaluation is needed.
- *Linguistic pairing* stands for the task or phenomena in which linguistic features associate two linguistic elements. These can be syntactic or semantic features or both. The most interesting linguistic pairing for adding linguistic features in the evaluative linguistic expressions is the one which *pairs* the referent with the evaluative word.
- *Markedness* arises to represent the importance of the linguistic context (not extra-linguistic) for a word. A sentence α is more marked than a sentence β if α is acceptable

in less contexts than β. It can be determined either by the judgments of the speakers or by extracting the number of possible context types for a sentence [36]. Therefore, a canonical constraint or property (C_α) is never context dependent. For example, $C_\alpha(DET \prec NOUN)$. A borderline constraint or property (C_γ) is context-dependent if the degree of unacceptability triggered by its violation varies from one context to another. For example, in Spanish, canonically, determiners do not precede proper nouns, that is $C_\alpha(PROPN \otimes DET)$. However, such constraint can be violated when what the structure $\{DET, PROPN\}$ is triggering the meaning of a football team, "*El (DET) Barcelona (PROPN) era mejor con Messi que ahora*" ("*The Barcelona was better with Messi than now*"). Such a feature is important to characterize and clarify both the referent and the evaluation. Following the last sentence, the evaluation of *was better with Messi than now* would have a biased referent if the grammar would understand that *the Barcelona* meant *the city of Barcelona*, and not *the football club*.
In this case, the violation of the property, accepted only in few contexts, displays and characterizes a *marked structure* ($DET \prec PROPN_{[sem:cities]}$) ($sem$: means semantics), with a *marked meaning* ($DET \prec PROPN_{[sem:footballteam]}$), expressed as: $IFF\ C_\beta(DET \prec PROPN); ANDPROPN_{[city]} THENC_\gamma(DET \prec PROPN_{[sem:footballteam]})$.
Additionally, in semantics, structures are marked when they do not allow interchangeability of elements, and yet keep the same meaning. A non-marked structure would be: "*Mary's house, the nice one, is in Elm Street*". I change the elements and yet I can get almost same meaning "*My sister's home, the one when you were last time, is next to mine*" (knowing that *Mary* is *my sister*, *the nice one* is *the one when you were last time* and *next to mine* is *Elm Street*)'. However, this cannot happen with idioms, or other marked structures such as "*Mark is a pain in the ass*" by *Mark is a pain in the finger/eye/foot/chest/etc.*, or "*it is raining cats-and-dogs*" by *it is raining elephants-and-giraffes, etc.* Therefore, idioms tend to have marked meanings. Another example: "*No shit, Sherlock*", meaning '*judgment over a statement that was obvious*'. It is implausible to exchange such construction for other elements such as: *No turd, detective*, or *No smoke, Einstein*. Moreover, FNL should not purse to characterize extra-linguistic extreme-implied (non-)evaluations that demand extreme knowledge of the context, such as *the one when you were last time* understanding that such a construction is a very polite way of saying *I am referring to the nice one, not the ugly one*.

- *Semantic Coercion* stands for *implausibility of meaning*. Coercion is a typical effect in defining and identifying metaphors, which non-literal meanings are triggered due to the implausibility of such meaning. To summarize, it is the similar effect of markedness but focused on the semantic domain.
- *Compositionality* is typically understood as that the summarization of meanings brings us the final meaning, i.e., "*it a strong rain*", meaning: [*it* + *is* + *a* + *strong* + *rain*]. However, compositionality does not always work taking into account the previous example *it is raining cats-and-dogs*. It does not actually mean that *animals are falling from the sky!*. Therefore, the evaluative sentence *it is raining cats-and-dogs* does not fall on the logic of compositionality.
- *Lexical unit*, in FPGr, stands for those structures that work as a single part-of-speech, that is as a single unit, and, therefore, they only count as a one category. For example, in *the chief (NOUN) executive (NOUN) office (NOUN) of Amazon is Jeff Bezos*; FPGr would parse it as *the [chief executive office (NOUN)] of Amazon is Jeff Bezos*, and not as *the [chief (NOUN) executive (NOUN) office (NOUN)] of Amazon is Jeff Bezos*. Therefore, the *chief executive office* is working as a single *NOUN*. In fact, that is why the tendency is to reduce it to *CEO*, *the CEO of Amazon is Jeff Bezos*. The same applies to evaluations such as *it is raining cats-and-dogs*, which stands for *it is raining really heavily* or *it is pelting down*, or *it is bucketing down*, which stands for *it is raining very, very heavily*. Therefore, the notion of the lexical unit serves both the evaluation and its referent.

4.2. The Concept of Evaluative Expressions

An evaluation is a concept characterizing particularities of a specific object (object understood in a broad sense, as people are objects too). That is the characterization of a referent.

Examples of linguistic evaluations are the following ones:

(1) I <u>love</u> *you* <u>very much</u>.

- Express affection. The verb *love* is the evaluative word. The referent is '*you*'.

(2) *Plane food* is <u>disgusting</u>.

- Express a judgment. The evaluative word is '*disgusting*'. The referent is '*plane food*'. The referent operates as either a lexicalized *NOUN* ('*plane food*' is *NOUN*), or as a *NOUN* with an adjective fit which modifies the other *NOUN*: '*plane*' ($NOUN_{[xADJ]} \rightsquigarrow_{mod}$) '*food*' ($NOUN_{[subj]}$).

(3) *John* is <u>not</u> a <u>bad</u> person, but *he* can be a <u>snake</u>.

- Express a judgment. '*Snake*' is fitting a metaphorical meaning, '*treacherous*', and not *the animal*. The referents are *John*, and *he*.

(4) *John* looked like <u>this (showing at a tomato)</u> when Jennifer asked *him* for a date.

- Express a judgment. '*this*' is a deictic work. Thus, it is empty of meaning by itself, and the context is needed to grasp the meaning that is intended to be communicated. The context reveals that it *probably* means *John was shy*. *Probably* is stressed since the meaning is not known for sure. Only an implication can be made by linking the linguistic input, its linguistic context, world knowledge, and communicative context.

If we accept that all the above sentences express concepts that are a matter of degrees, then we have a fuzzy set: $A : M \longrightarrow [0,1]$. Every element can be associate with types: M_δ stands for '*John*', M_ϵ stands for the concept of '*being bad*', M_θ stands for *the sentiment of the concept* (positive or negative), and M_o express a membership degree, creating a complex set of functions: $A : M_\epsilon \times M_\delta \times M_\theta \rightarrow M_o$.

Therefore, an evaluative linguistic expression is an evaluative concept expressed through a language system characterizing a referent. The key elements are the evaluator and the object being evaluated.

Additionally, the linguistic evaluative expressions can be understood under the notion of *linguistic construction* [32,33], which stands that a linguistic construction is a pair of structure and meaning. Therefore, defining both linguistic syntactic and semantic features of an evaluative construction is necessary. An evaluation construction is a linguistic input evaluating a referent. This referent can be found in the linguistic input itself or can be extra-linguistic (found in the communicative context or the common knowledge).

4.3. Semantics of Evaluative Expressions

To express the generation of an evaluative linguistic expression by being the evaluator at the centre of the concept, we have provided a semantic hierarchy of the evaluation represented in Figure 2.

Figure 2 expresses the hierarchy of the different levels in which the semantics of an evaluative concept are found:

- On the first level, closer to the thought, we will find a *semantic prime*, always understanding semantic primes as those most abstract concepts which will define a fuzzy set. This idea is inspired in [37]. However, this author considers as semantic primes only the concepts of *good-bad*. While in this work, we consider primes as all those triplets that create a *fundamental trichotomous expression* such as [*ugly-medium-beautiful*], [*small- medium-big*], [*easy-medium-complex*], etc. Any prime has to be a prototypical meaning, that is, non-context dependent.

- On the second level, we would find those evaluations that are sensitive to the linguistic context. Those words that are given a specific structure trigger a non-prototypical meaning. That is the case of Example 3), in which the syntactic relation between the referent *he*, meaning a person, the verb 'to be', and the word *snake*, trigger a borderline meaning on the word snake due to the implausibility that a person would be an actual animal. This effect of implausibility is called semantic coercion [38–41]. However, it is clear that meaning **is not** a matter of probabilities in both the semantic prime, and in the linguistic context stage. The semantics of linguistic inputs related with those stages can be characterized using logic and linguistic features.
- On the third level, and further from the semantic prime, we would find those evaluations that need extra-linguistic context. Such concepts can only be understood when the communicative context is known or expresses a common knowledge shared by the interlocutors. Example 4) is a clear example of extra-linguistic meaning. Therefore, it is impossible to extract its meaning from the linguistic input's information to us. These cases are acknowledged as being *extremely borderline*. We will not formalize this type of evaluative expression here.

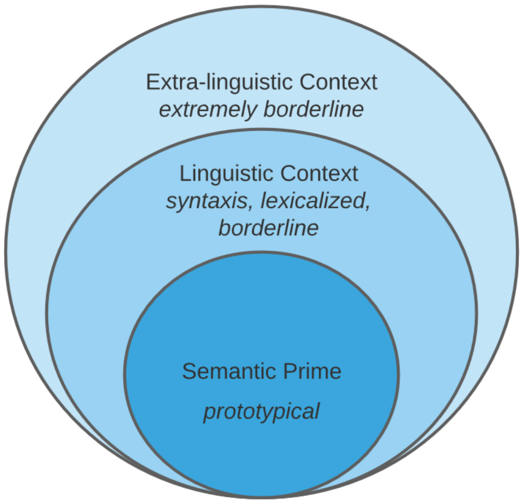

Figure 2. Semantic hierarchy of evaluative meaning

Summing up, evaluative expressions are linguistic inputs that express a concept of an evaluation that is a gradient and has a sentiment. The semantic hierarchy gives structure to identify the abstract types of the meaning of an evaluative concept. The meaning of an evaluation can be closer to a prototypical evaluation (a semantic prime), to a borderline evaluation (needing of a characterization of the linguistic context), or closer to an extremely borderline evaluation (needing of the information of the communicative context).

4.4. Syntax of Evaluative Expressions

Recall from (9) that the general form of an evaluative linguistic expression is

$$\langle \textit{linguistic hedge} \rangle \langle \textit{TE-adjective} \rangle \tag{8}$$

This form poses two problems in linguistics: the confusion of the term "hedge" and the fact that a TE-adjective is not necessarily an adjective.

The term "linguistic hedge" is used in pragmatics for what is called *hedging* defined as people use hedging when they try to avoid criticism [42–44] . Some other definitions can also be found in [45]. Hassan and Said [45] define hedges as those elements "which serve human communication as more flexible, moderate, and convincing". Hedges convey "intentional vagueness","mitigation", "tentativeness", "politeness", "indirectness", "possibility", "evasiveness" , "lack of full commitment", etc. Hedges can be characterized as expressing the writer's attitude towards both the propositional information and his/her awareness of the readers. Words that are present in hedging strategies are "*I think*", "*I don't know*, "*a little bit*", "*in my view*", "*quite*". Some of this hedges can be found also as part of an evaluative expression; however, it is important to differentiate the intensifier strategy than the discourse hedging strategy:

- *I think* this is *quite* right, but...
- Your paint seems *a little bit* odd.

The discourse function of the pragmatics of language of the terms "*quite*" and "*a little bit*" is different from the intensifying semantic function in terms of widening or stretching the degree of vagueness of the TE-adjective "*right*", and "*odd*". That is why it would be better to define this first part as simply ⟨*intensifier*⟩.

Regarding the use of the concept of ⟨*TE-adjective*⟩, it is necessary to change it to ⟨*TE-head*⟩. Firstly, not necessarily an adjective will be the head of an evaluative expression itself. For example, in English, we will find differences of such things:

(1) Mark is *very intelligent*:
  ⟨*intensifier- very*⟩⟨*TE-head intelligent (an adjective)*⟩.
(2) Mark is *an Einstein*
  ⟨*intensifier- none*⟩⟨*TE-head Einstein (a Proper Noun)*⟩.
(3) I *love* Mark's intelligence *very much*
  ⟨*intensifier—very much*⟩⟨*TE-head love (a verb)*⟩.

Example (1) is what we would consider a canonical evaluative expression if we consider that the prototypical evaluative heads in the English language are adjectives. That is because using an adjective as an evaluative head is very productive in English.

Example (2) has a proper noun as an evaluative head, which could be considered a borderline form of the evaluative term "intelligence" since, in English, proper nouns do not usually bear the quality of being evaluative. Additionally, we can satisfactorily apply a constituent replacement test of the word "*Einstein*" for "*intelligent*". The test is a success since we keep the same meaning, and the constituents work similarly. Such cases will lead us to distinguish between prototypical and borderline evaluative heads. It must be kept in mind that each language will decide which linguistic categories are prototypical productive or borderline for bearing an evaluative semantic meaning. Therefore, sentences (1) and (2) are synonyms but display different evaluative heads.

Example (3) shows a verb being used as an evaluative head. This case helps us to stress why the formula of an evaluative expression in its general form should bear the notion of ⟨*TE-head*⟩ and not ⟨*TE-adjective*⟩. The evaluative verb "*love*" is not considered a borderline evaluative head here since the verb love is prototypical an evaluative verb even though verbs do not prototypically bare evaluative meanings.

We establish the following rules to determine if a word is a prototypical evaluative head or a borderline one:

- If the evaluative head is canonically and productively used as an evaluative, the evaluative head is prototypical.
- If the evaluative head is not canonically and productively used as an evaluative, but it passes a constituency test by being replaced by a prototypical evaluative head, then the evaluative head is borderline.

From the above follows that the general form of an evaluative expression should be:

$$\langle \textit{intensifier} \rangle \langle \textit{TE-head} \rangle \tag{9}$$

Figure 3 represents the formal characterization in FPGr of the basic structure of a linguistic construction of an evaluative expression in terms of linguistic constraints.

Construction	:	[(Intensifier) □Evaluative Head]
Evaluative Expression		$Int \rightsquigarrow_{xmod} EH\ EH \rightsquigarrow_{xdep} Ref_{[pairing \vee extraling]}$

Figure 3. Characterization of the universal construction of evaluative expressions.

- The elements within the construction can be found between brackets [].
- The first element is the intensifier, defined as optional, that is why it is between parenthesis ().
    - It is also defined with a linguistic dependency of modifier; meaning that the intensifier will always be dependent of the evaluative head as a modifier, no matter the language or grammar.
- The second element is the evaluative head, which is mandatory. That is why it is represented with the constraint of obligation □.
    - Additionally, the evaluative head will bare a dependency on its referent, that is, the element which is being evaluated. Because we want to keep this formalization as the most linguistically universal possible, we do not state the dependency that the evaluative bears. That is why it is represented with $\rightsquigarrow_{[xdep]}$. In English, the most common evaluative construction is found as the object of a copular verb ("*to be*", "*feel*", "*seem*", "*become*", etc.) and as the subject as its reference: Subject-Copular Verb-Evaluative Construction. In such a case, we would say that the evaluative head has a dependency on the subject.
        - It is specified that the referent Ref experience a pairing with the evaluative head, which states if they are semantically compatible or if any coercion would be involved $_{[pairing]}$. A clear case of a coerced pairing can be found in the sentence "*Mark is a giant*". The pairing between "*Mark*" and "*giant*"is implausible since "*Mark*" bares the quality of being "+ *human*" and "*giants*" does not exist, they are mythological creatures. However, the paring is possible, and a coerced meaning is interpreted. If a pairing is not present in the linguistic context, the referent would be found in the communicative context; that is, it will be extra-linguistic $_{[extraling]}$.

The possibility of having different categories depending on the language makes the notion of the evaluative head provide universality to our model.

If we use an intensifier, we can make the evaluative head more precise. FNL does not imply that adjectives are always a typical evaluative head across languages. For example, Korean and Japanese do not have adjectives in the strict sense, but can use verbs as evaluative units. These kinds of structures are also possible in English where an evaluative expression such as "*I love your food*" has a verb as its evaluative head. The meaning of this structure would be paraphrased as " *Your food is excellent*". Both sentences would be computed with a high value in the degree of judgment. Therefore, with FNL we can characterize the core/depth structure of the evaluation semantics, extracting the exact core meaning of both sentences, independently of the surface structure of the linguistic construction.

4.5. Evaluative Expressions: A Formal Characterization

A formal characterization with the FPGr of the syntactic and semantic properties that a universal construction of an evaluative expression has to fulfill is presented in Figure 4.

$$\begin{array}{l}\text{Evaluative expression}\\ \left[\begin{array}{l} < insert - grammar > \\ \left[\begin{array}{l}\text{Intensifier}_{[INT]}\\ \text{X}_{[INT]} \rightsquigarrow_{xmod} \text{X}_{[EH]}\\ \\ \\ \\ \end{array}\right] \left[\begin{array}{l}\text{Evaluative Head}_{[EH]}\\ \text{X}_{[EH]}\Box\\ \text{X}_{[EH]} \rightsquigarrow_{[xdep]} Ref_{[pairing \vee extraling]}\\ \text{X}_{[EH]} \Rightarrow TE\langle v_L - v_S - v_R\rangle \wedge \Rightarrow LSV \begin{bmatrix}\text{PROT}_{(LSV_\alpha)}\\ \text{BORD}_{(LSV_\gamma)}\end{bmatrix}\\ \text{X}_{[EH]} \Rightarrow Sentiment_{TE-Judgment\langle v_L - v_S - v_R\rangle} \begin{bmatrix}\text{PROT}_{(S_\alpha)}\\ \text{BORD}_{(S_\gamma)}\end{bmatrix}\end{array}\right]\end{array}\right]\end{array}$$

Figure 4. Universal construction of evaluative expressions (syntax and semantics).

As shown in Figure 4, we consider three elements in the formal characterization of evaluative expressions:

- **The insertion of grammar** . $\langle insert - grammar\rangle$ stands for inserting an FPGr or other grammar with constraints (a universe), which will define the specific constraints of a language, as mentioned in Equation (4). This grammar will define those satisfied and violated constraints of a particular language. Therefore, FPGr will be able to characterize the degree of grammaticality of an evaluative expression with regards to a specific grammar.
- **The constraints of the intensifier**. The intensifier displays the same constraints as in Figure 3.
  - $X_{[INT]} \rightsquigarrow_{[xmod]} X_{[EH]}$ means any category X as intensifier $X_{[INT]}$ has a dependency as a type of modifier $\rightsquigarrow_{[xmod]}$ towards any category as an evaluative head $X_{[EH]}$.
- **The constraints of the evaluative head.** The evaluative head displays some of the same constraints observed, as in Figure 3, such as:
  - $X_{[EH]}\Box$ meaning any category X as an evaluative head $X_{[EH]}$ is mandatory $\Box$, leaving the intensifier as optional.
  - $X_{[EH]} \rightsquigarrow_{[xdep]} Ref_{[pairing \vee extraling]}$ means any category X as an evaluative head $X_{[EH]}$ has a non specified dependency $\rightsquigarrow_{[xdep]}$ towards a referent Ref, which can be found in the linguistic context with linguistic pairing or in the extra linguistic context $Ref_{[pairing \vee extraling]}$.
  - Additionally, the evaluative head displays semantic constraints here that are necessary to complete such a universal characterization of the constructions of an evaluative expression.
    * $X_{[EH]} \Rightarrow TE\langle v_L - v_S - v_R\rangle \wedge \Rightarrow LSV$. Meaning that any category X as an evaluative head $X_{[EH]}$ requires to be part of one of the sets of a trichotomous expression $\Rightarrow TE$, either the left one v_L, the one in the middle v_S, or the right one, v_R. And ($\wedge$), the trichotomous expression, requires to be tagged with a Linguistic Semantic Variable (LSV). The trichotomous expression can be incorporated in any constraint-based grammar in terms of hyponym and hypernymy (being the hypernym interpreted as our semantic prime) simply by using $\langle v_L - v_S - v_R\rangle$ as a constraint. Therefore, lexical items as *"beautiful"*, *"difficult"*, *"pig"*, and *"hate"*, can be defined with such constraints as:
      · *"beautiful"*, $ADJ_{[EH]} \Rightarrow TE\langle v_R\rangle \wedge \Rightarrow LSV\langle beauty\rangle$.
      · *"difficult"*, $ADJ_{[EH]} \Rightarrow TE\langle v_R\rangle \wedge \Rightarrow LSV\langle complex\rangle$.
      · *"pig"*, $NOUN_{[EH]} \Rightarrow TE\langle v_L\rangle \wedge \Rightarrow LSV\langle Pleasing - Likability\rangle$.
      · *"hate"*, $VERB_{[EH]} \Rightarrow TE\langle v_L\rangle \wedge \Rightarrow LSV\langle Esteem\rangle$.
    * Moreover, it can be specified whether such lexical items are a prototypical or borderline evaluative expression, **always** with regards to the Linguistic Semantic Variable (the semantic prime). If the evaluative head is prototypical

with regards to the prime, it will be defined with the semantic constraint $[PROT_{(LSV_\alpha)}]$. If the evaluative head is borderline with regards to the prime, it will be defined with the semantic constraint of $[BORD_{(LSV_\gamma)}]$. For example:

- *"beautiful"*, $ADJ_{[EH]} \Rightarrow TE\langle v_R\rangle \wedge \Rightarrow LSV\langle beauty\rangle[PROT_{(LSV_\alpha)}]$.
- *"pig"*, $NOUN_{[EH]} \Rightarrow TE\langle v_R\rangle \wedge \Rightarrow LSV\langle cleanliness\rangle[BORD_{(LSV_\gamma)}]$.

– The last constraint is $X_{[EH]} \Rightarrow Sentiment_{TE-Judgment\langle v_L - v_S - v_R\rangle}$. Meaning that any category X as an evaluative head $X_{[EH]}$ requires a sentiment to be assigned $\Rightarrow Sentiment$. Sentiment is characterized as a trichotomous expression of judgment $_{TE-Judgment\langle v_L - v_S - v_R\rangle}$, such as $\langle negative - neutral - positive\rangle$. As with before, the sentiment can be prototypical or borderline, since it is considered that any evaluation can be potentially used in both ways [16]. For example:

  * *"This song is <u>excellent</u>"*, it is interpreted as positive because the word *"excellent"* is prototypical positive: $ADJ_{[EH]} \Rightarrow Sentiment_{TE-Judgment\langle v_R\rangle}[PROT_{(S_\alpha)}]$
  * *"This song is <u>excellent</u> for deaf people"*, it is used as a borderline negative because of the linguistic context: $X_{[EH]} \Rightarrow Sentiment_{TE-Judgment\langle v_L\rangle}[BORD_{(S_\gamma)}]$

Summarizing, in FNL we define an evaluative expression as a linguistic construction characterized by a lexical unit tagged as Evaluative Heading (EH), which is a subjective evaluation of an object. Evaluative heads have the following properties:

- They occur in each member of a triplet of expressions –an *evaluative trichotomy*–, such as *small-medium-big*, *short-medium-tall*, *beautiful-average-ugly*. A trichotomous expression is a characterization of a general semantic feature –a *semantic prime*– called a *linguistic semantic value*. Examples of these linguistic semantic values are *height*, *beauty*, *complexity*, *intelligence*, etc. Technically, we can refer to *features* of a given object.
- They have a sentiment value expressed in terms of positive, negative degree. Sentiment is computed by ordering all the trichotomous expressions as protoypically negative v_L, protoypically medium v_S, protoypically positive v_R, and converting those to borderline sentiment when needed.
- FNL can characterize the interpretability of an evaluation even if it is subjective.

5. Towards a Lexicon of Evaluative Expressions

The formal characterization of evaluative expressions we have presented in this paper constitutes a robust mathematical model that is inapplicable without a lexicon of evaluative expressions. One of the main reasons for this is because linguistic categories, or part-of-speech, are not enough to identify an evaluative expression. It is, therefore, necessary to establish a procedure to find and classify evaluative expressions in trichotomous structures by identifying semantic primes and assigning values on a sentiment scale.

Taking into account the need to have a lexicon of evaluative expressions, we have carried out a first experiment, as a proof of concept, to identify trichotomic expressions in Spanish and English. We have performed a linguistic evaluation for FNL over a sentiment analysis corpus entirely build on evaluative words.

For our proof-of-concept we have chosen SO-CAL, lexicon. https://github.com/sfu-discourse-lab/SO-CAL. SO-CAL has two tagged sentiment corpus, one in Spanish, and another one in English. SO-CAL has three different lexicons for each language: (1) a lexicon for evaluative adjectives, (2) a lexicon for adverbs, and (3) a lexicon for intensifiers. SO-CAL lexicon was built through pairing of DSm tools. The corpus merely tagged each word with a value from −5 to +5 without further detail.

SO-CAL [46] was the best option for building up a lexicon with FNL, since it already has a classification of 11-point scale, which fits with the *theoretical extension* of FNL (Figure 5).

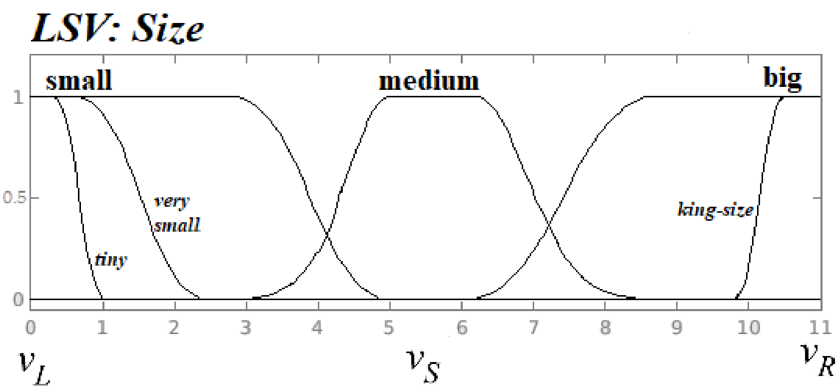

Figure 5. Trichotomous Expression of [*small-medium-big*] in FNL.

We have taken the SO-CAL lexicon and re-distributed its adjective-lexical units. We were interested in re-building the lexicon for characterizing evaluative adjectives with FNL providing more linguistic information for each EH, and re-distributing the sentiment polarities.

In order to built a lexicon underpinned in SO-CAL lexicon, two researchers elaborate *Linguistic Semantic Variables* (LSV) scales. One worked with an English Lexicon, and the other worked with a Spanish Lexicon. Without having contact with each other, they had to find the Prime Evaluative Heads (EHs) for each LSV scale. They have also to tag every adjective into an LSV scale, under a Prime EH.

The English adjective lexicon has 2827 lexical units, and the Spanish Adjective lexicon has 2049.

In Figure 6, the x-axis displays the sentiment polarity for each adjective cluster [−5, 5]. At the same time, the y-axis represents the number of words (in proportion from one corpus to the other) for each polarity set in the lexicon. Therefore, thanks to Figure 6, we confirm that SO-CAL does not demonstrate substantial differences in the classification of the adjectives' polarity in English and Spanish. Moreover, SO-CAL lexicon demonstrates a preference for medium values. Most of the adjectives are classified in the polarity of [+2, +1], and [−2, −1], leaving the 0 value just with one case, with the word *better*.

On the other hand, we re-classified the SO-CAL lexicon applying the criteria from FNL. We manually re-built half of the lexicon for both languages. We re-tagged 1419 adjectives for the English language, and 1549 adjectives for the Spanish Language. Therefore, it allowed us to evaluate FNL cross-linguistically.

After manually tagging each adjective under an LSV, and under a prime EH, the general result was that the evaluation values' distribution considerably changed in both FNL lexicons.

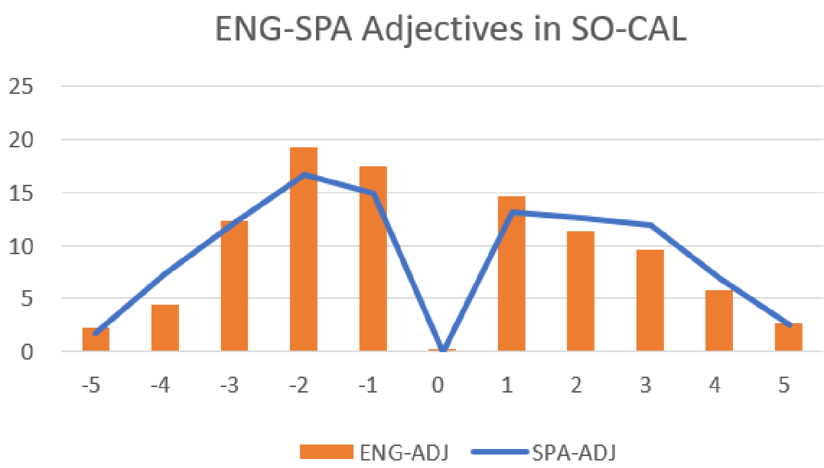

Figure 6. SO-CAL Adjectives by polarity.

In both Figures 7 and 8, the FNL lexicon preferred extreme values rather than middle ground values. However, both classifications coincide in leaving the very mid almost empty, with the exception that in Figure 7, it has a visible small peak in the mid value in contrast with Figures 6 and 8. These results can be explained by taking into consideration the following:

- Evaluation of the plots;
- Universality of the mid-value;
- Struggles with TE-adjective in LSV.

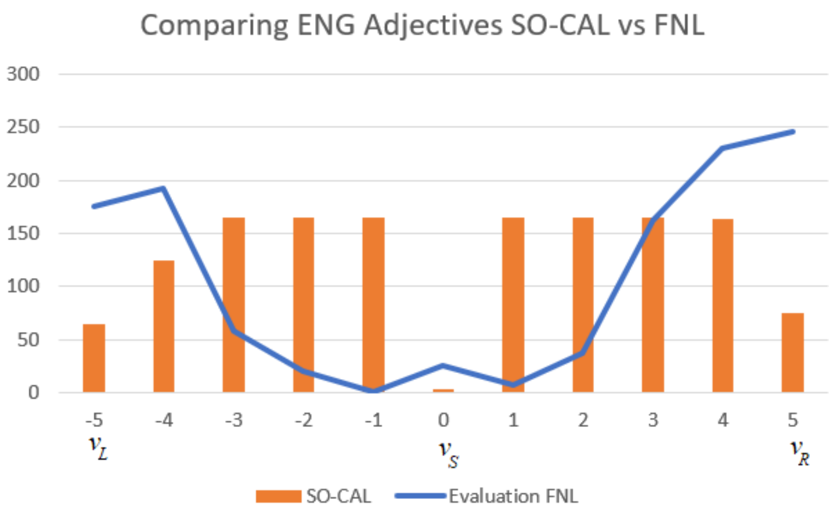

Figure 7. English Adjectives SO-CAL vs. FNL lexicon.

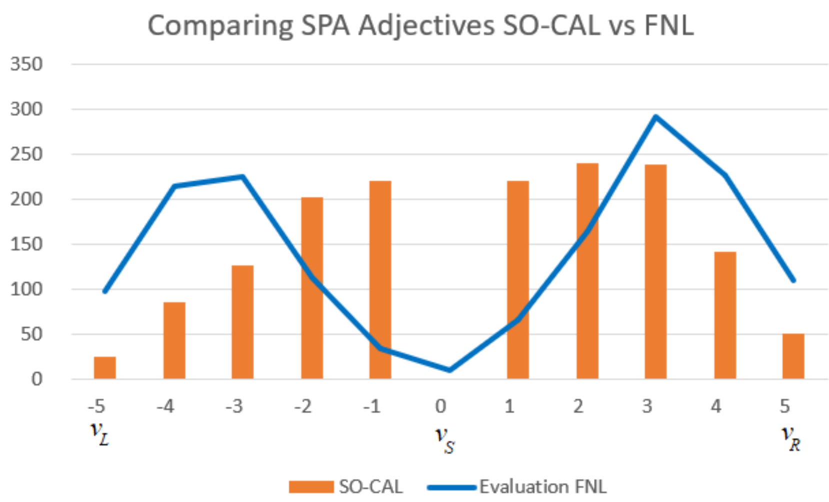

Figure 8. Spanish Adjectives SO-CAL vs. FNL lexicon.

Regarding *evaluating the plots*, it was more natural to classify the plots roughly either in v_L or v_R. Acknowledging the context was unnecessary to decide whether the word is placed in v_R or v_L or v_S. We conclude that the universality of FNL resides in the rough understanding of fuzzy prime EHs. Therefore, an EH is usually roughly either a v_R or v_L. However, when we try to fine-grain a particular value, we do need the linguistic context to clarify whether that word is a prototypical closer to the extremes of either v_L or v_R, or whether it is a lexical unit closer to the middle plot v_S, which intersections with v_L or v_R.

Regarding the *universality of the mid-value* v_S, it turns out that we could barely classify words in v_S. Most of them are general enough to be included in almost every LSV. Some examples are: *ordinary, average, average-sized, grey, central, medium, adult, similar, normal*. We jump into the following conclusion according to this phenomena. Mid words are the universal words in an evaluation scale. Because of their lack of markedness, they can flexibly be included in most of the scales as v_S, and they still keep the mid-meaning. Words in v_S can be considered the fuzziest semantics units since they do not show any clear-cut semantic traits, and yet they roughly fit in several LSV. Table 2, shows some TE-adjective with an X in the middle. X means that the mid-plot is still existing; however, there is no specific prime EH for such plot.

Table 2. Linguistic Semantic Variable (LSV) and Prime Evaluative Head (EH) tags in Fuzzy Natural Logic (FNL) Lexicon.

FNL Tags in English and Spanish Lexicon					
LSV	Judgment	Esteem	Beauty	Size	Capability-Skills
Primes EH	⟨negative/bad-medium/normal-positive/good⟩	⟨hated-X-loved⟩	⟨ugly-X-beautiful⟩	⟨small/short-medium-big/long⟩	⟨disable-average-capable⟩
LSV	Complexity	Fear-Courage	Fullness	Indeterminacy	Intelligence
Primes EH	⟨simple-normal-complex⟩	⟨scared-X-brave⟩	⟨empty-X-full⟩	⟨blurred-X-clear⟩	⟨stupid-average-intelligent⟩
LSV	Generates-Interest	Pleasing-Likability	Proximity	Veridicality	Similarity-Usual
Primes EH	⟨boring-X-interesting⟩	⟨disgusting-X-pleasing⟩	⟨far-central-close⟩	⟨fake/false-X-real/truth⟩	⟨different-similar-usual⟩
LSV	Speed	Strength-Intensity	Temperature	Time-Lifetime	Worth-Value
Primes EH	⟨slow-medium-fast⟩	⟨weak/fragile-X-intense/strong⟩	⟨cold-X-hot⟩	⟨life/new/young/beggining- medium/adult-death/old/end⟩	⟨worthless-X-worthy⟩
LSV	Value (economical)				
Primes EH	⟨cheap-affordable-expensive⟩				

Finally, regarding *struggles with TE-adjective in LSV*, Table 2 displays the tags that have been found and agreed after manually tagging both the Spanish and English corpus.

We have found more satisfying those scales that classifies more specific LSV, such as *Fear-Courage, Esteem, Complexity, Capability-Skill, Temperature, or Value (economical)* in contrast with these scales with a more general LSV such as *Size, Beauty, Pleasing-Likability, Fullness*, and so on. Using hyper-generic LSV such as *Size*, or *Pleasing-Likability* can bias a fine-grained classification, since it is easy to fit too borderline cases into those scales. Examples of too borderline cases in the LSV of *Pleasing-Likability* would be: *happy*, *funny*, or *clean*. Assuming that all these words transmit a semantic value of something being *pleasing*. The LSV of *Fullness* is a particular one. This LSV is a mishmash of evaluative heads that cannot completely fit in other LSV without creating a specific scale with almost no adjectives. Some of the cases are: *informative* as (full of information), *illogic* as (empty of logic), words with the morpheme *full* like *help-ful* as (full of help), same with words with *-less* or *-free* like *painless* (empty of pain), and *dramafree* (empty of drama), among others.

Therefore, one of the significant challenges in the classification of an FNL lexicon is (1) not being too specific without reason during the extraction of LSVs, and (2) not pushing the fit of borderline cases in a hyper-generic LSV.

On the other hand, two other big struggles arise when tagging adjectives:

(1) It is complex to know under which LSV tag the adjective should be classified if we do not look at the linguistic context of the word,
(2) Some adjectives might be suspicious of being able to appear in more than one LSV scale. It is the case of *beautiful* which could be *Beauty*: *she is beautiful*, and/or *Pleasing-Likability*: *the food taste beautiful*, and/or *Judgment*: *it is a beautiful job*.

These two struggles brought us to implement a new feature in the FNL lexicon. We are implanting a sub-tag of prototypical LSV (LSV_α) and borderline LSV (LSV_γ). This tag is particular for each lexical unit. Which means that if a prime EH such as *beautiful* is a tag with LSV_α and LSV_γ does not necessarily imply that the lexical units under this prime will require the same specific tagging.

Table 3 displays how every particular lexical unit is tagged with prototypes, borderline, and sentiment features. In the case of Table 3, the TE-adjective membership coincides in the three cases. Let us go back to Table 2. We will realize how all the TE are prepared for automatically converging in most cases: v_L is usually equivalent for a prototypical negative, v_S is usually equivalent for a prototypical neutral, and v_R is usually equivalent for a prototypical positive.

Table 3. Example of a tagged lexical unit.

	Lexical Unit: *Beautiful*	
LSV_α	*Beauty*	v_R
LSV_γ	*Judgment, Pleasing-Likability*	v_R
Sentiment	*positive*	v_R

However, in some cases, some adjectives do need a dual tag for *prototype sentiment* (S_α) and borderline sentiment (S_γ). These are the example of words such as *sick*, *geek*, among others.

Table 4 provides two examples in which its lexical units have borderline cases in LSV and sentiment. Both cases clearly specify that the borderline case is activated only when a specific LSV is triggered. Therefore, within a particular context, *sick* would trigger S_γ in a sentence such as *Jordan's game is sick* (*skills*). Same situation for *geek*. It would trigger a borderline sentiment in a sentence such as *I am a Netflix geek* (*generates-interest*).

Table 4. Tagging lexical units with borderline cases.

	Lexical Unit: *Sick*			**Lexical Unit: *Geek***	
LSV_α	*Judgment*	v_L	LSV_α	*Similarity-Usual*	v_L
LSV_γ	*Pleasing-Likability* *Capability-Skills*	v_L v_R	LSV_γ	*Intelligence*	v_R
S_α	*negative*	v_L	S_α	*negative*	v_L
S_γ	*positive* {IFF capability-skills}	v_R	S_γ	positive {IFF generates-interest}	v_R

Therefore, thanks to FNL, it is only necessary to specify the borderline LSV_γ, and in which side of the fuzzy-graph the lexical unit will be in the borderline case (v_L or v_R).

We must mention that the borderline cases are challenging to extract. They arise as words with extreme variability, making it very difficult to know which exact word-pairing are borderline, and which borderline properties are triggering. The first step in our future work is working on an FNL lexicon with tagged-nouns. Therefore, we will be in a better position to evaluate the characterization of borderline cases.

Summing up, with this experimental work, we aimed:

- To evaluate the model's advantages and limitations when building a lexicon with FNL—improving the model with new linguistic properties.
- To check if it is feasible to convert adjectives from the semantics of the evaluative expression into an equivalent *positive-negative* value.
- To check in which cases the linguistic context is needed to classify an evaluative adjective in a LSV under a prime EH.

6. Conclusions

The model we have introduced takes into account the four main features when describing evaluative expressions:

- Firstly, evaluative linguistic expression's syntax, semantics, and sentiment are vague and gradient. The vagueness and gradience of its syntax and semantics are definable through the concepts of grammaticality and coercion.
- Secondly, the semantics of an evaluative linguistic expression can be associated with a semantic prime with a sentiment value. A real number cannot represent the extension of this prime most of the time. Therefore, it is necessary to consider an abstract extension representing an intensity similar to a Liker-t scale.
- Thirdly, every evaluative linguistic expression has a single lexical unit as an evaluative head. Such heads are not necessarily adjectives and have to be defined in terms of prototypical and borderline meanings.
- Lastly, syntactic structures that violate syntactic constraints detonate semantic intensions equivalent to a semantic prime. Therefore, variability does not compromise the final processing of the meaning of the construction.

Our findings and research provide the basis for creating a lexicon of evaluative expressions for future computational applications. Furthermore, we have expanded the trichotomous expressions, extracting new ones from a sentiment analysis corpus by experts.

Additionally, we outline the following aspects related to some of the theoretical criticism this model might receive.

- The linguistic mechanisms displayed in this paper to define evaluative expressions are mainly found in Sections 3 and 4. Those mechanisms are mainly the linguistic constraints from FPGr (Section 3) and selected concepts of Fuzzy Natural Logic (FNL) adapted to FPGr (Section 4), which consist of using the description of the trichotomous expression $\langle v_L, v_S, v_R \rangle$ as a constraint to define the semantics of an evaluative head. So, for example, some evaluative heads would have a constraint of $\langle VR \rangle$ that define its semantics, such as "*big*", "*tall*", "*complex*", "*beautiful*", and so on. In summary, the general approach to the model, its mechanisms such as the linguistic constraints, and its architecture are married to how FNL compute evaluative expressions.
- Evaluative expressions as a "component" are identified with a lexicon. Therefore, building a lexicon is fundamental for applying both FPGr and FNL to characterize evaluative expressions, mainly because an evaluative head does not have a fixed linguistic category.
- Our proposal is theoretical, including a proof-of-concept of how to build a lexicon of evaluative expressions. In the future, it is necessary to extend the tags on the evaluative expressions because it does need a lexicon to identify them, so their special fuzzy semantics can be characterized.
- Regarding whether the system prevents over-generation or not, FPGr and FNL system does not generate language, treebanks, or tree structures; they only characterize language. The generation of constraints or establishing the number of constraints for each language is up to each language's grammar or the experts configuring such grammar. If there is a problem with the overgeneration, it is not a fault of the system or the architecture. It is a fault of how the system was applied to define a particular language.
- The grammaticality of syntax is considered, as the gradient is a fundamental part of the FPGr. However, the notion of gradient grammaticality is not as "radical" as it might seem under the architecture of FPGr. First, as observed in Section 3, the grammar is defined as a set of constraints. Thus, the set of constraints represents the knowledge of grammar. These constraints can be prototypical; therefore, they are, for sure, constraints of a specific grammar, or borderline, so they are "sometimes" constraints of specific grammar. That is, they are marked, and they appear in specific contexts that are not prototypical. Therefore, the grammar is fuzzy because it considers both prototypical and borderline constraints and weighs them. Secondly, a natural

language input will have a degree of membership of a specific grammar according to the number of satisfied and violated constraints of such specific grammar. Therefore, the degree of grammaticality is defined as the degree of belongingness of an input, with regards to specific natural language grammar. For further information, see Torrens-Urrutia [19].

- FPGr and FNL do not consider extra-linguistic interpretations, since such a case would entail pragmatics. Therefore, it cannot generate from an input such as "*I love your food*" an output as: "*I love the fact that you cooked for me, regardless of the quality of the food*". Such an interpretation is considered pragmatic due to extra-linguistic reasons, i.e., theory of politeness, context, intention, implicatures, etc. (see Figure 2). Semantics in FPGr only focuses on the essential part of the meaning, the most primitive one, that is why we defend the notion of semantic primes as a hypernym, and the system defines constraints of evaluations regarding a prime. These constraints are $\langle v_R, v_S, v_L \rangle$.

7. Future Work

The future work for Fuzzy Natural Logic involves expanding the *fundamental trichotomous expressions and LSVs*. For such a task, it will be necessary to either explore computational techniques which can automatically extract the LSV, or to perform a systematisation of surveys in which a significant number of native speakers with linguistic knowledge of their language perform classifications of words. Regardless of the method, the final objective should be the creation of an ontology of the evaluative meaning based on the feature descriptions that this work pointed out.

Figure 9 shows an ontology made *ad hoc* as a guidance for a future design of a computational one. On the top, at the same level, we find both the *Prime Sentiment*, and *Prime semantics*, which will typically share polarities; that is, v_L will be prototypically negative. At the same time, v_R will be prototypically positive. From the most abstract notion of prime, we will find the next level, at which we find the *fundamental trichotomous expressions* with their $LSVs$. The closer we get to the bottom, the more metaphorical evaluations will be found. The prototypical relations are marked with a straight line, while fractured lines denote the borderline relations. The lines will state the semantic distribution between the prime and the related words if they have a relationship to v_L, v_S, or v_R. For example, *Einstein* has a borderline relationship of being a metaphorical evaluation with a semantic polarity of v_R in the LSV prime of *intelligence*, which means that it will be included in the fuzzy set of the $TE - EH$ of *intelligent*. The ontology must be able to define evaluative words as a combination of several *fundamental trichotomous expressions*, such as the case of *cute*. Typically, something *cute* is referred for something closer to be *pretty*, but at the same time, it shares traits with something being *quite small*. We would not say that a *big truck* is *cute*, but a *cartooney small toy truck* could be *cute*. Independently of how right is this semantic analysis, the main advantage of such an ontology is that it provides 'explainability', and the particular cases can be changed and improved. Thus, if a semantic relation is inaccurate, it could be fixed. Some words might have a lot of semantic relationships. It is a case of *do-it-yourself*. This lexical unit operates as an evaluation, providing a lot of different borderline meanings.

Creating several ontologies would help linguistics evaluate complexity of the syntax and semantics across languages for future experiments and linguistic applications in explainable AI. That is, computing with constraints how similar the meanings between languages are, elaborate ontologies of the history of language through the evolution of importance, and the evaluation of the linguistic universality in the semantic domain, among others.

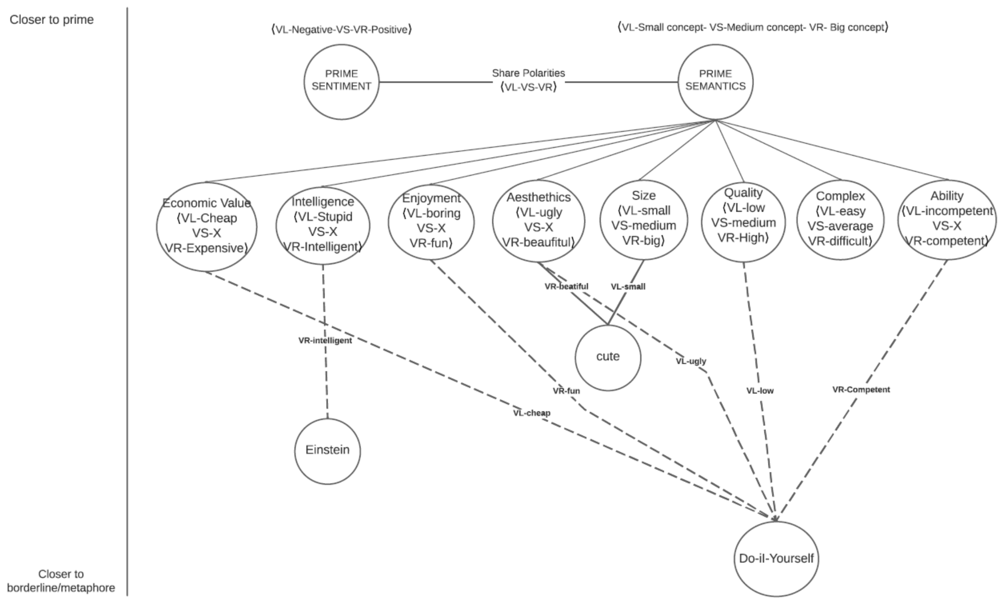

Figure 9. Ontology of evaluative expressions.

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