Modeling Lexical Organisation and Access: Bilinguals and Multilinguals

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Abstract

This article attempts to present a comprehensive account of models of lexical organisation and access to understand bilingual and multilingual language processing. The increasing number of bilingual and trilingual speakers has given rise to the question of how these speakers manage, control, and access multiple languages. Linguists, philologists, and psycholinguists turned to investigate how multiple languages are organised and accessed in the mental lexicon of bilinguals and trilinguals. It not only traces the earliest attempts to understand the bilingual language processing but also discusses various contemporary models including both the hierarchical models, and the computational models by identifying the interrelationship between the factors that influence lexical organisation and access in the mental lexicon. The nuanced understanding of bilingual and multilingual lexical organisation and access has practical implications for the multilingual society at large like Pakistan and linguistic and pedagogical implications in particular where teachers and students both take advantage of their linguistic competence of multiple languages.

Keywords: *Lexical organisation and access, Mental lexicon, Hierarchical models, Computational models, Multilink model.*

1. Introduction

Psycholinguistics has focused on studying the characteristics, processing, and relationships between speakers' many languages as the number of bi- and multilingual population has increased. Various bilingual models, some of which were later expanded to accommodate multilingual speakers, have been proposed to examine the organisation and access in bi/multilingual mental lexicon. In Pakistani context, the need to explore theoretical and experimental frameworks of lexical organisation and access has increased manifold owing to the linguistic diversity of speakers. This article endeavours to present a comprehensive theoretical account of the lexical processing frameworks. These models initially attempted to investigate the lexical organisation and access in the bilingual mental lexicon. Weinreich presented the first significant study in 1953 that explained how bilingual speakers process and interact with two different languages.

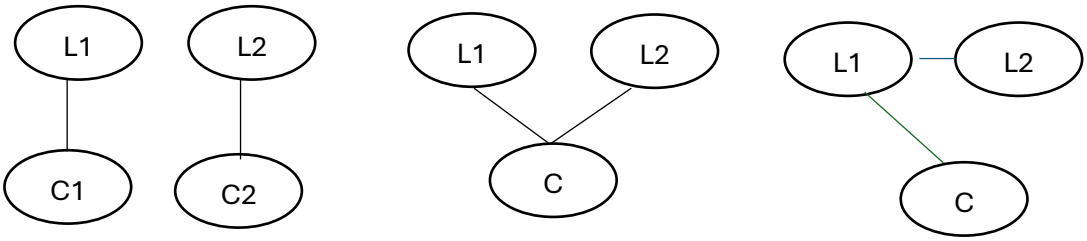
2. Earliest Lexical Processing Frameworks

For examining the structure and functionality of a bilingual mental lexicon, Weinreich (1953) proposed the coordinate, compound, and subordinate mental configurations. In a coordinate bilingual framework, two distinct conceptual representations correspond to two different lexical stores in a bilingual speaker. The coordinate model suggested that each language has its own separate language system, with no relationship between the systems of the two languages. Unlike the coordinate model, the subordinate and the compound models supported a common semantic representation. However, the main distinction

between the two models rested in the mode of acquiring the second language. Bilinguals acquiring the two languages concurrently stored comparable lexical items in both languages in a single conceptual store; however, speakers who learned the second language did so by using translation equivalents in their native tongue. The Compound Model presupposed direct access to a single shared conceptual store from the lexical stores of both language systems. The Subordinate Model, on the other hand, suggested that one could access the meaning of words in a second or non-native language only through the mediation of mother tongue (L1), i.e., by using translation equivalents in the original tongue. The Subordinate Model states that lexical item meanings are accessed via their translation counterparts in L1, while the Compound Model views word meanings as directly accessible from a shared conceptual store.

Figure 1

The Coordinate, Compound and Subordinate Model



(Source: Weinreich, 1953)

Two separate levels of bilingual lexical processing and memory are evident from the examination of the coordinate, compound, and subordinate frameworks put forth by Weinreich (1953): conceptual and lexical. The long-running debate between concepts and lexis was sparked by these bilingual lexical access frameworks, which also introduced methodically organized cognitive research on bilingual speakers' language processing. Because of their background, Ervin and Osgood (1954) took these frameworks of bilingualism a step further and explained them in detail, albeit from a behavioristic perspective.

In contrast to the way that two languages are organised and correlate in the memory, Ervin and Osgood (1954) further expounded two models of Weinreich, emphasizing context and how speakers acquired both of their languages, either exclusively or using their mother tongue. According to Ervin and Osgood, linguistic markers in two languages come to express the same meanings or representational processes in a compound language system. They compared learning a foreign language in school, where the learning process was aided by vocabulary lists, to the compound language approach. The two languages were also designated for various situations, with unique signs for each set denoting distinct meanings via same meditational processes.

A bilingual person who acquired two languages simultaneously and spoke both languages interchangeably with the same people is an actual example of a compound language system. In such

cases, a common representational process can be created, although supremacy cannot be expressed in words. Conversely, "the set of linguistic signs and responses" associated with two "different sets of representational processes" for each language is referred to as a coordinate language system (Ervin & Osgood, 1954, p. 140). When interacting with close family members at home, bilingual speakers use their primary language; in school, they use their second language. A coordinate bilingual, according to Ervin and Osgood (1954), is a "true" bilingual who has mastered the usage of two languages in two different settings. Compound bilingualism and coordinate bilingualism are historically derived from Ervin and Osgood's 1954 compound and coordinate language systems.

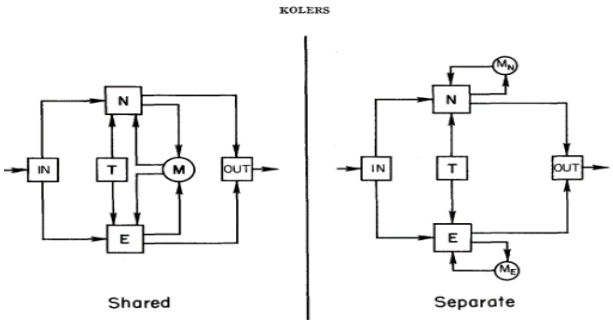
Kolers (1963) criticized the dichotomy between coordinate and compound bilingualism, despite the fact that it still exists today. Since the distinction only described how the second language was acquired—independently or through mediation of their original tongue—it was questioned if it was helpful in explaining the underlying psychological processes. He maintained that bilinguals who used these two approaches to acquire a second language tended to converge and show comparable linguistic ability. However, two bilinguals who had learned the same technique tended to produce very diverse results. Kolers (1963) redirected the debate over bilinguals' memory storage and the link between their two languages, proposing the Independence/Interdependence Hypothesis. Furthermore, he highlighted the question of how multilingual individuals organise their languages, whether in a single memory bank or two distinct memory banks one corresponding to each language. Notwithstanding the results of his tests, Kolers laid the groundwork for the multilingual memory storage, which is a major area of study today.

Kolers (1963) tested the viability of a separate/shared hypothesis for lexical organisation using four word-association tasks involving thirty-four bilingual individuals divided into three groups. Four test conditions made up the experiments: two crosslinguistic paradigms, a lexical item in English translated into the subjects' mother tongue, and a stimulus word in their mother tongue translated into the non-native language of participants, English, two within language paradigms, a stimulus word responded to in the same language. The bilingual individuals spoke English as a foreign and Spanish, Thai, or German as their mother tongue. Five semantic categories comprising fifty-five lexical items served as the experiment stimuli. In interlingual examinations, only two-thirds of the responses were translations or lexically comparable words. The findings showed that only one-third of the responses were translated, and the scores were also similar for both within language condition and between language condition. The semantic category of lexical elements had a significant impact on the frequency of similar linkages. Furthermore, bilinguals' connections with lexical elements in their mother tongue differed from those with their corresponding translations in their second language. The information indicated that lexical items acquired corresponding to both languages were kept apart and not in a single repository. The experiment's results therefore confirmed the independent hypothesis of the separate store, according to which each speaker's native language was associated with a distinct memory store. He said that it was necessary to convert descriptions of experiences from one language into another. In contrasts to abstract

nouns, which are relatively intangible and varied for different languages, concrete nouns showed essentially similar associations for the two languages of bilinguals, according to him, defying the independent store theory.

Figure 2

Shared and Separate Hypothesis



(Source: Kolers, 1963)

Kolers' shared or separate store theory was subsequently evaluated in two distinct studies, Potter et al. (1984) and Scarborough et al. (1984). These studies examined the ways knowledge of first-language experiences was transferred only to situations involving the use of an L2. To investigate the transference of knowledge from one language to another, they tested bilingual subjects in Spanish and English using two-word recognition tasks. In the first experiment, participants who were fluent in two languages had to answer affirmatively to a sequence of lexical decision items in the native language. This was succeeded by a second series of lexical decision trials in the second language, which included some new words and non-words as well as translation counterparts of lexical items that had already been seen.

The second segment of the experiment, which entailed translating words that participants had already seen, was not disclosed to the participants. Therefore, there wasn't much of a need for translation in part 1. No indication of transmission from Spanish to English or vice versa was seen in the findings of the task. In the second experiment, if the stimulus was a real word in the target language, the participants were expected to respond favorably. Additionally, there were two sections to this experiment: the pure language condition and the mixed language condition. These sections differed mostly in the stimulus kind. Using 50% of high-frequency words and repeating 50% of the stimuli were two additional factors. According to the results, bilinguals behaved as though they were monolinguals in the experiment.

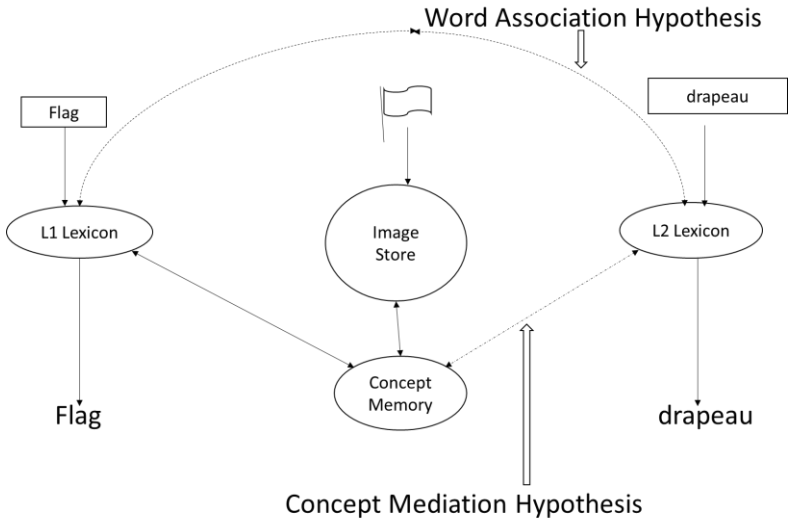
The results of both studies supported the idea that individuals might have language-specific memory access. They went on to explain the results by saying that bilingual speakers' vocabulary was divided into several languages and that their lexical access was selective. It should be mentioned that the research subjects recruited by Scarborough et al. (1984) had to determine if the words were part of a target language. The word recognition task did not necessitate the activation of conceptual levels or the

stimulation of underlying processes; rather, it was a surface activity that only required participants to distinguish between words and non-words. Reliability of the study's methodology has been questioned in as much as it offered a suitable arrangement for examining the prevalent representations of translation equivalents.

Potter et al. (1984) developed the Word Association and Concept Mediation frameworks using Kolers's distinct and shared premise as well as the compound and subordinate frameworks presented by Weinreich (1953). They clarified the relationship between a bilingual speaker's vocabulary elements in both languages. The word association theory, according to Potter et al. (1984), suggested a direct correlation between newly learned second- and first-language terms. Up until the L2 was less common than the L1, this relationship was useful. The concept mediation theory, on the other hand, proposed that speakers' second-language lexical items were connected to shared ideas rather than directly to first-language lexical items. They asserted that bilingual speakers have distinct lexical stores corresponding to the lexical elements of each language and a single conceptual store for both languages. Additionally, they supported having a shared picture storage where word representations could be kept. These two theories proposed distinctions between the conceptual and lexical representations of lexical elements.

Figure 3

Word Association and Concept Mediation Hypothesis via Example



(Source: Potter et al., 1984)

According to Potter et al.'s (1984) word association model, translation counterparts from L1 are the sole way to access the meanings of words from L2. Conversely, the concept mediation model suggested unmediated access to meanings in both languages. Potter et al. (1984) employed a picture-naming task and a translation production task to compare the linguistic skills of proficient Chinese-English bilinguals to low proficiency English-French bilinguals. The experiment was designed with the hypothesis that the

picture-naming task should take more time in accordance with the word association hypothesis, while the assumptions of concept mediation hypothesis predicted that both studies would take the same amount of time. The results of both tests showed no differences in the naming scores of the two bilingual participant groups, demonstrating that conceptual access was necessary before access to words in the second language for both tasks. Under the experimental conditions, the participants' relative proficiency level had no impact on their scores. In order to approximate bilingual lexical representation more exactly, the concept mediation model was used. The insignificance of participants' relative skill levels also made a significant impact, as both proficient and less fluent bilinguals produced results that were comparable.

The results of Scarborough et al. (1984) and Potter et al. (1984) were noteworthy because they produced opposing results. This led to a long-standing controversy in psycholinguistic research, with some investigations supporting dependent/shared conceptual stores and others supporting independent/separate conceptual stores. Research has shown findings that support both theories, however there is more evidence in favor of a common conceptual store than a distinct conceptual store. A common conceptual store was supported by Potter et al.'s (1984) investigation. Various researchers questioned and tested the fundamental assumption that concepts mediate between the two languages of bilinguals regardless of language combination. These studies included those by Kroll and Stewart (1990) and Kroll and Curley (1988), which resulted in the development of the hierarchical models.

3. Hierarchical Models of Lexical Organisation and Access

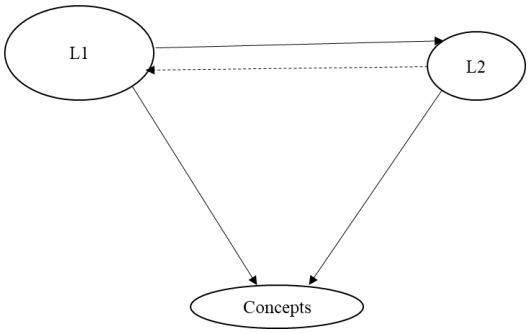
Kroll and Curley (1988) hypothesized that the participants in the study by Potter et al. may have attained the critical period of acquiring L2, they reproduced the research conducted by Potter et al. (1984) using a diverse group of bilinguals. The experiment involved the performance of two groups of bilinguals—one had learnt L2 for less than two years and the other had learnt it for longer than two years—in order to test the hypothesis. The study's findings supported the developmental concept. The word association hypothesis was supported by the scores of those who had learnt the L2 for less than two years; these individuals translated more quickly into the second language than they could have named pictures in the language. Conversely, the findings of the study by Potter et al. (1984) indicated that the conceptual mediation of L2 was supported by the responses of participants who had more exposure to language. Thus, transitioning from lexical links to concept mediation, the results showed a developmental change in bilinguals' L2 acquisition. Less proficient bilinguals mediated the two languages lexically, however proficient bilinguals mediated the two languages conceptually, according to the study, which validated the hierarchical arrangement of the two models. Kroll and Curly (1988) conducted an additional experiment on the concept mediation hypothesis in addition to this one. In two scenarios, the bilinguals identified words, translated sentences, and named images in both their first and second language. Lists of mixed words from several semantic categories were included, however the stimuli were all classified

in category one conceptually. They anticipated that the conceptually mediating fluent bilingual individuals would use the semantic categorization of lists. The experiment's results, nonetheless, defied logic. The way that the lists were arranged semantically affected the fluent bilingual participants' performance, although it was more of an interruption than a facilitator. Comparing semantically organized lists to heterogeneous lists, the participants scored higher in translation task. In the same way, every participant took longer to name the pictures in their L1 because only the fluent bilinguals showed interference rather than facilitation, the pattern of data suggested a developmental transition from word association to conceptual mediation. Nonetheless, instead of category facilitation, category interference was observed.

To solve the problem of translation asymmetry, Kroll and Stewart (1990) suggested an updated version of the hierarchical model of bilingual lexical organization. According to the updated model, during bilingual language processing, both conceptual and lexical linkages are active. But how well a bilingual speaker can communicate in an L2 and how much each language influences each other determines how they work. Kroll and Stewart (1994) redesigned the hierarchical model to examine the organization of bilingual memory and processing by reproducing the category interference effect through both tasks: the picture-naming task and the translation task. The RHM (revised hierarchical model) combined elements of the concept mediation and the word association hypothesis to explain the contradictory results of both models, especially with regard to the developmental shift. The RHM framework presumed that multilingual speakers had one common conceptual store and two distinct lexical stores for each of their two languages. Given that L1 is supposed to have more information than L2, it was suggested that L1 have a bigger lexical storage than L2.

Figure 4

Revised Hierarchical Model



(Source: Kroll & Stewart, 1994)

According to the asymmetric RHM model, bilinguals' acquisition of an L2 beyond early infancy leads to the development of a robust bond between the L1 and the conceptual store. The lexical items of L2 are connected to the previously formed system through lexical linkages with L1 during the early phases

of L2 acquisition. Direct conceptual ties are developed as bilinguals reach higher levels of second language competency. Even with the establishment of direct conceptual ties, word relationships at the lexical level persist. When it came to the quantity and strength of two-way mutual links between the two stores, the RHM was more detailed than the previous models. According to the model, there are greater chances of strong relationship from L1 to L2 than from L2 to L1. Additionally, it fostered a stronger conceptual connection between both the languages. The irregular link strength was enhanced by the fact that bilinguals normally learnt native language lexical items first and depended on translation to learn words in the nonnative language. Likewise, it was supposed that there was a superior relationship between the first language and the conceptual store than there was between the second language's lexical elements and the conceptual store. This suggests that the model proposed two different paths for translation: one would be lexically mediated from L2 to L1, while the other would be conceptually mediated from native language to second language. Alternatively, the RHM anticipated category interference while translating from L1 to L2 for proficient bilinguals.

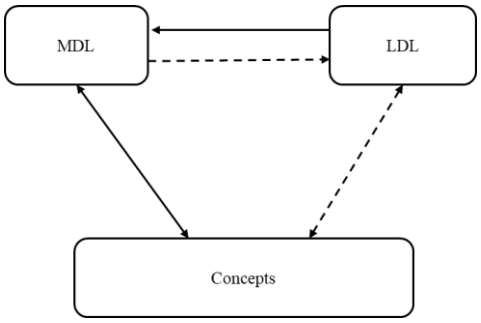
Kroll and Stewart (1994) examined the RHM hypothesis on Dutch-English bilingual subjects in three different trials. Both the picture-naming experiment and the translation production experiment were administered in lists that were mixed lists of words from various categories and lists that were semantically categorized, such as all fruits, all animals, etc. Translation from L2 to L1 was shown to be more accurate and faster in contrast to translation from L2 to L1, according to the investigation. Semantic categorization also had an impact on translation from L1 to L2, but not in reverse direction. The emergence of lexical and conceptual representations, the existence of distinct lexicons for both languages, and the asymmetry between both languages were the main characteristics of RHM. Lastly, it aided the developmental shift in bilingual speakers.

Since 1994, RHM has served as the basis for several research investigations, the majority of which focused on proving or validating a single attribute. The bilingualism research has been systematized by RHM. It has a significant impact on later studies on bilingualism. Brysbaert et al. (2010) carried out a study from 1993 to 2009 that measured the impact and tested the aspects of RMH. They administered a thorough assessment of 166 experiments that examined various facets of RHM. Of the studies that were conducted, 64 testified to the asymmetry between the processing of first and second languages, 30 investigated at how bilingual speakers developed, 13 examined into whether bilingual participants had a single conceptual store, and 6 investigated the existence of two distinct lexicons and the language-selective perspective on language processing. Common conceptual storage and language selective access continued to be the least researched components, according to a critical examination of these studies. As previously mentioned, RHM has served as an inspiration for numerous studies on the organisation and lexical access in multilingual participants. Consequently, some research modified the RHM's initial architecture. One such adjustment was introduced by Heredia (1996), who also offered a revised RHM. In a former research, Heredia (1995) reported on studies with bilingual subjects speaking

Spanish and English. The study varied the concreteness and word frequency factors, and the participants completed translation tasks including task recognition and translation. The exercises concentrated on translation in both directions, from L1 to L2 and vice versa, with the idea that the task was facilitated by the lexical concreteness effect. However, in the abstract word situation, translation in the opposite direction (from L1 to L2) and translation recognition task showed lower latency scores than translation from L2 to L1. The experiment's results did not match RHM for two reasons: first, there was no language asymmetry because conceptual factors affected translation in both directions; second, translation from L2 to L1 in the abstract condition required more time than translation in the other direction, which also showed sensitivity to conceptual factors. These findings run counter to RHM's characteristics.

Figure 5

Re-Revised Hierarchical Model



(Source: Heredia, 1996)

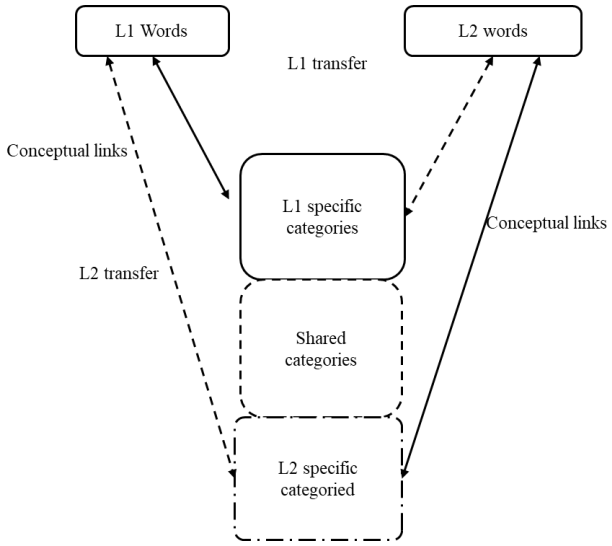
Heredia (1996) provided an explanation for the difference between his results and RHM, stating that the participants in his earlier research (1995) were extremely skilled speakers of the two languages. Although English was their L2, it was more common as they mostly acquired their official education in it and because it was used more frequently for everyday work. Heredia asserted that RHM did not take linguistic dominance into account and instead evaluated the participants' degree of language competence. He argued that while RHM may explain multilingual memory in early bilinguals, it could not explain highly advanced bilingual speakers. He therefore changed the RHM by claiming that the Re-Revised Hierarchical Model (R-2 HM) placed more emphasis on the relative dominance of each language—that is, the Less Dominant Language (LDL) and the More Dominant Language (MDL)—than on the sequence of learning each language. The second language was able to take center stage as the updated model did not make a distinction between first and second languages. Furthermore, it was assumed that neither of the two lexicons was bigger; nevertheless, because the LDL lexicon was not as widely used, it was not easily accessible. However, the structure of the connections between two lexicons and the connection to the conceptual store was unchanged from the RHM.

The Modified Hierarchical Model (MHM) was another modification of the RHM of bilingual lexical organisation and access proposed by Pavlenko (2009). The advantages of the SAM (Dong et al., 2005),

the RHM (Kroll & Stewart, 1994), and the DFM (De Groot, 1992) were still present in it. After analyzing the fundamental principles of all three models, Pavlenko suggested one that kept the RHM framework, hence named modified hierarchical model (MHM). However, there were three key areas where MHM deviated from the models it borrowed from: (i) how the conceptual store was organized; (ii) how conceptual transfer was acknowledged; and (iii) how second language learners performed.

Figure 6

Modified Revised Hierarchical Model



(Source: Pavlenko, 2009)

To accommodate for context-dependent bilingual competency, code-switching, and lexical borrowing, the MHM offered distributed representation that might wholly or partially overlap or specialise to one language rather than a single conceptual store. It also made a distinction between conceptual and semantic representation. Two requirements for conceptual transfer were proposed by the modified version of the model: first-language conceptual transfer would occur if second-language words aligned with first-language linguistic categories, and vice versa.

Fundamental assumptions of the RHM have been contested, as Brysbaert and Duyck (2010) questioned the efficacy of the model. The following aspects have been disputed: (1) lack of evidence supporting distinct lexical stores; (2) lack of justification supporting language selective access; (3) excitatory connections hindering lexical recognition; (4) stronger connections between second language lexical items and their meanings than with RHM; and (5) differentiation between language-dependent and language-independent semantic features. According to the study, a computer model has to be modified to take into consideration how bilingual or multilingual speakers organise and access language.

Apart from the various modifications of Hierarchical Models, a number of computational models, including distributed and localist models, that are based on connectionist principles have been proposed at various points in time to explain representation and processing in bilinguals.

4. Computational Models of Bilingual Organisation and Access

The majority of computer models for multilingual word representation and processing have followed connectionist conventions; that is, they have drawn inspiration from the ideas behind neurocomputation. Neural processing concepts underpin the operation of these models. To explain the characteristics of bilingual language representation, understanding, and comprehension, researchers concentrated on two kinds of connectionist models: distributed and localist models. The neural principle, which underpinned both models, predicted that basic processing units coupled to networks would do all calculations. Units in computational models had an activation level, and each unit affected the activity level of other units. Regarding how the strength of connections varied according to experience and whether or not individual units in the network were assigned a previous identity, these models varied.

4.1 Distributed Models

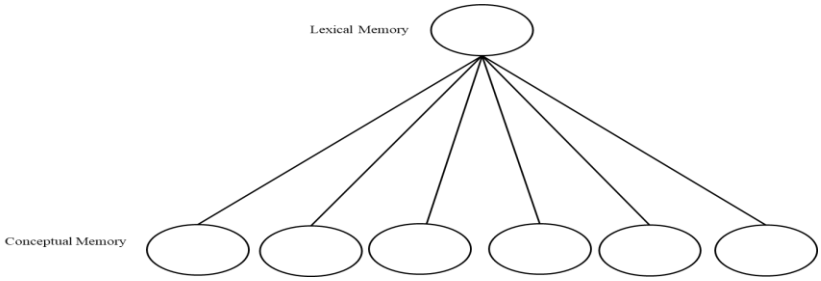
The distributed models depicted words as patterns of activity spread across groups of items. In computational models, the entity that a network renders is realized as a code that spans several things rather than as an object itself. Furthermore, these models placed a strong focus on experience-driven change, especially when it came to distinguishing between codes for different types of data, including words with diverse meanings in different languages. The algorithm would learn to associate each word with its meaning; the link strengths would be random at first but would change with time. Furthermore, these networks included a large number of "hidden" processing elements that, as they learned, formed internal representations that mediated the complex relationship between input and output. Given that distributed models take experience-driven modifications into account, they could be applied to issues pertaining to language acquisition, language learning, and shifts in language dominance over time.

Research in the field of bilingual lexical organisation has projected two levels of meaning; the conceptual level and the lexical level, as has been identified by Potter et al., 1984 and Scarborough et al., 1984. Previous research suggested that a word's meaning was represented by one node at the conceptual level and by one node at the lexical level. According to De Groot (1992), a lexical node might match to multiple concept nodes that address different facets of meaning rather than just one concept node. In order to explain bilingual memory representation and processing, De Groot (1992) developed the Distributed Conceptual Feature Model (DCFM), which is one of the first connectionist models by analyzing data from some of the former investigations on bilingual lexical organisation and suggesting alternative accounts in place of new data. According to the DFM, a lexical node that corresponds to its conceptual node should have linkages or links to all of the conceptual representation's

meaning elements rather than just one (De Groot, 1992). A lexical item's presentation triggers the activation of all pertinent components due to its association with the lexical node.

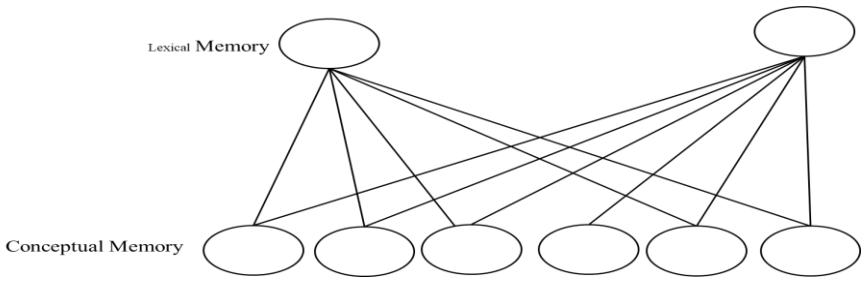
Figure 7

(a) A Distributed Conceptual Representation in Memory



(Source: De Groot, 1992)

(b) A Distributed Conceptual Representation in Memory (overlapping translations)



(Source: De Groot, 1992)

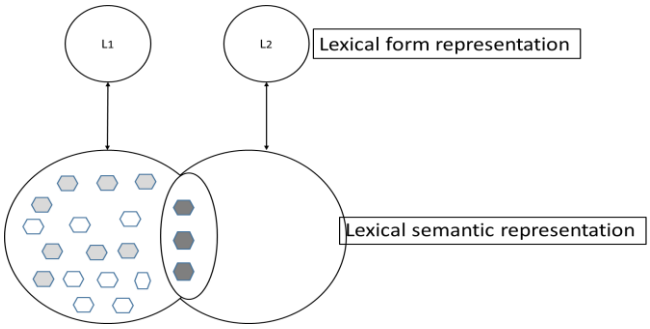
One lexical node's several conceptual representations are referred to as "distributed." Alternatively, according to De Groot (1992, p. 390), the idea node "can be seen as built up from several meaning elements." Particularly with abstract terms, the meanings of lexical items do not always match those of lexical items in the other language used by bilingual speakers. In actual terms, it could, however, overlap more. The degree of dissimilarity in translation equivalents may be better explained by the different conceptual nodes. This is because certain words could fully match conceptual representations while others might not match certain properties.

According to a critical evaluation of DCFM by Finkbeiner et al. (2004), languages differ in the range of senses that words can have since this is a property unique to each language. They put out the Sense approach, another distributed approach, to take multilingual asymmetry in translation counterparts into account. In contrast to the shared characteristics of translation counterparts, the sense model placed emphasis on the extent of activation of lexical representation. This concept is different from previous bilingual representation and processing models in that it explains translation asymmetry outside of the bilingual lexicon. Rather, it would clarify how the language priming effect works. The sense model

projection states that the lexical pairings that result in the same priming imbalance in lexical choice are also those that successfully display the anticipated representational asymmetry.

Figure 8

The Sense Model (Representation of Two Translation Equivalents)

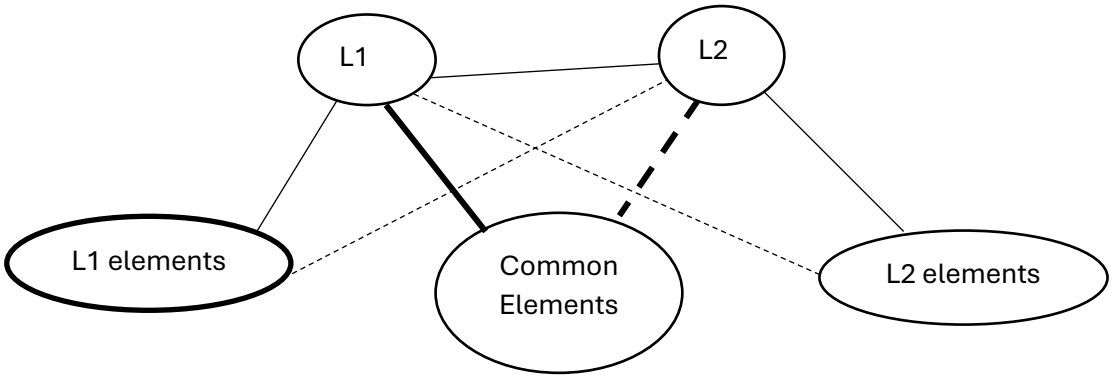


(Source: Finkbeiner et al., 2004)

Dong et al. (2005) proposed the Shared, Distributed, Asymmetrical Feature model (SAM) as an additional distributed model for bilingual lexical representation and processing. This model looks at how conceptual linkages are shared between language- or culture-specific components and translation equivalent pairings. It provided a dynamic perspective that took into consideration aspects common to both native and second languages as well as language- or culture-specific characteristics. The model consisted of two relatively smaller stores, one for each language, and a larger store with common characteristics for language or culture-specific units. The shared (distributed) asymmetrical (SAM) model assumed that there were more shared conceptual components than differentiated linguistic or cultural features. Furthermore, there were a variety of intricate relationships between the lexical and conceptual storage. It showed how the interplay between the two languages led to the formation of conceptual convergence, or the emergence of an intermediate level of representation.

Figure 9

The Shared (distributed) Asymmetrical Model



(Source: Dong et al., 2005)

Three distinct, independent conceptual stores without any direct linkages between them were presented by the shared (distributed) asymmetrical model. However, Pavlenko (2009) criticized SAM for lacking sufficient information on the structure and nature of conceptual representations.

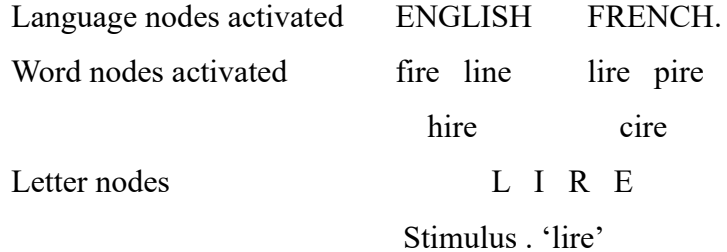
4.2 **Localist Models**

Localist models, in contrast to distributed models, tend to attribute discrete properties to individual units. For example, they divide networks into levels of units that correspond to words, letters, and other linguistic aspects. Furthermore, learning-based model modifications were not considered in these models. As an alternative, the idea was applied directly using connection strengths that were predetermined. The word detector models from the 1970s are the ancestors of the localist models. Localist models were primarily used to investigate the static architecture of bilingual speakers' lexical recognition and processing systems. One major benefit of localist models was that activation at each unit could be easily interpreted, making all network states understandable. Despite the surface-level simplicity of these models, the interplay between teams inside and across layers may give rise to complex functions. Bilinguals' language representation and processing were taken into consideration by extending the interaction model designed for a single language.

Grainger and Dijkstra (1992) proposed an interactive connectionist model called the Bilingual Interactive Activation (BIA) Model, which was built upon the Interactive Activation model of monolinguals (McClelland & Rumelhart, 1981). They used two different word recognition model frameworks— the serial search model and the interactive activation model—to test two different hypotheses: the language tag and language network. It sought to address the problem of how bilingual speakers identified which words belonged to which language; a particularly related problem would be how language material obstructs regular language comprehension processes; one of the main issues concerned the relationship between stored knowledge and external information. The findings of two experimental tasks, language selection and lexical decision task, and effect of language context on lexical recognition furnished evidence for bilingual interactive activation.

Figure 10

Bilingual Interactive Activation-Example of lexical item ‘lire’



(Source: Grainger and Dijkstra, 1992)

The BIA model consisted of three interrelated representational levels: letter, word, and language. Every node connects to every other node across adjacent levels; for example, every word in a language is related to that specific language node. In a non-interactive version of the model, where the links between language nodes and lexical components were unidirectional, the language tag proposition of language representation was used. In other words, the data was oriented forward, preventing any back-feeding from word nodes to language units and from letters to word nodes. Activation of language nodes would thus not affect word-level processing in this situation. Conversely, in an alternative iteration of the BIA model that utilized the language network hypothesis, bidirectional connections were assumed between language specific units and lexical units within a language. Thus, variations in language node activation would affect word unit activation at the same time. The Bilingual Interactive Activation supported an integrated lexicon and non-selective lexical access via a top-down inhibitory method. The monolingual connectionist language processing method has been effectively extended to bilingual speakers. Three tests were carried out with French-English bilingual participants by Grainger and Dijkstra (1992): neighborhood affects across languages, language decision and lexical decision, and language context impact during lexical recognition.

In lexical decision task, participants had to decide if a lexical item was a word in a specific language or another, while in the other, they decided if a series of letters comprised a lexical item or not, irrespective of language. To conclude that lexical decisions were performed faster than language decisions, the scores of the languages and lexical decisions were compared. In order to investigate the intralingual and interlingual semantic priming impact, the bilinguals were instructed to perform mixed language tasks in the second experiment. The results confirmed that quicker lexical decision scores were caused by primes from the same language. These lexical priming effects could be regarded as supporting the bilingual interactive activation model framework. The last trial assessed the neighborhood influence both within and between languages.

Three different categories of stimuli designed explicitly to investigate the neighborhood effects were given to the participants. According to the revised BIA model that asserts that bilingual mental lexicon is integrated across languages and lexical access is language non-selective that the experiment's results validated bilingual individuals' language-independent lexical access. Alternatively, the Bilingual Interactive Activation framework preserved the simultaneous activation of all the lexical representations from the two languages that share letters with the stimulus associated with a particular letter string.

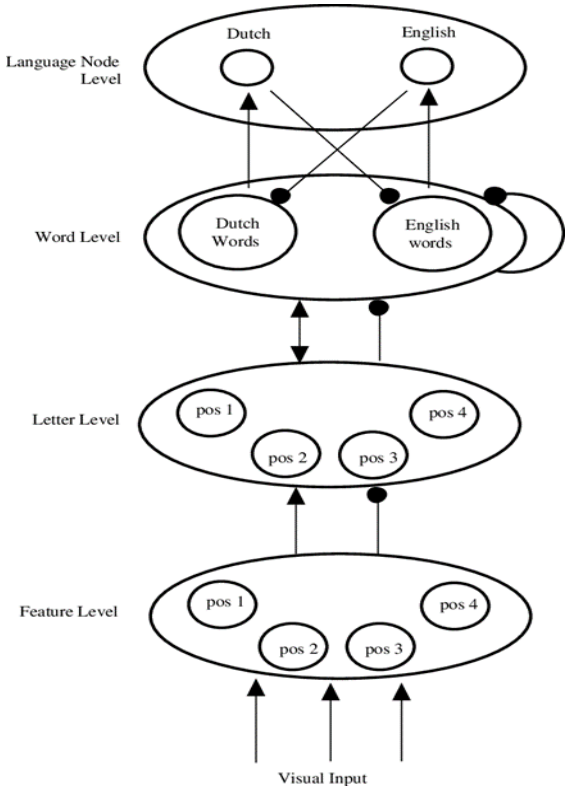
Following the first BIA (1992), Lewy and Grosjean (1997) introduced the Bilingual Interactive paradigm of Lexical Access (BIMOLA), another localist-connectionist paradigm. Although BIMOLA was an interactive model, it was different from previous interactive models, especially the BIA model, in that it supported having independent memory stores for the two languages that bilingual individuals spoke. Language nodes, phonemes, lexemes, and feature levels were among the properties that

BIMOLA and other models have in common. On the other hand, the feature level in BIMOLA was language neutral. In contrast to the BIA approach, which required languages to be separated at the phoneme and word levels, phonemes and word levels were arranged according to languages.

The original BIA model (1992) disregarded phonological and semantic elements in favor of orthographic representations. The original BIA was improved, and the model structure was thoroughly revised by Dijkstra and Van Heuven (1998). There were four tiers of nodes in it. It kept the integrated mental lexicon structure in which every word would activate at the same time. However, lateral connections would let them inhibit and compete with one another.

Figure 11

Bilingual Interactive Activation Model



(Source: Dijkstra and Van Heuven, 1998)

The figure reflects that the framework allows top-down inhibition. The representation of words and languages, interlingual homographs and cognates, stimulus-response linkage in lexical decision-making and language switching, under-specification of context effects, and task structure implementation were among the other shortcomings.

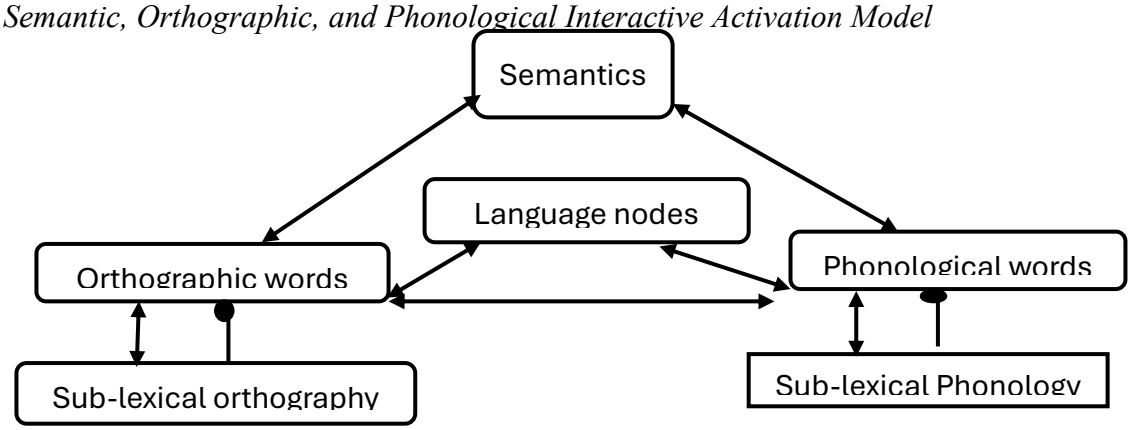
In order to address the selection and competition issues raised by previous studies, particularly those reported by Dijkstra and Van Heuven (1998) and Kroll and Stewart (1994), Green (1998) proposed the Inhibitory Control (IC) Model, another connectionist model that reflects how bilinguals manage their

two languages. Rather than gathering information from individuals who were bilingual, Green based the assumptions of the IC model on an analysis of the results of many prior investigations. Though it was similar to earlier research in many aspects, it was not the same as the previous studies on inhibitory control mechanisms; the previous investigations on bilingual lexical organisation and access used a bottom-up or top-down inhibition strategy. Nonetheless, the IC model proposed two layers of control: the internal control, also known as endogenous control or top-down control, and the external control, also known as exogenous control or bottom-up control. One important aspect of the concept was that reaction time would be significantly influenced by the dominant language, and rivals' levels of activation would determine whether replies were suitable. Task schemas would be used to enforce control. According to the model, switching languages would take time since it would need modifying one's language lemma for a specific job and overcoming the inhibition from prior language tags.

Van Heuven and Dijkstra (2001) developed an enhanced model that includes new nodes to represent phonology and semantics besides orthography and language nodes in order to account for semantic and phonological features. To account for all of the model's features—phonological, orthographic, lexical, and language levels—it was dubbed the Semantic, Orthographic, Phonological Interactive Activation (SOPHIA) Model (2001). In terms of the relationships between nodes, this architecture was different from BIA. Both excitatory and inhibitory connections were present in BIA. The latter connections, though, were taken down from SOPHIA. However, in order to achieve different effects, like the language-switching effect approximated with BIA, eliminating these inhibitory connections requires new strategies. These weaknesses were addressed in a later version of BIA.

Figure 12

Semantic, Orthographic, and Phonological Interactive Activation Model



(Source: Van Heuven and Dijkstra, 2001)

Dijkstra and Van Heuven (2002) suggested a further modification of BIA+ while keeping the fundamental elements of the previous model to address the shortcomings of the BIA model. The lexical identification and task systems were clearly separated by BIA+, which may explain a wider range of varied experimental results. The expanded model comprised a response selection and choice system

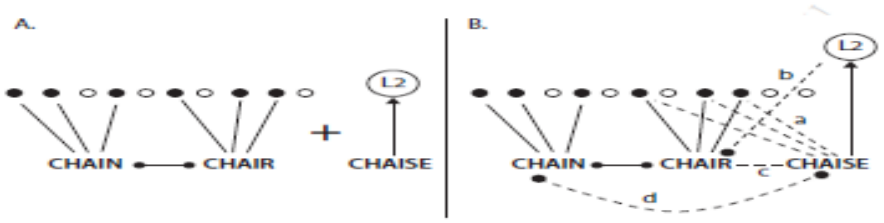
operating as a subset of the schema, and an identification system providing evidence for stimulated representations from two languages. In terms of the length of time it takes for bilinguals to identify words, the relationships between different intralingual representations, interlingual representations, and language tags, BIA+ was noticeably more explicit than the BIA and IC models. Furthermore, the model made a distinction between how language and nonlinguistic environments affected performance. The BIA+ model states that although nonlinguistic context affected the decision system, linguistic context directly affected the word identification system's performance.

Developmental Bilingual Interactive Activation (BIA-d) is a further modification of the BIA model that was developed by Grainger, Midgley, and Holcomb (2010). The model considered how multilingual speakers' competency evolves over time. It emphasized that a modified Hierarchical model might transform into a bilingual interactive activation model by a series of adjustments in the connection of two languages of late bilinguals. Adult speakers exposed to a second language would be the first step. Therefore, late learners of a second language would benefit from the model. Beginning familiarity with a language other than one's home tongue would create links between translation equivalents, which would get stronger as exposure to a second language increased according to Hebbian learning principles. Direct connections were formed at the same time as ties between translation equivalents were strengthened between lexical units in second languages and pre-existing semantic representations. Up until now, the developmental pattern has followed the outline provided by the RHM (Kroll & Stewart, 1994).

The connection between translation equivalents changed as L2 lexical representations were integrated into a shared lateral inhibitory framework for words from both languages, just like BIA model (Dijkstra et al., 1998). This was due to the strengthening of the direct links between L2 words and L2 semantic representations. For bilinguals, the straightforward mapping of lexical units to semantic representations was a "magic moment" since it reduced the work involved in learning a second language. An important step in the expansion of second language vocabulary was enhanced control over second language activation, which was linked to a qualitative shift in the linkage of lexical units and semantic representations of translation equivalents of two languages. The capacity to globally suppress first-language words when processing lexical items from second languages would improve because of this improved control, and vice versa. The BIA model's language nodes carried out the task. Excitatory linkages between the translation equivalents of two languages prevented the creation of this kind of regulating mechanism. To explain these developmental alterations, BIA-d used simple learning processes. By employing dynamic and robust models that utilized fundamental learning principles in several domains of cognitive development, BIA-d advanced beyond the inert modeling method of the RHM and BIA

Figure 13

The BIA-d Model



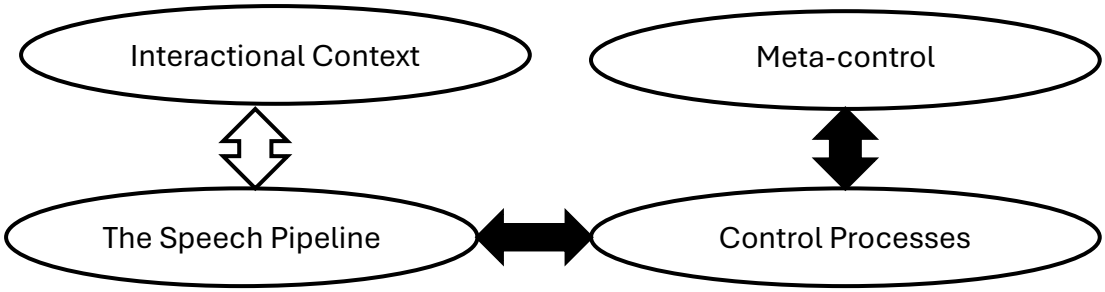
(Source: Grainger & Midgley, 2010)

Although the BIA-d model was designed to denote visual/orthographic word-only representations, it was anticipated that it would also hold true for spoken/auditory forms. The approach was deemed appropriate for language pairings including bilingual participants who spoke French and English and whose orthography was close to that of Grainger et al. (2010). Two phases of vocabulary acquisition were proposed by BIA-d, which substantially overlapped: an initial phase that involved supervised classroom instruction was followed by unsupervised learning. It would result in the information specifying that the new word was a lexical item in the L2 node as well as the co-activation of L1 lexical forms, L2 lexical representations, and their accompanying semantic representations. Lexical elements would therefore quickly merge into a unified lexicon, developing dual language inhibitory linkages—which are semantically discordant and formally parallel—according to BIA-d.

Adaptive control theory was proposed by Green and Abutalebi (2013) to explain control processes in bilingual and multilingual lexical representation and processing. Three distinct interactional settings make up the adaptive control framework: one with a single language, one with two languages, and one with dense code-switching. Each of these situations is governed by a set of (eight) control mechanisms. The framework's fundamental premise is based on the different adaptive response patterns needed in three different types of interactional settings.

Figure 14

Adaptive Control Hypothesis

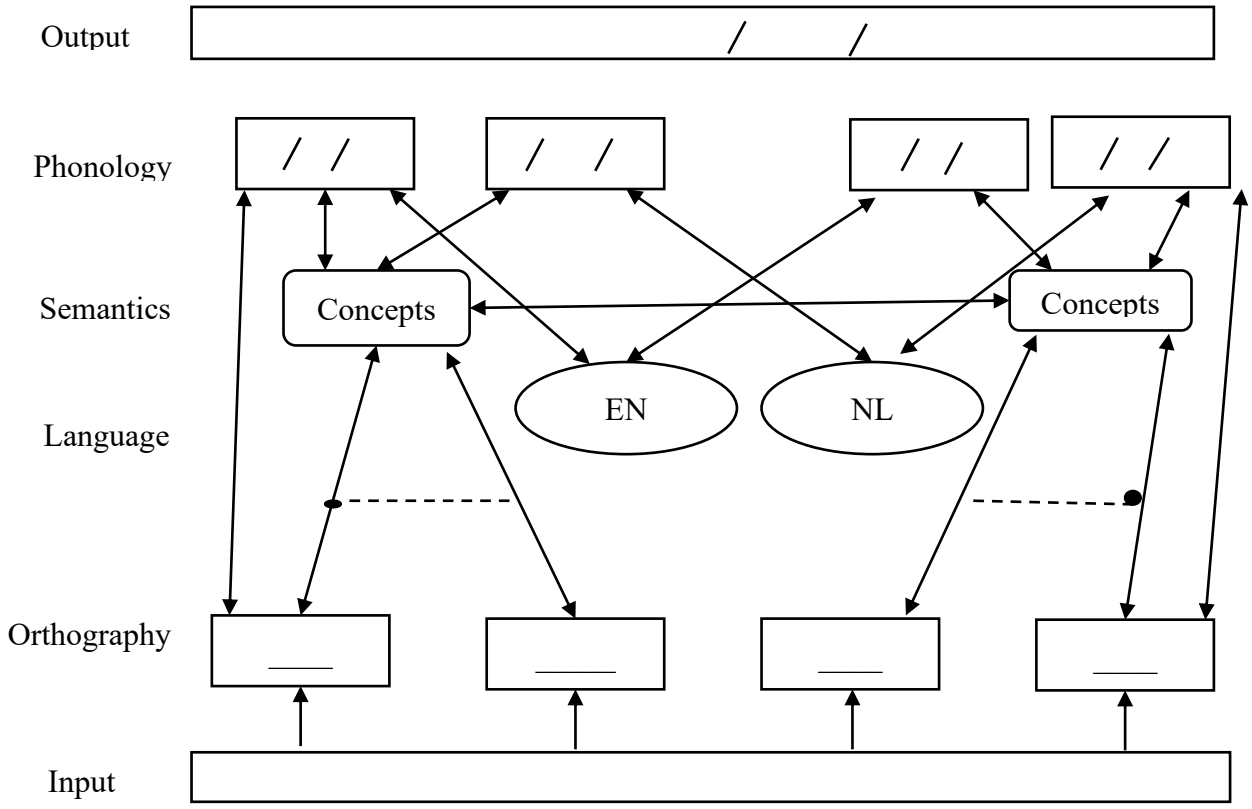


(Source: Green & Abutalebi, 2013)

A relatively recent computational localist-connectionist model known as the Multilink model was proposed by Dijkstra et al. (2018) that integrates the fundamental presumptions of RHM and BIA+. The design of the Multilink model was specified by five underlying principles. It promoted an integrated lexicon that does not impede language acquisition within or between languages. Multilink provided non-selective lexical access in addition to the integrated lexicon, implying that simultaneous activation of lexical elements from different languages. The Multilink model included an additional assumption on the occurrence of word association, namely that translation was accomplished through conceptual mediation by linking lexical item forms from different languages based only on their semantic forms, rather than word association. Moreover, lexical elements in second languages and their meanings had stronger relationships than those predicted by RHM. In other words, word shapes are determined by word frequency. Proficiency in a second language also affected lexical form and meaning in addition to frequency. Thus, language ability may have a major impact on how strongly meaning are connected to output phonology. Lastly, all-inclusive meaning representations that are completely shared or completely distinct across the languages were taken into consideration in Multilink.

Figure 15

The Multilink Model for Bilinguals



(Source: Dijkstra et al. 2018)

According to the model, there are different levels of representation and processing involved in lexical organization and processing, and these levels are interconnected by a network of linkages. These representational levels mapped onto several language levels, including semantic, syntactic, and phonological information. As per the model, there exists a network of connections connecting all these linguistic levels of representation, enabling the activation and integration of information at various levels. For example, when a sentence is processed, the syntactic structure is activated by the phonological representation of lexical elements, and the semantic representation is further activated by the syntactic structure. Numerous psycholinguistic studies (Dijkstra et al., 2018; Woumans et al., 2021; Vanlangendonck et al., 2020) have used the multilink model to explore a variety of lexical organization and processing phenomena particularly unitary mental lexicon and simultaneous activation of linguistic resources from all languages. The multilink model was subjected to rigorous evaluation and discussion by Van Heuven and Wen (2019) and Mishra (2019), with a particular emphasis on the model's universal applicability. According to Mishra's analysis of Multilink model, it is a unique model that combines pre-existing frameworks and suggests a control mechanism to deal with false activations in multiple language organisation and access. Some future studies may test the model for trilingual and multilingual participants.

The different bilingual lexical organisation and access theories and models have been thoroughly explained in this section. A few of these models were modified and adjusted to take into consideration the way the growing multilingual population processes heteroglossia and multilingual activities. A thorough explanation of multilingual lexical representation and processing models has been covered in the section that follows.

5. Models of Multilingual Lexical Organisation and Access

Besides bilingual lexical organisation and access, psycholinguistic research has been conducted to account for the characteristics of multilingual speakers as the number of multilingual people has increased. As will be explained below, certain models of bilingual lexical organization and access were modified to take into consideration the characteristics of multilingual lexical organization and access.

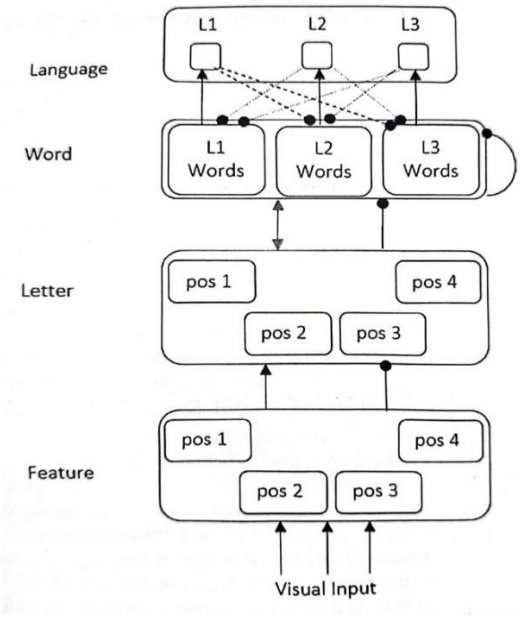
5.1 Multilingual Interactive Activation Model (MIA)

MIA, one of the earliest models of multilingual language processing, was created by modifying the architectural framework of BIA+ to accommodate a second language. Dijkstra (2003) put out the MIA model, which is predicated on three key tenets. The fundamental idea behind this paradigm was that speakers may switch between their native tongues and access a specific language based on the work at hand thanks to an integrated vocabulary for French, English, and Dutch. Furthermore, many languages were simultaneously engaged, making words from different languages compete for selection; nevertheless, speakers had the option to prevent some languages from activating. Lastly, with

multilingual speakers, the characteristics of words from different languages helped speakers choose lexical elements. Compared to BIA+, the MIA model yielded a denser word network or a larger lexicon.

Figure 16

Trilingual Interactive Activation Model



(Source: Dijkstra, 2003)

According to Dijkstra's (2003) theoretical framework, more cross-lingual conflict would lead to slower lexical access than bilingual lexical access, which would increase name latencies-adding words to the mental lexicon causes answers to be delayed by 30 milliseconds. A larger density would result in a slower lexical access since words from all languages would be competing more fiercely. The Multilingual Processing Model—which draws from BIA+—is covered in the next part.

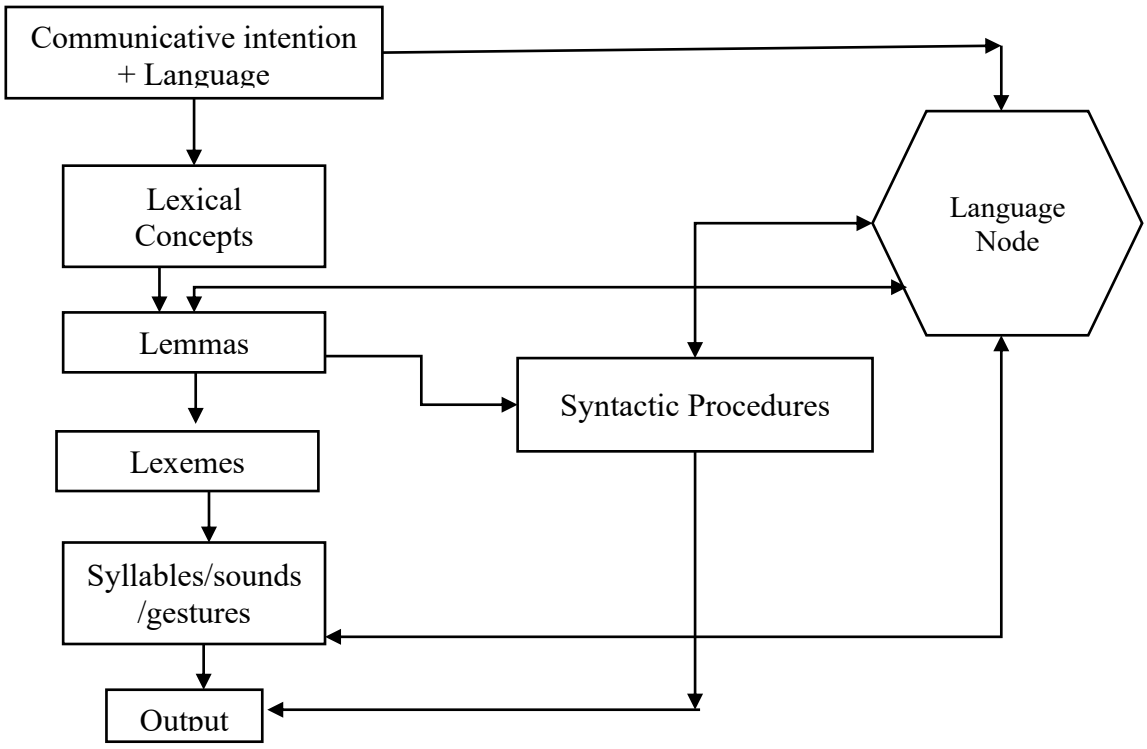
5.2 Multilingual Processing Model

The Multilingual Processing Model was another model used to explain how more than two languages of speakers were organized and activated. It was proposed by De Bot (2004), who emphasised non-selective lexical access due to the nature of lexical arrangement and access, which centered on language production. Regardless of the number of languages spoken, the paradigm is typically used to both bilinguals and multilingual individuals. It promoted three stores: one for form components, another for syntactic operations, and the third one for conceptual properties. These stores were further divided into subsets that were particular to each language but languages are related, these language-specific subsets—particularly cognates and interlingual homographs—exhibited overlap. The proposed language's component parts were processed by the language node. The

choice to choose a certain language would cause both the lexical forms and the language node to be activated at the conceptual level. According to earlier research, the lexical concepts would contain all language choice information. Some traits, though, such as purposefully assuming a foreign accent, would be difficult to manage in this way. The language selection would be controlled by an external language node. The language node would alert all relevant components—which include syntactic and form aspects about the subsets to be activated—when a certain language was to be employed. More stimulation would lead to the proper linguistic components being chosen. Crucially, subsets of various languages would exchange information on the activation of subsets. On the other hand, stimulating language A's syntactic characteristics would relay this information to other language nodes, which would then excite the subset of form-related components. As a result, activation of one aspect would activate other levels of that language.

Figure 17

Multilingual Processing Model



(Source: De Bot, 2004)

Apart from the successive activation of different levels of a single language node, the overlap between language subsets would also activate matching components in separate languages at the same time. Information would be transferred from the conceptual level to the next level and between the lower ones by the language node. It would collect data on the various languages' activation status and serve as a monitoring tool to compare the predicted language with the language practically used. Nevertheless, it

may have been easier to implement the processing speed. Because time restrictions play a significant role in language processing, there was a chance that different degrees of activation and processing speed might interact. Specifically, items that activated sooner were more likely to be picked than those that took longer.

5.3 Dynamic Model of Multilingualism

In order to address the changing character of languages, Herdina and Jessner (2002) devised the changing Model of Multilingualism. In sharp contrast to the former linear models of lexical organisation and access, the DMM model enabled the adaptive and dynamic design of multilingual systems (Levelt, 1989). It focused on creating a sophisticated system since learning a new language adds new characteristics to the multilingual vocabulary. This characteristic put the DMM model in line with the theories put out by Grosjean (1998) and Cook (2006), according to which the language ability of monolinguals and bilinguals caused substantial differences. Alternatively, Jessner (2006) asserts that bilinguals' ability to speak many languages fluently contributed to their multi-competence. It was believed that multilinguals' many languages were interrelated. The frequency of language usage determined access to a certain language system since language loss results from avoidance techniques or from using a language less often. The DMM was a speaker-oriented model that gave importance to linguistic aptitude, self-esteem, language anxiety, language motivation, and cognitive ability. It also suggested that, depending on the learner's resources, language acquisition necessitates time, energy, and interaction with relevant language information. Thus, nonlinearity, interconnectedness, reversibility, quality change, stability, and complexity were a few of the fundamental characteristics of DMM. DMM highlights the interdependence of language systems, the variability among learners, and the nonlinearity of language development. As a result, the model takes into consideration how the dynamics of the language system affect how well a language learning course is taught (Jessner, 2006). The development and accessibility of language systems were shown to be influenced by a number of elements, including motivation, perception, and anxiety levels, all of which were linked to the speakers' skill. In contrast to other models, DMM was not well investigated in experimental linguistic setups. Another potential multilingual model, the Multilink Model, has been explained thoroughly with bilingual participants, its mechanism may be extended to encompass three or more languages of trilingual speakers. The model takes substantial inspiration from the previous bilingual models, in particular RHM and BIA+ incorporating characteristic factors that influence lexical processing in bilinguals and multilinguals.

6. Conclusion

The comprehensive account of bilingual and trilingual models to explore the nature of lexical organisation and access has brought forth fundamental principles of lexical interaction. It also highlights the strengths and weaknesses of theoretical paradigms along with significant contribution of different theoretical orientations in shaping contemporary scholarship. The analysis of studies exhibits unitary

repertoire and non-selective lexical access as dominant theoretical principles. Owing to the presence of multilingual speakers across the globe, particularly Pakistani society in the context of current study, still necessitates further exploration of diverse linguistic combinations particularly to test the recent developments in the field of Psycholinguistic research to understand how multilinguals regulate their languages to effectively manage the communicative process as it carries linguistic implications for marginalised languages and pedagogical implications for optimising classroom practices and language policies.

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