Reintroducing Few Basic Ideas in Cognitive Linguistics: An Elementary Computational Model

Indranil Sen(M.Sc,M.A)
Research Scholar, Department of Linguistics
Aligarh Muslim University
Aligarh, UP, India

1 Introduction

1.1 Introducing Cognitive Linguistics and the Conceptual Domain

Immanuel Kant, in his *Critique of Pure Reason*, first introduced the notion of *categorization*. However, his context was little different. He introduced this very notion of *categorization* in the context of existence and pure knowledge/reason. *Ludwig Wittgenstein* introduced the notion of *family resemblance*, which, we will see later that, is nothing but *explicitly written form of a category*. Anyway, in various areas apart from *Linguistics* the idea of the *categorization* was slowly being introduced and discussed. Finally it got its structured and rigorous shape in a discipline called *Cognitive Linguistics* during 80s and 90s. The very way we comprehend our surrounding world is quiet an enigmatic one. How do we experience our existing world? How we give things their names? Cognitive Linguists tried to provide the answer to these age-old questions in a new perspective. They claimed that the capacity of categorization of human brain is innate. We experience our surrounding world, being unaware of this very truth that simultaneously our brain continue to make *categories* out of hundreds of things. We simply select things, compare or discard them, include or exclude them somewhere in the furthest most corner of our brain and we do all of these unknowingly, atleast not consciously. The process we are engaged in is actually to know/identify/understand/recognize one thing in terms of another. The technical term of this process is called *categorization*. Lakoff.G in his numerous writings pointed out that when we are in the process of understanding the daily life that surrounds us, we do take help of *categorization* almost all the time, no matter how minimal that understanding is. All our daily mundane activities somehow fit in some *category* or other. *Furniture,tree, birds, emotion, vehicle, political party, little magazine, safety pin*, every single insignificant element fits in some or other *category*. (Later we will see that *senses* too, form a *category*). Now this *categories* emerge from the mutual reciprocity between human being and its surrounding. We understand/realize/identify this knowledge through our own body. Therefore, the primary

understanding stands through the embodiment of those thoughts. Now *Cognitive Linguists* call this embodied knowledge about surroundings*experiential realism.*
Before proceeding further let us describe few other notions and ideas of *Cognitive Linguistics* which will act as the foundational ground work for the idea of *conceptual domain*. Most importantly, these ideas will be helpful to understand the process of bridging between one abstract idea and one concrete idea ontologically. We will discuss elaborately the notion of *family resemblance* and mathematical formalization of generalized category and finally the idea of *idealized cognitive Model*(henceforth ICM).

1.2 The Computation Model of Few Basic Definition

1.2.1 Family Resemblance and the Formal Definition

The first theme we will try to formalize is the idea of *Family Resemblance* described by *Wittgenstein.L* in his *Blue and Brown Book*. He stated that people always search for the common properties and by accumulating those common properties an entity gets its general name. This is perhaps the basic procedure underlined in nomenclature in general. He argued that the category *GAME* disobeys people's natural tendencies to look for some common properties among the members of an aggregate. Because there is no single common property exists to unite all the *games* in the category *GAME*. As per *Wittgenstein* they come under one single category due to *Family Resemblance (henceforth FR)*. To describe this, *Lakoff* says categories are like families. He says *...members of a family resembles one another in several ways, say, few members have a particular color in their eyes whereas few relatives share the shape of their nose.*
Wittgenstein's notion of *FR* can be viewed as $m \times n$ matrix i.e a matrix with m rows and n columns if we extend his view little further and consider a category consists of n members, namely $x_1, x_2, x_3......x_n$.. Let us assume that each $x_k, k = 1, 2, 3.....n$. has a set of properties $\{p_{1k}, p_{2k}, p_{3k}....p_{mk}\}$. (Here a question may arise on the fact that how does each and every member in the category has the same number of properties. Without loss of generality we may easily fix m as the maximum number of properties one member can have and assign null in those places where other members may lack that particular property). So the representation of *FR* in matrix notation may finally look like

$$FR_{m\times n} = \begin{pmatrix} p_{11} & p_{12} & p_{13} & \cdots & p_{1n} \\ p_{21} & p_{22} & p_{23} & \cdots & p_{2n} \\ p_{31} & p_{32} & p_{33} & \cdots & p_{3n} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ p_{m1} & p_{m2} & p_{m3} & \cdots & p_{mn} \end{pmatrix}$$

Wittgenstein's idea of *FR* is actually something more general than of a category. One can recognize it as an explicitly written form of a category.
Here an interesting point may be noted that the total number of columns is actually the number of members in a category whereas the number of rows is the list of properties of the members of that category. Number of members in a category and their properties, together they form the matrix. In this situation we may rename our $FM_{m\times n}$ in a different way. This particular way of writing a category explicitly can be renamed as $EXCAT$ (Explicitly

written Category).From the nomenclature itself the difference between one Category(CAT) and its $EXCAT$ form now becomes clear.

1.2.2 Introducing the Extended Category EXCAT

Let us discuss the idea of $EXCAT$ with an example. Consider the category $BIRD$.It is evident that this is not possible to write down all the names of the birds and their properties. Without losing generality we are choosing five birds from the wide range distributively keeping the fact in the mind their vast range of properties.Let us consider the Category $BIRD$ and its members are Penguin, Eagle,Chicken,Dove and Sparrow i.e
$CAT_{BIRD} = \{Penguin, Chicken, Sparrow, Dove, Eagle\}$ We are selecting six properties of $BIRD$, namely, type of *Bill,Tail and Wing* respectively,*Food Habit, Ability of Flight* and *Ability of Swimming*.Taking these five birds and their six properties we can compute our 6×5 matrix but as the entries of this matrix will be non numeric in nature it will be better to write down our 6×5 matrix in a form of a table with thirty cells distributed in six rows and five columns.(Clearly a typical $(i, j)th$ entry of a matrix is maintaining it's $1 - 1$ correspondence with $ijth$ cell of the table in the natural mapping $(i, j) \rightarrow ij.)$ So our $EXCAT$ table for $BIRD$ denoted by $EXCAT_{6\times5}BIRD$ may look like

Birds→ Properties↓	**Penguin**	**Chicken**	**Sparrow**	**Dove**	**Eagle**
Bill	Long Thin Short Thick	Short Rounded	Short Stout	Short Thin	Hooked
Tail	Short Wedge Shape	long Flowing	long Rounded	Short	Long
Wing	Evolved into Flapers	Smaller	broad	short Round	Broad
Food Habit	Carnivorous	Omnivorous	Omnivorous	Omnivorous	Carnivorous
Ability of Flight	No	Not Much	Yes	Yes	Yes
Ability of Swimming	Yes	No	No	No	No

The diverse nature of the properties of the category $BIRD$ is clearly seen from the above table/matrix and it is also an interesting point to note that no two columns have exactly same entries.Some entries from the columns of $Chicken$ may be similar to some entries from the column of *Dove* but the vast diverse nature of properties does not pose any hazard in one's mind to club all the members under the single category $BIRD$ in spite of the fact that few members even disobey the archetypical property of flight possessed by a *bird*.
Before proceeding to the further, let us generalize the category *BIRD*. Let us consider the category *BIRD* with n numbers of *birds* each having m numbers of properties. So our explicitly written category of *BIRD* is actually a $m \times n$ matrix. Therefore our further discussion will be based on $EXCAT_{m\times n}BIRD$ matrix.

1.2.3 Idea of Centrality

Next idea introduced by *Wittgenstein* was the notion of *Centrality*.In classical notion all members in a category share all the properties of that category.In other way there were no best examples existed to represent that category.Though interestingly these categories have got their existence through time. Human mind, probably through the innateness of the idea of *categorization* in their brain recognized this process standing against the classical theories. *Wittgenstein* introduced the idea of *centrality* and gave some light into the idea of the fuzziness of one category. Later *Eleanor Rosch* developed this very notion in her path braking idea of *Prototype*.Loosely, the idea of *centrality* is simple enough.It is the best possible example of a category.The example which carries as much possible properties to turn out as the superior candidate to represent the *category*.Later the concept was further expanded by Lakoff in his concept of *Idealized Cognitive Model*(Henceforth *ICM*).
Interestingly when we talk about *birds* we always prefer to give example like *Dove,Sparrow, Cuckoo* etc.It is rare to encounter the examples like Chicken or Penguin.We never say or perhaps never visualize *Roosters are flying high above the trees.*Though the incident is not rare but perhaps we never think in our absent mind that *...in a leisure afternoon a chicken came and sat on my windowpane.* So *centrality* of the category *BIRD* is a kind of ideal example *The Bird* which in reality is not a part of our $EXCAT_{m\times n}BIRD$ matrix. Therefore the *centrality* or the ideal *bird* is not a member of CAT_{BIRD} also.We are choosing the example of an ideal *bird* from the explicit matrix of the properties of the *birds* according to the closeness of a particular column of $EXCAT_{m\times n}BIRD$ with the properties of the ideal *bird*. If we include the ideal *bird* in the set of CAT_{BIRD} and consider the *centrality* or the properties of the ideal *bird* as an idealized column of the *EXCAT* of *BIRD* (henceforth *ICol BIRD*) then cardinality of the set CAT_{BIRD} will be $(n+1)$ instead of n and the matrix $EXCAT_{m\times n}BIRD$ will be $EXCAT_{m\times(n+1)}BIRD$. Clearly *ICol BIRD*, the $(n+1)th$ column of the matrix $EXCAT_{m\times(n+1)}BIRD$ is an $m\times 1$ matrix with entries $p_{1(n+1)}, p_{2(n+1)}, p_{3(n+1)} \ldots\ldots p_{m(n+1)}$. In matrix notation therefore
$ICol_{m\times 1}BIRD = \{p_{1(n+1)}, p_{2(n+1)}, p_{3(n+1)} \ldots\ldots p_{m(n+1)}\}^T$.
Here we are placing the column of the ideal *Bird* in the right most column of the matrix for the sake of maintaining the natural convention of direction. The idea is,the more the entries of a column is becoming similar to the corresponding ideal entries of the $ICol_{m\times 1}BIRD$,the more that particular column is eventually becoming one example of the category *Bird*.
Obviously $ICol_{m\times 1}BIRD$ is an abstract idea, situated in our thought and emerged from our real life experience.Therefore an *example* of the category*Bird* (EX_{BIRD}) is/are the column(s) which is(are) closer to $ICol_{m\times 1}BIRD$. More precisely, in notation EX_{BIRD} is the $kth, (k = 1, 2, 3....n)$ column of the matrix $EXCAT_{m\times(n+1)}BIRD$ which is closer to the $(n+1)th$ column of the matrix $EXCAT_{m\times(n+1)}BIRD$ i.e closer to the matrix $ICol_{m\times 1}BIRD$.
Let us summarize all the notation in a more general way. We consider a category C consisting n number of members $x_1, x_2, x_3......x_n$. each having m number of properties $\{p_{1j}, p_{2j}, p_{3j} .... p_{mj}\}$, $j = 1, 2, 3.....n$. So our explicitly written category will be the $m \times n$ matrix
$EXCAT_{m\times n}C = (p_{ij})_{m\times n}, i = 1, 2, 3....m; j = 1, 2, 3....n$. If we include the ideal example of the category which is derived from the notion of *centrality*, then the cardinality of the category C will be $n+1$ that is CAT_C will consist of $n+1$ elements and the explicitly written form of the category will be $EXCAT_{m\times(n+1)}C$ that is $EXCAT_{m\times(n+1)}C = (p_{ij})_{m\times(n+1)}$

$$= \begin{pmatrix} p_{11} & p_{12} & p_{13} & \cdots & p_{1n} & p_{1(n+1)} \\ p_{21} & p_{22} & p_{23} & \cdots & p_{2n} & p_{2(n+1)} \\ p_{31} & p_{32} & p_{33} & \cdots & p_{3n} & p_{3(n+1)} \\ \vdots & \vdots & \vdots & \cdots & \vdots & \vdots \\ p_{m1} & p_{m2} & p_{m3} & \cdots & p_{mn} & p_{m(n+1)} \end{pmatrix}$$

Clearly *ICol C*, the $(n+1)th$ column of the matrix $EXCAT_{m\times(n+1)}C$ is an $m \times 1$ matrix with entries $p_{1(n+1)}, p_{2(n+1)}, p_{3(n+1)}......p_{m(n+1)}$. In matrix notation therefore $ICol_{m\times1}C = \{p_{1(n+1)}, p_{2(n+1)}, p_{3(n+1)}......p_{m(n+1)}\}^T$. Finally EX_C will be the $rth, (r = 1, 2, 3....n)$ column of the matrix $EXCAT_{m\times(n+1)}C$ which is closer to the $(n+1)th$ column of the matrix $EXCAT_{m\times(n+1)}C$ in terms of it's entries i.e closer to the matrix $ICol_{m\times1}C$.
The reason why the notion of *centrality* or $ICol$ will not be exactly same in many cases with the idea of ICM lies in the fact that ICM may contain many more members as it will include thousand of real life experiences about the members of that category, in many cases they may not be strictly called *the property* of that category.

1.2.4 More about Centrality

J.L.Austin in his paper *The Meaning of a Word* written in 1940 and published in 1961 discussed about words and their related meaning extensively. *Lakoff* in his *Women, Fire and Dangerous Things* has shown that *...the relationship between Austin's observation and Wittgenstein's: the sense of a word can be seen as forming a category.* In classical theory the case was not so. *Senses* do not have any *category.*Let us analyse the idea computationally with the same example Austin worked; the meaning and associated ideas attached with the word *healthy.*
Dictionary meaning associated with the adjective *healthy* roughly are
{*in a good physical condition,in a good mental condition,in good health,well, alright,fine fit,physically fit,in good trim,in good shape, in fine fettle,in good kilter,in top form,aerobicized,in tip-top condition,flourishing,blooming,thriving hardy,hale,hear- ty,robust,strong,vigorous,hale and hearty,fighting fit,fit as a fiddle,fit as a flea,bursting with health,the picture of health,in rude health,informal OK,in the pink,right as rain,up to snuff,(of a part of the body) not diseased,indicating or promoting good health,good for one,good for one's health, health giving, healthful,wholesome,nutritious,nourishing,beneficial, salubrious, salutary,of a very satisfactory size or amount*}.
Austin discussed with two examples. One is *healthy exercise* and another is *healthy complexion.* Austin argued in *healthy body* there is a sense which predominantly present in *healthy complexion* and *healthy exercise.* Austin called that sense *nuclear* or *primary.* Let us call the projection of that *primary* or *nuclear* or the *central* sense of *healthy* in *healthy exercise* and in *healthy complexion* as the *secondary* senses of *healthy.* Generalizing the notion of *secondary* sense, let us call the projections of *primary* sense of *healthy* on the respective expressions simply as $secondary_1$, $secondary_2$, $secondary_3.....secondary_n$.Therefore, following the same construction discussed in the section of *Family Resemblance* and *Centrality*, let us define the *category* of senses of the adjective *healthy.* Here we are going to modify our previous notation of CAT and $EXCAT$ as senses were not regarded as categories in classi-

cal theories. Another reason is to demarcate the types of the categories according to their qualitative nature. For sense category let us use the notation CAT as $SCAT$ and $EXCAT$ as $EXSCAT$.So for *healthy* $SCAT$ and $EXSCAT$ will be
$SCAT_{HEALTHY} = \{primary/central, secondary_1, secondary_2.....secodary_n\}$, n runs through the set of all natural numbers $\mathbb{N}$.
As we are discussing about *sense* which involves many naturally longer expression/usages than of a single atomic expressions like *yes/no* or *long/short* etc.it will be wise not to write $EXSCAT$ in conventional matrix form. Later, we will have all the sense columns in row-transposed form.
Austin has shown primary sense of *healthy* as in *healthy body* is partly contained in the sense of *healthy* as in *healthy complexion* and in *healthy exercise* which are in reality *...resulting from a healthy body* and *...productive of a healthy body* respectively. Let us call the sense of *...resulting from a healthy body* as $secondary_1$ and *healthy exercise* as $secondary_2$. Clearly *healthy complexion,healthy hare, in good shape,picture of health, bursting with health* etc. all can be said as *resulting from a healthy body*(There can be many more examples, as we are dealing with language which is infinitely productive in nature) whereas *healthy exercise, healthy food, healthy habits* etc are the *productive of a healthy body.* There is an obvious problem to deal with this as heavily loaded subjectivity is involved to determine the categorical exactness of the properties like senses.Few examples may fall under some other headings but the overall structure will be the same. Keeping the fact in mind let us describe the *primary/nuclear/central* sense of *healthy. Healthy body,not diseased,in good health* etc. are predominantly occupied by the primary sense of the adjective *healthy. Lakoff* referred this *contained-partly* relationship as *metonymy -where the parts stands for the whole.* So *resulting from a healthy body* and *productive of a healthy body* has the partial sense of *healthy* whereas the central sense (ideal member in our previous discussion developed from the idea of centrality) of $SCAT_{healthy}$ (as our previous discussion) is actually the primary or nuclear sense of *healthy.*These two partial senses of *healthy* are like the extension of the central sense of *healthy* and Lakoff argued that *the rule of extension is metonymy.*
Let us take the example of *healthy relationship.* Google is telling that a healthy relationship is *Communication based on honesty and trust, Respect and Trust. In healthy relationships, you learn to respect and trust important people in your life.* There is almost no projection of the *primary* sense of *healthy* in this explanation and also in our daily mundane understanding of *healthy relationship.*Here we conceptualize the abstract idea of *relationship* through the common understanding of *healthy body* i.e through the *primary/central* sense of *healthy.* So this extended correspondence includes the sense of *healthy* as in *healthy body* in the category of all senses of *healthy*,i.e in $SCAT_{healthy}$ as a secondary sense, say as $secondary_k$, for some $k \in \mathbb{N}$. Here the rule of extension is *metaphor.Healthy competition* is another example of *metaphor* in same manner.
Now let us construct our $EXSCAT$ matrix. Clearly $secondary_1, secondary_2...secodary_n$ will be the n columns of the matrix,e.g $column1$ may be
(*healthy complexion,healthy hare, in good shape,picture of health, bursting with health...*)^T, in similar way $column2$ may be (*healthy exercise, healthy food, healthy habits...*)^T. (It is needless to say that the ordering of the matrix columns are not strict.It occupies respective position according to the working examples). We are going to change another notation here; we will denote $ICol$ as *primary sense column*(Henceforth PSCol). For sake of definiteness let us fix

the primary/central sense of *healthy* as $(n+1)th$ column of the matrix. So $column(n+1)$ will be $(Healthy\ body,not\ diseased,in\ good\ health...)^T$. As we have already our column of centrality in the matrix so the formation of $EXSCAT_{m\times(n+1)}HEALTHY$ already exists.
Let us generalize the overall idea in this way.
Let us assume there are n secondary senses and a *primary/central* sense of a particular word W. Then $SCAT_W = \{primary/central, secondary_1, secondary_2...secodary_n\}$, n runs through the set of all natural numbers $\mathbb{N}$.
Now, if each $secondary_j, j = 1, 2, 3...n$ has m number of *sense containing expressions* s_{1j}, s_{2j}, $s_{3j}...s_{mj}$ and the *primary* sense has m number of *sense containing expressions* $p_{1(n+1)}, p_{2(n+1)}$, $p_{3(n+1)}...p_{m(n+1)}$ then the matrix
$EXSCAT_{m\times(n+1)}W$ will be

$$\begin{pmatrix} s_{11} & s_{12} & s_{13} & \cdots & s_{1n} & p_{1(n+1)} \\ s_{21} & s_{22} & s_{23} & \cdots & s_{2n} & p_{2(n+1)} \\ s_{31} & s_{32} & s_{33} & \cdots & s_{3n} & p_{3(n+1)} \\ \vdots & \vdots & \vdots & \cdots & \vdots & \vdots \\ s_{m1} & s_{m2} & s_{m3} & \cdots & s_{mn} & p_{m(n+1)} \end{pmatrix}$$

1.2.5 Metaphor and Metonymy:The Hint of a Modelling

The fuzziness of the ideas like *metonymy* and *metaphor* can be analysed systematically in this model where we include if not possible all the senses of a word in a single category. If we define *degree of projection* of the *central/primary* sense on the other senses then that degree will determine alone whether the member of the category is a metaphor or a metonymy or an undecided case. If we fix the value of centrality or the central/primary sense as 1 and fix the value as 0 when projection of primary sense on the other senses is absent, then the rule of extension *metonymy* will always get the values less than but closer to 1 and the tail end will be *metaphor*. We can draw an analogy from *calculus*(keeping the fact in mind that,here the nature of the data involved is discrete) if we say:
A sense expression will be metonymy when the projection of the primary sense on it goes as much away from 0 and closer to 1 from left and a sense expression will be more metaphoric when the projection of the primary sense on that sense expression $\rightarrow (0+0)$.
To be more precise let us first define a set $SCAT_W^*$ of all senses, associated with a word W except the primary sense. Let a *Cover* is the value associated with each projection of primary sense on the non primary senses, i.e. the *cover* is the mapping from the set $SCAT_W^*$ to the half-closed set of real numbers [0,1) such that
$Cover(sense_i) = t$ where each $sense_i \in SCAT_w^*, i = 1, 2, 3...n.$ and $0 \le t < 1$. Clearly sense expression will be more metonymy if it's *cover* goes as much away from 0 and closer to 1 from left and will be metaphoric it it's *cover* $\rightarrow (0+0)$.

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