Lexical Semantic Organization

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The mental lexicon is thought to include a huge number of words. Several words are kept in the mental lexicon. According to a study, a literate adult of a particular native language will know more than 150,000 words and employs it 90% of the time in conversations [1]. The function of semantics and word meaning as the organizing principle of concepts in the mental lexicon is highlighted within the larger context of semantic memory. As a result, the models that were suggested were based on the agreed meaning of words, with the assumption that meaning played an important role in how they were organized.

Lexical-semantic organization in the developmental population further proposed the inclusion of two broader categories to classify the semantic relationships, namely: Attributive and Evaluative responses.

Attributive relations refer to perceptual/ physical characteristics, and part-whole relationships shared between words. E.g., Pillow- Cotton, Cotton- white/ soft, etc.

Evaluative relations refer to experiences or thoughts that are internalized, generalized sayings, idioms, etc. E.g., Candy – Really like/ bad health. The semantic relations listed above may be inspected through various perspectives, including neurolinguistic and psycholinguistic realms. The literature has mentioned these two methods, a majority slightly tilted toward the psycholinguistic aspects. The lexical semantic organization has been extensively studied over the course of a decade's worth of literature on the developmental population, as previously established. This also proposes a trajectory of the shift in dominance of one kind of organization through the course of childhood, but very few instances are available of this trend being tracked over the course of adulthood. To begin with, a profound appreciation of the storage of the concepts in the lexicon is necessary; this is provided by models of Semantic organization.

To gain insights into the lexical-semantic organization, here are a few models that have been proposed to explain how this organization takes place in the mental lexicon:

According to a study, on the façade, theories of mental lexicon may be viewed as representing a holistic front or the attributes of the words [2]

I. **Attribute/ Feature-based** models include the semantic feature comparison model.

II. **Holistic** models may include the Hierarchical Network model, spreading activation model, Adaptive character of thought model, Compound cue model, Distributed Memory model, WordNet model, Statistical models, etc.

a. **Hierarchical Network Model.**

It was put forth by a study to explain the storage and retrieval mechanisms in Lexical storage [3]. It proposed the existence of a network of words related by commonly shared concepts, put as nodes. This model proposed three tiers of relationships: The connection was said to happen in two logical ways, namely: category membership relation and property relation. In the former relation, an outline of how the words were linked is suggested, and in the latter, the attributes that are shared by items in a hierarchy are suggested.

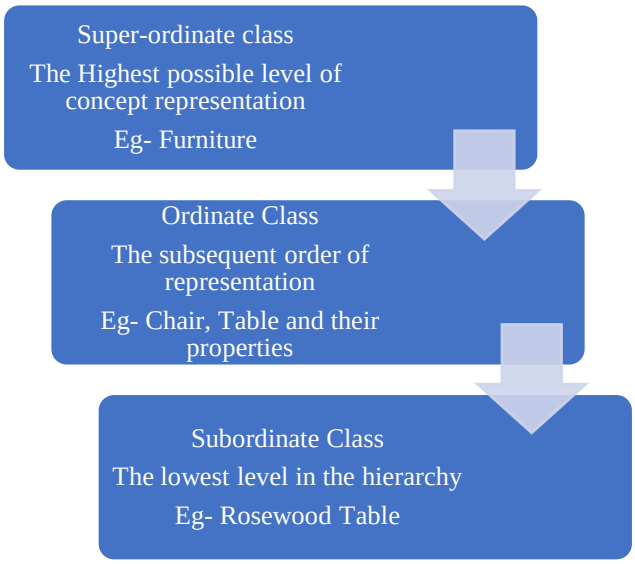

Figure 1: Schematic representation of Hierarchical Network Model

The base of this model is rooted in the principle of cognitive economy. This postulates that common information (property) is stored at only one level (the highest level). Many subsequent behavioral investigations negated the validity of this principle, as it failed to explain many aspects, including that of the familiarity effect [4]. Thus, this theory could not stand to explain all the aspects of a functioning mental lexicon.

b. Spreading Activation Model.

The spreading activation model designates words to be organized in an interconnected nodal network [5]. It works on the principle of familiarity and relatedness, i.e., more commonly recognized, and closely related words are activated more strongly. The above-mentioned nodes have networks and are activated based on the strength of the relatedness and distance amongst words. Thus, when one node is activated, many nodes are triggered in parallel; but only the strong nodes remain intact. The strongest nodes that are triggered are said to be primed. Hence, the relationships that words share become significant. This model is effective, as it helps in projecting the **storage and processing** aspects of Semantic Memory. The connected nodes in the model help in deciphering association and explain associative priming better. This model is widely accepted as it can account for several events, including- the familiarity effect, typicality effect, etc.

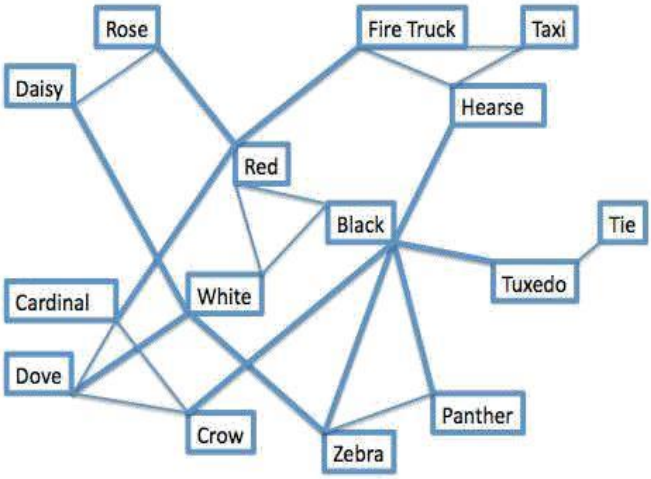

Figure 2 Schematic representation of the spreading activation model [5]

a. Adaptive Character of Thought (ACT) Model.

This computational model was proposed, and it includes aspects of the Spreading activation model linked to an execution system for production [6]. The model proposes that concepts are stored in isolation, unrelated to words, but words are associated with concepts in their storage, thus stating the contextual and environmental influence of words in the storage.

b. Compound Cue Model [7]

The **compound cue model** describes lexical-semantic activation as a comparison that occurs between cues in short-term Memory vs. long-term memory. As soon as a word (prime) say X, is delivered, a compound cue (Y) is generated in the short-term memory. The prime and the generated cues (X-Y) are subsequently compared to those that previously existed in long-term memory. Hence, in long-term memory, X-Y, as a pair, would generate stronger associations than R-S or X-R, etc. Thus, this model also relies on familiarity and relatedness of previously learned associations. The difference between the Spreading activation model and the current is the inclusion of short-term memory processing.

c. Distributed Memory Model [8]

Distributed Memory Model proposed was originally derived from the Hopfield net [9]. This model proposes that storage occurs in terms of a network of concepts interlinked to each other and assumes only one level of processing as opposed to the connectionist principles (Input- hidden layer- Output). The stronger linkages are said to be triggered in a simple yes/ no format, and these linkages are further fortified by learning because of the addictive nature of their functioning. After repeated triggering by a particular prime, learning is complete, and stabilization occurs.

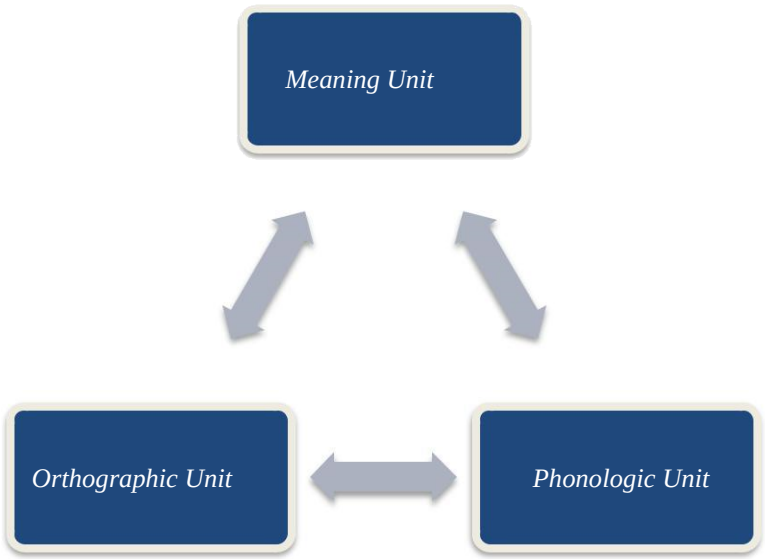

Figure 3 Schematic representation of modules in distributed memory model

d. WordNet Model.

A study proposed an electronic database based on the principles of the Hierarchical network model [10]. This functions by storing the words in the form of synonyms known as Synsets, and when to rectify the fact that not all words may share the same synonyms, the concepts of hyponymy and hypernymy were suggested to expand the organization further. The drawbacks of this model include the fact that it cannot account for the use of the lexicon at the discourse level.

The above-described semantic models of lexical semantic organization do not account for all the functions of the lexicon; hence this gave rise to the statistical models listed below:

- **Featural and Unitary Semantic Space Model.**

This model was put forth, which gives importance to the organization being a modality-based and feature-wise representation of concepts [11]. It assumes that concepts are linked to other linguistic aspects (Phonology, morphology, syntax) through lexical-semantic association. Thus, the lexical-semantic organization may be partly understood through the above-mentioned prominent models. The conceptual structuring of the lexicon, maybe viewed in the following manner, i.e., through hierarchical/context-based/ egoistical/feature-based affiliations. The samples provided in the available works of the literature suggest that the majority of it has assessed the hierarchical and context-based mode of organization.

The above-established relationships between words and the conceptual organization of the same in the lexicon may be viewed through various perspectives. A few of them have been summarized:

A few *neurolinguistic investigations* that suggest the dominant views of the organization are summarized below: The neuro-anatomical correlates of taxonomic and thematic responses were studied using fMRI [12]. They employed a lexical decision task with short stimulus onset asynchrony (200ms) across four conditions-thematically related, taxonomically related, unrelated, and nonsense words, and made use of the imaging data to predict the neuro-anatomical correlates of the related words. They concluded that thematic associations activate cortical areas such as the left inferior frontal, middle temporal, and occipital regions, while taxonomic associations activate the right middle frontal gyrus, left precuneus, and left thalamus.

A recent neurolinguistic study was conducted through Magnetoencephalography while employing a taxonomically and a thematic-based priming task. Its findings suggested that the Anterior Temporal Junction is linked to taxonomic association, while thematic associations activate Temporo-Parietal Junction [13]

Inference: Hence, thematic and taxonomic associations may be viewed as *two different facets* because several neurolinguistic studies suggest varied neural activation pathways for the two.

A few works of literature in this context have addressed the modality-based differences that exist in lexical semantic organization: study explored the above using an Event-related Potential (N400), and found that auditory modality has an early onset latency and is more persistent over the visual modality [14]

The study gave support to the above findings through a lexical decision task. The available literature concerned with exploring *developmental aspects* of lexical semantic organization is in abundance. There are studies that support the occurrence of a "shift hypothesis" in children [15]

At a younger age, taxonomic and thematic associations are present [16]. Younger-aged children prefer thematic relations (event-based coordinates) over taxonomic connections (category coordinates) on cued and serial recall tasks. The taxonomic associations are bolstered by the fast development of vocabulary at that age. Owing to the expansion of vocabulary in the preschool period, children have a change in the tendency to prefer taxonomic over thematic associations. This phenomenon has been termed as the *shift hypothesis*. As the child's vocabulary develops, the words are organized hierarchically, and stronger relationships amongst certain concepts emerge over time.

In the Indian context, notable studies suggest the plausibility of the shift hypothesis in developmental aspects. The study investigated the lexical-semantic organization in bilingual children of age 6-8 years [17]. Repeated word association task with thematic and taxonomic examples was administered, and the results of the study indicated that children at 6 years of age were dominantly associated thematically, and in the developing years, a paradigmatic (taxonomic) shift was noticed. Thus, this is in support of the association shift paradigm in children. A few studies have attempted to investigate the *lexical-semantic organization in children and compare the results with those of adults:* In an investigation, they employed a match-to-sample task in which the participants were forcibly asked to match the given stimuli to either a taxonomically or a thematically related item, found that *children and the elderly preferred thematic relationship*, whereas *adults* have a preference towards *taxonomic matches* [18]. In contrast to the above study, compared the semantic organization between adults and children through a lexical decision task [19]. The method employed used semantically related and unrelated word pairs to verify the effects of semantic priming. Through the findings, he concluded that the semantic organization in children beyond 6-7 years of age could be equated to that of adults.' This is in a continuum with the shift hypothesis mentioned in children. There have been few mentions in the literature about the preferential associations in adults. Thus, there have been very few attempts in the past to establish semantic associations *beyond the developmental frame*, and those that exist are *inconclusive.* Further, the methods frequently used to study the associations have been *closed-set tasks*, including matching, sorting, or recall tasks. This has the potential to *bias* the participants and affect the results.

A study has proven this by comparing tasks involving stimuli that were strongly taxonomically organized with stimuli that were strongly thematically organized, and the participants were asked to perform a sorting task [20]. The adult participants preferred taxonomic associations in the former task and thematic associations in the latter. Hence, the method of testing and the stimuli have always played a major role in identifying the associations under test. The study conducted an online survey wherein the participants were supplied with a questionnaire that contained 659-word pairs, and they were asked to rate them as being taxonomically or thematically related to two different sets of instructions. The results revealed that the participants rated the stimuli as being dominantly taxonomic/ thematic, based on the instruction given before each task, thus affecting the outcome of the data [21]

Inference: Thus, it is seen that closed-set tasks may cause bias. A new approach will aid in gaining another perspective on the adult lexical-semantic organization, as the current literature has modest answers. Hence *open set association* tasks will serve the purpose of establishing the lexical-semantic organization. These include free word associations, discrete word association tasks, etc. These terms may be defined as:

Free word association task- Participants are asked to list as many words that come to their minds as soon as they are presented with stimuli.

Discrete word association task **-** Participants are asked to list as many words that come to their mind in relevance to the presented stimuli as it is being presented.

There have been attempts to make word association norms for children and adults [22], but very rarely in older. Some of the earliest views comparing the elderly with the younger demographic on word association tasks stated: "They are represented better by hierarchies of association principles that differ in the probability of use, rather than by hierarchies of specific word-word affinities" [23]. They studied free association in older adults and revealed that the *associations were affected by vocabulary, irrespective of age* [24]. One of the early views to oppose the above findings included those of the study [25,26], who employed a free association task, to compare the younger and elder populations, where they concluded that word relationships in the semantic memory affects the association to a given word, and this may be affected with increased age. In the study they compared younger and older adults, with mean ages 20 and 63, respectively, in a free association task and found that the *elderly participants produced less commonly associated responses, with less consistent responses in repeated trials,* as opposed to their younger counterparts [27]. Thus, suggesting *differences across age groups.*

Since then, there has been more support from works of literature that made an attempt at making word association norms for younger (mean age- 21.7 years) and older adults (mean age – 71.6 years) [28]. The two groups were asked to give out relevant words to the stimuli presented, which included verbs, nouns, and adverbs. The auditory stimuli presented were simultaneously augmented with visual stimuli on a card. The participants were not restricted in terms of the number of responses for each word. The results took into account the three most common responses in each group under investigation.

The study revealed that the three most popular responses had a *high variability index* of *39.5%*, which further strengthens the impression that there may be a variation in responses between the younger and the older population, which are yet to be explored. In 2014, a study aimed to investigate age-related differences among children, adults, and the elderly through a word association task. Graphical analysis of the responses obtained suggested that there was an increase in the connectivity of the network across ages, reaching its peak in young adults, and a slight decline was witnessed in the elderly [29]

The existing literature illustrates that a few attempts have been made at comparing the *typical and atypically aging population.* The typically aging individuals are shown to have a mild increase in multi-word responses to lexical naming tasks due to word-finding difficulty [30]. The study compared word association responses between the elderly population with and without dementia and reported that the elderly tended to give multi-word responses and blank responses. These findings further fortify the plausible shift in word association due to word finding and retrieval difficulty due to aging [31]

In the context of Indian literature, a few studies in recent years have made use of *free association tasks in order to explore the semantic organization in developmental populations.* These include:

The study compared children across 6-9 years of age using free association tasks on a set of abstract and concrete word stimuli, and the results were suggestive of a dominant attributive relationship, followed by the taxonomic, introspective, and thematic relation in the case of concrete words [32] The study employed the same methodology to compare nouns in children of 4-7 years of age and found a more dominant thematic relationship, as opposed to taxonomic [33] A noteworthy attempt to explore the lexical-semantic organization in Indian adults through word association tasks [2] The study aimed to determine the mental lexicon for nouns and verbs in adult speakers of Kannada. The participants were given concrete and abstract nouns and verbs. They were asked to give out words that came to their mind as soon as the target stimulus was presented. The responses were analyzed, and a set of possible words associated with the target word were determined.

In summary, past research has established many views on the organization of the mental lexicon in the developing population, with an auxiliary role played by the Indian literature. There have been very few works that focus beyond the developmental frame. To add to this, in the available reports of adults, there have been rare employments of open set tasks to investigate the Lexical semantic organization. In addition to the existing need

to explore the domain, there have been very few mentions of open-set stimuli-based association tasks to explore the lexical-semantic organization in typical adults *in the Indian scenario.* Thus, the current study will serve as a preliminary attempt to explore the lexical-semantic organization in typical adults and compare it to aged individuals.

References

[1] Seashore RH, Eckerson LD. The measurement of individual differences in general English vocabularies. Journal of Educational Psychology. 1940 Jan;31(1):14.

[2] Prarthana.S, K.S. Prema. Role of Semantics in the Organization of Mental Lexicon. Language in India. 2012;12(ISSN No: 1930-2940.

[3] Collins AM, Quillian MR. Retrieval time from semantic memory. Journal of verbal learning and verbal behavior. 1969 Apr 1;8(2):240-7.

[4] Conrad C. Cognitive economy in semantic memory. Journal of Experimental Psychology. 1972;92(2):149–54. doi:10.1037/h0032072.

[5] Collins A.M, Loftus E.F. A spreading-activation theory of semantic processing. Psychological review. 1975 Nov;82(6):407.

[6] Anderson JR. ACT: A simple theory of complex cognition. American psychologist. 1996 Apr;51(4):355.

[7] Ratcliff R, McKoon G. A retrieval theory of priming in memory. Psychological review. 1988 Jul;95(3):385.

[8] Masson ME. A distributed memory model of semantic priming. Journal of Experimental Psychology: Learning, Memory, and Cognition. 1995 Jan;21(1):3.

[9] Hopfield JJ. Neural networks and physical systems with emergent collective computational abilities. Proceedings of the national academy of sciences. 1982 Apr;79(8):2554-8.

[10] Miller GA. WordNet: a lexical database for English. Communications of the ACM. 1995 Nov 1;38(11):39-41.

[11] Vigliocco G, Vinson DP, Lewis W, Garrett MF. Representing the meanings of object and action words: The featural and unitary semantic space hypothesis. Cognitive psychology. 2004 Jun 1;48(4):422-88.

[12] Sachs O, Weis S, Krings T, Huber W, Kircher T. Categorical and thematic knowledge representation in the brain: Neural correlates of taxonomic and thematic conceptual relations. Neuropsychologia. 2008 Jan 1;46(2):409-18.

[13] Lewis GA, Poeppel D, Murphy GL. The neural bases of taxonomic and thematic conceptual relations: An MEG study. Neuropsychologia. 2015 Feb 1; 68:176-89.

[14] Holcomb PJ, Neville HJ. Auditory and visual semantic priming in lexical decision: A comparison using event-related brain potentials. Language and cognitive processes. 1990 Oct 1;5(4):281-312.

[15] Fischer GM, Daltrozzo E, Zumbusch A. Selective NIR chromophores: bis (pyrrolopyrrole) cyanines. Angewandte Chemie International Edition. 2011 Feb 7;50(6):1406-9.

[16] Waxman S, Gelman R. Preschoolers' use of superordinate relations in classification and language. Cognitive Development. 1986 Apr 1;1(2):139-56.

[17] Chithra.R. Lexical- semantic organization in bilingual children. (Masters dissertation, University of Mysore), 2008.

[18] Smiley SS, Brown AL. Conceptual preference for thematic or taxonomic relations: A nonmonotonic age trend from preschool to old age. Journal of Experimental Child Psychology. 1979 Oct 1;28(2):249-57.

[19] Radeau M. Semantic priming between spoken words in adults and children. Canadian Journal of Psychology/Revue canadienne de psychologie. 1983 Dec;37(4):547.

[20] Murphy GL. Causes of taxonomic sorting by adults: A test of the thematic-to-taxonomic shift. Psychonomic Bulletin & Review. 2001 Dec;8(4):834-9.

[21] Landrigan JF, Mirman D. Taxonomic and thematic relatedness ratings for 659-word pairs. Journal of Open Psychology Data. 2016 Feb 8;4(1):e2-

[22] Palermo DS, Jenkins JJ. Word association norms: Grade school through college, 1964.

[23] Moran LJ, Swartz JD. Longitudinal study of cognitive dictionaries from ages nine to seventeen. Developmental Psychology. 1970 Jul;3(1):21.

[24] Lovelace EA, Cooley S. Free associations of older adults to single words and conceptually related word triads. Journal of Gerontology. 1982 Jul 1;37(4):432-7.

[25] Riegel KF, Riegel RM. Changes in associative behavior during later years of life: A cross-sectional analysis. Vita humana. 1964 Jan 1;7(1):1-32.

[26] Bolton M, Haimson H. Hierarchical effect of semantic memory on verbal learning. Perceptual and Motor Skills. 1975 Dec;41(3):843-6.

[27] Perlmutter M. Age differences in adults' free recall, cued recall, and recognition. Journal of Gerontology. 1979 Jul 1;34(4):533-9.

[28] Burke, D., & Peters, L. Word Association Norms for Young and Older Adults. (Dissertation, National institute of aging), 1987.

[29] Zortea M, Menegola B, Villavicencio A, Salles JF. Graph analysis of semantic word association among children, adults, and the elderly. Psicologia: Reflexão e Crítica. 2014; 27:90-9.

[30] van Loon-Vervoorn WA, Willemsen I. Selective disturbance in lexical knowledge in the elderly with or without dementia. Tijdschrift voor gerontologie en geriatrie. 1989 Apr 1;20(2):59-65.

[31] Fitzpatrick T, Playfoot D, Wray A, Wright MJ. Establishing the reliability of word association data for investigating individual and group differences. Applied Linguistics. 2015 Feb 1;36(1):23-50.

[32] Nithya,K. Mental Lexicon. in children. (Masters dissertation, University of Mysore), 2017.

[33] Prema KS, Prarthana S, Abhishek BP. BILINGUAL LEXICAL DECISION: EFFECT OF LANGUAGE PROFICIENCY AND PRIMES. Journal of the All-India Institute of Speech & Hearing. 2013 Jan 1;32.