Doctoral Dissertations 1896 - February 2014

1-1-1978

Semantic memory of bilinguals.

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SEMANTIC MEMORY OF BILINGUALS

A Dissertation Presented

By

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Submitted to the Graduate School of the
University of Massachusetts in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

September 1978

Psychology

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ABSTRACT

Semantic Memory of Bilinguals

(September, 1978)

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Two experiments were conducted which used a priming technique in a bilingual version of two types of tasks: a lexical decision task and a category judgement task. The lexical decision task required coordinate Spanish-English bilinguals and English monolinguals to classify single letter strings as words (e.g., canary) or nonwords (e.g., panary) in either Spanish or in English (all English for monolinguals). On each trial a probe word was preceeded by a prime (SOA of 500 msec) which could have been either semantically related or unrelated to the probe. For bilinguals on half of the trials a language switch occurred between the prime and the probe. Three levels of semantic relatedness were used. It was found that reaction time varied with the semantic distance between the prime and the probe, that the semantic relatedness effect existed for both monolinguals and bilinguals, and that there was no effect of language switch on bilinguals' reaction time.

The category judgement experiment used the same type of subjects as the lexical task experiment. Subjects' task was to decide whether or not two probe words belonged to the same category as each other. The

probe words were preceeded by either a related category name, unrelated category name, or a neutral nonword. Three SOAs were used: 250 msec, 500 msec, and 2000 msec, with a language switch sometimes occurring between the prime and the probes. A facilitation and inhibition effects were found for identical (same word repeated twice) and different (two words belonging to the same category) probes for monolinguals and bilinguals for all three SOAs. There was no effect of language switch on bilinguals' reaction time. Results of the two experiments are interpreted as indicating a single semantic store memory structure for coordinate bilinguals.

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CHAPTER I

INTRODUCTION

One of the basic questions in cognitive psychology has to do with how our knowledge is organized in memory. There are several subquestions connected with this general issue: how the knowledge is acquired, how it is stored, and how it is retrieved. A subpart of the total world knowledge store, the semantic memory store, has been dealt with in a number of psychological research programs, and several theoretical hypotheses have been proposed. On the other hand, there has been an extensive amount of research done on bilinguals and their semantic structure. The current project attempts to find a common ground for these two areas of research and reports a series of experiments which throw some light on bilingual semantic structure as well as semantic organization in general.

Bilingual Semantic Processing

Several aspects of bilingualism have been studied by a number of researchers using a number of different experimental techniques. These aspects have included the types and measurement of bilingualism, the amount of overlap in the linguistic system of bilinguals, the extent to which a bilingual can keep his linguistic systems separate from each other, the ability to switch from one language to the

other, and the ability to translate.

Linguistic separation. Language interference was studied extensively by means of a bilingual version of the Stroop Color word task (Preston and Lambert, 1969; Dyer, 1971; Hammers and Lambert, 1972). All of the experiments showed that even in a task when it is to subjects' advantage to ignore semantic aspects of words and attend only to the physical aspects, subjects are unable to ignore semantic properties of words in a different (but familiar) language. It would seem that however independent the two languages of a bilingual person are, activation of a set of processes in one language does not make the other language system totally inoperative.

Another aspect of bilingualism is organization and interlingual facilitation in free recall. Some of the experiments done in this area have used lists in which items in the same language or an item and its translation were repeated a variable number of times (Kolers, 1966), whereas others used lists which could be organized according to the semantic or linguistic categories to which the items belonged (Lambert, Ignatov and Krauthamer, 1968). Results of these experiments showed that even in unconnected lists subjects store items in terms of their semantic and not only morphemic properties. This semantic similarity seems to be the basis of the encoding of the items and to be relatively language free. Thus, it appears that there is some 'structure' in the mind in which language free meaning is accessed and utilized in tasks such as remembering.

<u>Compound-coordinate distinction</u>. In spite of the fact that the experiments mentioned so far address a general question involving bilingual's memory structure, namely how do bilinguals use their two languages in a bilingual context, they really do not deal with the bilingual semantic structure. One aspect of bilingualism which is related to semantic structure and which has been studied to certain extent is the compound-coordinate difference. It is a theoretical difference based on the differences of contexts or ways in which a bilingual acquired his two languages. The first attempt to make this distinction was done by Erwin and Osgood (1954). According to them, compound bilinguals attribute identical meanings to corresponding words and expressions in their two languages. There may be two reasons for this fusion of the meaning systems. One is that a bilingual acquired his two languages at the same time and in the same context. The second reason which may cause a compound language system is a school situation, i.e., when the second language is learned much later in life on the linguistic and semantic basis of the first language (Erwin and Osgood, 1954). The coordinate bilingual on the other hand has different or partially different meanings for corresponding expressions in his two languages. This type of bilingualism is a result of acquiring the two languages in different contexts, e.g., one at home and the other one in school or at work (Erwin and Osgood, 1954).

Several techniques have been used to study the differences between

compound and coordinate bilingualism: semantic satiation (Jacobovits and Lambert, 1961); concept learning (Lambert and Rawlings, 1969; Segalowitz and Lambert, 1969); speed and accuracy of translating (Lambert, 1958); and studies of aphasic bilingual patients (Leischner, 1948; Minkowski, 1928; Lambert, 1972). However, in the concept learning, satiation and translation studies the compound-coordinate distinction was confounded with language dominance and in aphasia studies it was confounded with cultural background or country of origin.

Semantic-episodic distinction. In spite of the fact that a number of studies mentioned so far focus on the theoretical distinction between coordinates and compounds, they do not define where the differences lie between the two types of bilinguals. Part of the problem may lie in the description of the memory store itself. It might be useful to make the distinction which Tulving (1972) makes between semanatic and episodic memory. "Episodic memory receives and stores information about temporally dated episodes or events, and temporal-spatial relations among these events. A perceptual event can be stored in the episodic system solely in terms of its perceptible properties or attributes, and it is always stored in terms of its autobiographical reference to the already existing content of the episodic memory...The system is probably quite susceptible to transformations and loss of information...Semantic memory is the memory necessary for the use of language. It is a mental thesaurus, organized

knowledge a person possesses about words and other verbal symbols, their meaning and referents, about relations among them, and about rules, formulas, and alogarithms for the manipulation of these symbols, concepts and relations. Semantic memory does not register perceptible properties of inputs, but rather cognitive referents of input signals. The semantic system permits the retrieval of information that was not directly stored in it, leaves it and retrieval of information from the system contents unchanged, although any act of retrieval constitutes an input into episodic memory" (p. 385).

This type of distinction has been a debatable issue for some time now. Some people, such as Collins (1976), argue against the distinction. On the other hand, Ortony (1976) argues in favor of the semantic-episodic distinction. He points out "a confusion of knowledge from experience with knowledge of experience", and he gives an example of the difference between a personal diary and an encyclopedia. To him, therefore, the distinction between episodic and semantic memory lies in the content rather than the structure.

Perhaps the resolution is suggested by the fact that our memory structure is very flexible, capable of being organized in many ways depending on what the task or situation demands from us. It seems plausible that there exists such a thing as a semantic memory which contains an abstracted version of the concepts we encounter and use in the world and in the language. This is our "encyclopedia" of knowledge. However, it is not a static encyclopedia but rather a hierarchy

of interrelationships which can be reorganized either on a temporary basis when we use language, or on a permanent basis, when something gets changed or added to this structure.

This semantic-episodic distinction may be of particular importance in the case of a bilingual person. The crucial difference between compound and coordinate forms of bilingualism may lie in episodic rather than semantic memory. The basic assumption of the model proposed here is that different types of bilinguals are thought of as having the same semantic store regardless of the way in which their languages were acquired. They would differ in the contents of their episodic memory in relation to the language and in the distance from the semantic store to the two lexical stores.

The compound bilingual is a person who acquired both languages at the same time. He therefore must have built one semantic store for both languages. Since he was using the languages interchangeably, all entries in that store should be equally easy to access from either language. Also, because of the same context situation, his episodic memories should not differ between languages. A coordinate bilingual on the other hand, acquired his two languages in different contexts and usually one somewhat later in life than the other. He therefore would have two episodic memories corresponding to the two languages. He would have one semantic store but some parts of it might be easier to access through one language than the other. The present study will concern itself only with one aspect of this compound-coordinate

distinction, semantic memory. Ideally, such study would use both compound and coordinate bilinguals as subjects. However, experiments described here used only coordinate bilinguals in order to show that even coordinates have one semantic system.

Studies of Semantic Memory

Information processing research has studied the structure of semantic memory in monolinguals. It has employed techniques which were more analytical than the research on bilingualism in capturing some aspects of semantic structure. The main question which has been studied in this area has to do with how the semantic store is organized and accessed. Most experiments have used reaction time to determine how easy or how difficult certain concepts are to access. Many experiments use the verification task in which subjects are supposed to indicate 'true' or 'false' to simple sentences describing some relationship among concepts. The sentences can typically be classified into two types: superordinate/subordinate sentences like 'An A is a P' ('A canary is a bird'); and property statements, 'An S has a P' ('A canary has skin'). Another common technique used in the semantic memory experiments is priming. In this task, processing of one stimulus is believed to be modified by a previous exposure to another stimulus. Priming has been used in both sentence verification experiments (Collins and Quillian, 1970; Ashcraft, 1976), and in category membership judgement experiments (Rosch, 1975). One of the advantages of using these tasks is the fact that quite extensive theories have been developed which try to account

for experimental results of the studies using them. The two major theoretical positions that employ these kinds of experiments and try to describe the semantic memory structure from different perspectives are the Collins and Quillian network model and the feature comparison model.

Spreading activation model. The Collins and Quillian model, which in its first version was an attempt to program a computer to comprehend language, is based on a metaphor of a network of related concepts. It assumes that a concept is represented as a node in the network with labeled links relating it to other concepts which might be properties of the first concept, or bear a set (superordinate or subordinate) relation to it. These links are directed and usually they can go in both directions. They also have weights attached to them which indicate how important a certain property or set relation is for a concept. From each of the nodes there are links leading to other nodes which in turn have further links to still other nodes. According to Quillian's model the full meaning of a word is represented by the whole network which is entered at that word since entering the network at a certain word activates pathways leading to and from the word in all directions. This activation is assumed to lose its strength as it travels further from the origin. Therefore, the links and nodes which are less closely related to the concept being processed will be activated less than the ones which are closely related. Also, activation will decrease over time or intervening activity. Activation is

released from a concept for as long as that concept is processed, so the longer the concept is processed (through reading, hearing, rehearsing), the longer the activation is released. Since activation affects different nodes and links to a different extent an idea of a threshold was introduced by Collins and Loftus (1975). The activation from different sources summates and when this summation reaches a certain threshold at the intersection, the path leading to that intersection is evaluated.

A second set of assumptions in the model has to do with the memory structure and processing. The basic idea here is that the memory network is organized in terms of semantic similarity. The more properties two concepts have in common, the more links there are between the two nodes corresponding to the concepts and therefore the more closely related they are. So for example the concepts of different birds would be closely related whereas the concepts of red things which might include red cars, roses, red roofs, etc. would not.

The predictions which this model makes and the research that has been done on it primarily involve verification of true sentences. The primary prediction is that the further apart two concepts are (how far from each other in the network) and/or the less closely related (how many connections between them) they are, the longer it will take to find a connective path between them. Verifying the sentence 'A canary can fly' should take more time than verifying the sentence 'A canary is yellow', since the property 'yellow' is probably stored at the node 'canary' whereas property 'can fly' is stored only at the node 'bird'.

The concept of cognitive economy is used in this argument, which assumes that properties which do not uniquely define a certain concept may be stored only at its superordinate and can be accessed only by a pathway leading through that superordinate. Verification of the sentence 'A canary can fly' would require then moving up one level to 'bird' and retrieving the property about flying. For the same reason (difference in semantic distance) the sentence 'A canary is a bird' should require less time to verify than the sentence 'A canary is an animal'.

The main problem with the Collins and Quillian model is that it deals almost exclusively with the verification of positive sentences. In two studies (1969, 1972), Collins and Quillian attempted to explain negative verification times in terms of the model. In both cases, several hypotheses were suggested and then rejected. The hypothesis which was finally adopted uses a contradiction within the model, that is activated pathways are supposed to be followed until a contradiction is encountered at the point where two (or more) pathways cross.

Feature comparison model. The feature comparison model is an example of a nonhierarchical approach to the semantic organization. The essential assumption of the model is that word meanings are represented as a set of features. "Within each set it is assumed that the features may vary continuously in the degree to which they confer category membership, with features at one extreme being those that are essential for defining a concept, while features at the other extreme are only characteristic of the concept" (Smith et al., 1974).

Therefore, each item in a category can be described in terms of a set of relevant semantic dimensions with weights associated with each dimension. Weights indicate how essential the item is in the definition of a word, with high weights representing more defining featur^s, and low weights representing less defining features.

The second assumption of the model is that two distinct, serial stages are used in the verification task. During the first stage, the list of features of the instance and the category are retrieved and compared, without distinguishing between defining and characteristic features. If this overall relatedness falls above a high criterion the response is 'true', and if it falls below a low criterion, the response is 'false'. However, if the result of stage one falls somewhere in between those two criteria then a second stage of processing must be executed. During this second stage the more defining features of the instance and the category are separated from the characteristic features on the basis of the weights attached to each dimension. Then only those defining features are compared and the decision is made.

The feature comparison model also has some problems in accounting for the data. There are a number of difficulties in dealing with property statements in terms of this model (Smith et al., 1974, pp. 20-22). Part of the problem may lie in the fact that nowhere in the model the concept 'feature' is defined or described. To what extent are features abstract or concrete? How are they acquired and to what extent personal or individual experiences have influence on them and/or are a part of them? Also the model does not state clearly what are the

differences between defining and characteristic features. This seems to be a difference of crucial importance since it is the basis of distinguishing between the first and second stage of processing.

The basic finding of the research on semantic memory is then the fact that related concepts facilitate processing of one a..other. Moreover, the closer the two concepts are related the stronger the facilitation and therefore semantic similarity seems to be the basis of memory organization. It is not, however, the purpose of this study to find a method for distinguishing between the two models of semantic memory but rather to use their basic conceptual approach in a bilingual context.

Plan of Research

Since research so far has concentrated on trying to show that bilinguals might have two semantic stores corresponding to their two languages I will first try to show that they have only one semantic structure. The only study done so far on bilinguals which relates in some way to the research done on monolinguals has been an experiment done by Meyer and Ruddy (1974). The experiment used English-German bilinguals and involved a lexical decision task. The subjects were members of the Bell Labs German Club, most of whom acquired their second language in high school or later in life. On each trial subjects were simultaneously shown two strings of letters, one above the other. They had to decide whether each string was a word in either English or German. If both strings were English words, German words, or a mixture of the two, subjects were supposed to indicate 'yes'. If one or both of the strings were not words, they were supposed to indicate 'no'.

Reaction time was used as a dependent variable. There were two types of linguistic conditions, pure (both words in the same language) and mixed (one word in English, one in German), and two types of semantic relations. In the associated condition two words referred to the same class of objects (e.g., animals) whereas in the unassociated case words were not related semantically. Since it has been found previously in studies done on monolinguals that associated pairs of words can be processed faster in this kind of task than unassociated ones (Meyer and Schvanedeldt, 1971), the question of interest was whether this effect would remain when two words are in different languages. The results of the Meyer and Ruddy experiment showed that mixed language pairs took significantly longer to verify than unilingual ones, and that responses were faster to associated words than to unassociated pairs. However, surprisingly the association effect was equal for mixed and pure pairs.

In summary, bilingual research has found certain general trends in the way in which bilinguals might process mixed language networks. It has also provided an important theoretical distinction between coordinate and compound forms of bilingualsim based on the linguistic environment in which the two languages were acquired. On the other hand, semantic memory research has provided theoretical approaches as to how a semantic memory system might be organized and has given a number of experimental methods of studying that system. The present study used some of these methods and some of the theoretical assumptions of the semantic monolingual research in a bilingual context.

The first experiment was a variation of the Meyer and Ruddy experiment described above. It also used a lexical decision task, but a number of details of the experimental design were changed. First, bilinguals participating in the experiment were more uniform in their linguistic background. All of them could be referred to as 'classic' coordinates since they acquired one language at home, started learning the second language in school, and most of the time used them in separate contexts. Second, the task itself was somewhat different because subjects were supposed to make a decision only about the second string of letters. The first string of letters was treated as a prime and subjects were only supposed to pay attention to it. Because of this change in the task a time interval of 500 msec was introduced between the presentation of the prime and the primed probes. Third, the degree of semantic association between the prime and the probes was varied. It was predicted that the results will show a semantic distance effect of the type described in monolingual semantic memory research. Thus, reaction time (RT) to make a decision about the second string of letters should decrease as the association between it and the prime increases. If this type of effect is obtained it is possible to assume that the task does indeed involve reaching a semantic level of processing. If lexical priming does involve semantic priming, and if coordinate bilinguals have one semantic system, then there should be an equal amount of priming when the prime and probe are in the same language as when the prime is presented in one language and the probe in the other.

Since the lexical decision task may not involve semantic structure

the second experiment involved in this study used a semantic categorization technique (Rosch, 1975). Subjects were first shown a prime (a name of a category e.g. 'birds'), followed by two probe words (instances of categories), with a language switch occurring between the prime and probe words on half of the trials (in the bilingual condition). Their task was to decide whether or not the two probe words belonged to the same category as each other. On some trials the prime named the category of the two words, and on still other trials it gave a neutral word. Decision time should be faster when the prime named the category of the probe words than when it named an unrelated categroy. Further, if bilinguals have one semantic store, the priming effects found should be the same for same and different language conditions.

The second experiment also introduced a control for an uninteresting possible reason for a priming effect. Given enough time, bilinguals might be able to consciously translate a prime into the other language. Their reaction time would then be unaffected by a language shift even if they had two semantic stores. To test this possibility, the time interval between the onset of the prime and onset of the probe words was varied from 250 msec to 2000 msec. An interval of 250 msec was thought to be short enough to prevent translation. If priming effects occurred only for the longer time intervals, priming across languages would not support a one store semantic system.

CHAPTER II

METHOD OF EXPERIMENT 1

Subjects. Sixteen English monolinguals and 16 Spanish-English coordinate bilinguals served as subjects. The bilinguals were native speakers of Spanish who started studying English in elementary school and, like the monolinguals, were enrolled as students at the University of Massachusetts.

Materials. Six three level hierarchies (Appendix 1) and their Spanish translations were used. Nonwords were obtained by randomly replacing a letter in a word to make it meaningless but pronouncable in both languages.

Procedure. Each subject received 144 trials grouped into six blocks of 24 trials and one practice block of 24 tirals, not included in the analysis. On each trial subjects were shown two strings of letters on a computer controlled video display (18 cm in width and 14 cm in heigth; letter size: .4 cm in heigth, .2 cm in width). The first one, a prime, was always a word and subjects were just supposed to pay attention to it. It was displayed centrally on the screen. The second string of letters, the probe, replaced the prime after 500 msec, and could be either a word or a nonword. It was displayed .58 cm down and .45 cm to the right of the prime preceeding it. Subjects were

supposed to indicate 'yes' or 'no' accordingly. There were four language conditions: English-English (English prime followed by an English word or nonword probe), Spanish-English (Spanish prime followed by an English probe), English-Spanish (English prime followed by a Spanish probe), and Spanish-Spanish (Spanish prime followed by a Spanish probe). In each of those conditions a prime could be either related or unrelated to the string following it. The degree of relatedness was divided into three levels. The probe was always an instance of a category (e.g., robin) or a distortion of such a word (e.g., tobin). For 'related' trials in L0 condition the prime would also be 'robin' or a Spanish equivalent of it; in L1 condition a prime would be e.g., 'bird' (or the Spanish equivalent); in L2 condition the prime would be, e.g., 'animal' (or the Spanish equivalent). For the 'unrelated' condition the prime could also be either an instance of a category (L0 condition), a subordinate of a category (L1 condition), or a superordinate of a category (L2 condition), but the probe was always an instance of an unrelated category. Reaction time was a dependent variable. For monolinguals all mixed language or pure Spanish conditions changed into pure English conditions.

The list of words used consisted of 189 English words (superordinates, subordinates and instances), their Spanish equivalents and nonwords corresponding to English and Spanish instances of categories. Each block of 24 trials was constructed in such a way that half of the trials included related pairs and half of the trials included unrelated pairs. One third of the trials included nonwords and they were

balanced across the related-unrelated dimension as well as the degree of relatedness dimension. The six hierarchies were evenly distributed throughout each list of 144 trials. A seventh hierarchy, 'measures', was only used in the practice block. The presentation of trials was randomized within each block. In order to get each condition in each language combination (English-English, English-Spanish, Spanish-English, Spanish-Spanish) four lists which were translations of one another were constructed. Four subjects out of 16 saw each list.

CHAPTER III

RESULTS OF EXPERIMENT 1

The overall analysis of variance of correct reaction times to words with group (monolingual versus bilingual) as a between subject variable showed a significant effect of relatedness, $F(1,30)=32.87$, $p < .001$ (See Table 1). The RTs were found to be faster for related primes than for unrelated ones. The interaction between relatedness and levels was also significant, $F(2,60)=3.37$, $p < .05$. Bilingual group RTs were slower in all conditions (difference in mean RT=313.11 msec), $F(1,30)=20.29$, $p < .001$. There was also a significant interaction between relatedness and groups, $F(1,30)=4.24$, $p < .05$. The difference in mean RT for monolinguals was 41.56, and for bilinguals it was 88.2 msec.

Separate analyses were done for monolinguals and bilinguals. Monolinguals showed a significant effect of relatedness, $F(1,15)=21.63$, $p < .001$ (See Table 1), and a significant interaction between relatedness and levels, $F(2,30)=10.18$, $p < .001$. For related items the slowest RTs were found for L2, next slowest for L0, and the fastest for L1. Scheffé test showed a significant difference between L2 and L1 (.05 level), a significant difference between L2 and L0 (.05 level) and a nonsignificant difference between L1 and L0. For bilinguals the effect of relatedness was also significant, $F(1,15)=17.99$, $p < .001$, but the relatedness by levels interaction was nonsignificant, $F(2,30)=.56$,

Table 1

Means for Relatedness by Levels Interaction for Different Groups:

Experiment 1

	Related				Unrelated			
	L2	L1	L0	Mean	L2	L1	L0	Mean
Monolinguals	681	629	646	652	684	716	681	694
Bilinguals:								
Same Language	967	888	965	940	1011	1017	1073	1034
Different Language	962	949	901	937	1039	1037	1005	1027
Mean (Bilinguals)	964	919	933	938	1025	1027	1039	1030

$p > .557$. However, bilinguals' mean RTs for the three levels of related pairs followed the same order as found for monolinguals. The prime language by probe language by relatedness interaction was non-significant, $F(1,15)=.0223$, which shows no difference in mean RT between same and different language conditions. The prime by probe interaction was also nonsignificant, $F(1,15)=.26$, $p > .616$. Subjects responded just as fast to same language pairs as to different language pairs, contrary to Meyer and Ruddy's (1974) findings.

Analyses of errors did not show any differences between conditions. However, bilinguals tended to make more errors (6%) than monolinguals (4%). There were also no significant effects found in the analysis of nonwords (Table 2) except for a significant difference between two groups, $F(1,30)=39.04$, $p < .001$. Monolinguals were found to be faster than bilinguals in their 'no' responses (difference in mean RT=505.48 msec).

Using a technique described by Clark (1973) min F' were found for the effects described as significant, using the six hierarchies as a random variable. All of them were nonsignificant, except for relatedness approached significance, min $F'(1,6)=4.13$, .10 level. A more detailed look at the individual hierarchies indicated that for five out of six of them, the mean RTs show the trend found in the analysis of variance treating subjects as a random variable. For five out of six hierarchies 'yes' responses to related pairs (prime and probe) were faster than to unrelated ones (exception: animal) and for five out of six hierarchies L2 condition was the slowest and L1 condition

Table 2

Means for Nonwords for the Two Groups: Experiment 1

		L2	L1	L0	Mean
Monolinguals	Related	737	838	761	779
	Unrelated	772	766	773	770
Bilinguals	Related	1264	1263	1217	1248
	Unrelated	1243	1326	1367	1312
Mean		1004	1048	1029	1027

the fastest (exception: buildings; See Table 3).

Table 3

Means for Positive Responses for Different Hierarchies: Experiment 1

	Animal	Food	Furniture	Professions	Buildings	Kitchen Utensils	Mean
L2	788	773	774	918	738	961	825
L1	783	760	719	830	767	771	772
L0	917	765	721	799	798	761	793
Mean	829	766	738	849	768	831	
Unrelated	804	798	876	858	837	966	

CHAPTER IV

DISCUSSION OF EXPERIMENT 1

The first major finding has to do with the relatedness effect found in bilinguals. An almost complete facilitation across languages has been found which would suggest one semantic store for both languages. Second, it was found that the degree of association did have an effect on the lexical decision. The slowest RT was found for pairs most 'distant' (animal-canary). However, the unexpected result was that the identical pairs (canary-canary) were not the fastest. This might have something to do with the surprise of seeing an identical stimulus since the effect disappeared in the condition where the cue and the probe were translations of each other. For bilinguals in the different language condition, the faster RT was for the semantically identical pairs, next fastest for L1 and the slowest for L2 (effect nonsignificant, Table 2).

The results support most of the predictions. However, the min F's were found to be nonsignificant and therefore the question arises of whether the results can be generalized beyond the material used in this experiment. First of all, min F's in this case are based on only six hierarchies which gives them very little power. Second, a more detailed analysis showed that the mean RTs for five out of six hierarchies follow the trend found in the overall analysis of variance. Therefore it seems that the results of this experiment can be general-

ized to the whole language.

An unexpected finding was that there was twice as large an effect of relatedness for bilinguals (difference in mean RT between related and unrelated pairs was 88.2 msec) as for monolinguals (difference in mean RT between related and unrelated pairs was 41.56). This might have been caused partly by the fact that all bilingual RTs were slower than monolinguals'. A second reason might lie in the nature of nonwords used in this experiment. Nonwords were very similar to words, with only one letter changed. They might have also activated semantic memory. If so, words could not be classified as words on basis of semantics alone but a lexical store would have to be searched. Monolinguals then would only have to search through one store, but bilinguals would have to search through two stores. Let us assume that for a bilingual, a prime entered in either language activates a certain lexical area in that language and through the semantic store also activates a certain area in the lexicon of the second language. For a related probe then, the search through both, the semantic store and lexical stores would be speeded up. For all unrelated words however two lexicons have to be searched. It would seem that this difference in the effect of relatedness between monolinguals and bilinguals should disappear if nonwords were semantically unrelated to words used in the experiment since the lexical search would no be necessary for the task.

The second experiment in this study should also eliminate the effect. It used a category membership decision task and therefore

the problem of nonwords was not involved here. Also since there might be some argument as to what extent the semantic memory is accessed in a lexical decision task this second experiment required semantic processing in a more direct way. It used priming techniques used by Rosch (1975). A subject was shown three words. The first word (a prime) was a category name. It was followed by two instances, both of which might or might not belong to the primed category. Subjects were asked to judge whether the two instances belonged to the same natural category as each other. The mechanism involved in this type of task can be explained in terms of a spreading activation model. When a prime is presented, it activates a certain area in the semantic memory. If the two words that follow it are in the range of this activation (are members of primed category) the reaction time to indicate 'yes' should be fast. However, under certain conditions interference should take place so that reaction time to inappropriately primed pairs or to pairs primed by a neutral (nonword) stimulus should be slower (Posner and Synder, 1975). Sometimes, the two probe words were identical, in which case the decision could be made rapidly on the basis of a physical match. Even here, though, it is predicted that reaction times to related primes should be again faster than to unrelated or neutral ones since according to Rosch (1975) some facilitory and inhibitory effects of priming take place at the encoding stage.

Since the focus of all mechanisms involved in this task lie in semantic memory the effects found should be the same for bilinguals regardless of the language condition (prime and probe presented in the

same language versus prime presented in one language and probe words in the other) if they indeed have one semantic structure for both languages. However, since it might be possible to obtain this pattern of results only when enough time is allowed between the prime and the probe words so that translation can take place, three delays between the onset of the prime and the onset of the probes were used: 250 msec, 500 msec, and 2000 msec.

CHAPTER V

METHOD OF EXPERIMENT 2

Subjects. Two groups of subjects were used: a group of 20 English monolinguals and a group of 20 Spanish-English coordinate bilinguals. The native language was Spanish but they started learning English in elementary school and, just as the monolinguals, were enrolled at the University of Massachusetts at the time of the experiment. The bilinguals were given a Bilingual Competency Test in order to determine their degree of bilingualism. The test consisted of three parts. The first part involved eliciting a verbal response (about 10 min long) from a subject which was taped and then rated on fluency, vocabulary, grammar, pronounciation, and understanding by two raters. The second part involved reading passages both silently and aloud in both languages and answering a number of questions about them. Again subjects were rated on the five measures. The third part involved writing a short essay which was also later rated. Appendix 2 describes the way people were classified according to the final rating.[1] All subjects participating in this experiment rated 5 or 6 in both languages and were therefore considered to be balanced bilinguals.

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[1]The test was administered by the bilingual program of the School of Education at the University of Massachusetts. I would like to thank Dr. Gloria Guevara for conducting this test and for her invaluable help in recruiting subjects for both experiments involved in this study.

Materials. Materials were based in large part on the materials used in a previous experiment. There were 25 categories used (Appendix 3) with at least seven exemplars in a category. Categories 21-25 were only used in practice block. Most of the exemplars were of high production frequency according to the Battig and Montague norms (1969). A total of 324 English words and their Spanish translations were used. For neutral conditions 36 nonwords were used. They were actually words in a language unknown to the subjects (Polish) which could be pronounced in English or Spanish but had no meaning in either language.

Procedure. On each trial subjects were shown three words. The first word (a prime) preceeded the probe words by either 250 msec, 500 msec or 2 sec. Then the two probe words were shown simultaneously. The subjects were supposed to indicate 'yes' if the two probe words belonged to the same category as each other and 'no' otherwise. The pair of words to be judged was shown simultaneously side by side on a computer controlled video display (14 cm in heigth, 18 cm in width). The prime was displayed centrally on the screen and the two probe words were shown on the same line as the prime separated by .45 cm.

There were six conditions for 'yes' responses and three conditions for 'no' responses. For 'yes' responses the prime could be either appropriate (the category name of the two words following it), inappropriate (the category name of a category different than the two words following it), or neutral (meaningless, pronouncable nonword).

The two probe words following the prime could be either two different words belonging to the same category (different condition) or a repetition of the same word (identical condition, Appendix 4). For 'no' responses the prime could be either related (the category name of one of the words involved), unrelated (the category name unrelated to either word following it), neutral (as above, see Appendix 4, for examples). The two words following the prime were always from two different categories.

In order to counterbalance materials across conditions five lists were constructed so that each pair of probe words was used in each condition. The reason for five lists was that there were twice as many related and unrelated conditions as neutral conditions and therefore only half of the related or unrelated probe pairs could be switched with neutral probe pairs at a time. Each list consisted of 300 trials: 200 'yes' trials and 100 'no' trials. They were grouped into 10 blocks of 30 trials each. The blocks as well as trials within a block were presented in a different random order for every subject. The first block of 30 trials was a practice block and it used categories and words not used in any other block. The practice block was the same for all five lists and was not included in the analysis.

The time interval between the prime and the probe words was varied from block to block (not from trial to trial) and the three time intervals were randomly distributed among 9 blocks. The practice block was always presented at the 500 msec interval.

In the monolingual group four out of 20 subjects went through each of the five lists. For bilinguals each list included four language conditions with a possible language switch occurring between the prime and the probe words. Thus in an English-English condition all three words were presented in English; in the English-Spanish condition the prime was presented in English and the two probe words in Spanish; in the Spanish-English condition the prime was presented in Spanish and the two probe words in English; in the Spanish-Spanish condition all three words were presented in Spanish. For each of the five bilingual lists a translation list was constructed. In this translation list all conditions which were 'same' language conditions (EE and SS) in the original list became 'different' language conditions (ES and SE) and vice versa. In order to get the same number of observations at each data point as for monolinguals, bilinguals then had to go through two lists: one of the original bilingual five lists, and its translation. Thus each bilingual subject saw each pair of items once in the same language condition and once in the different language condition. Four bilinguals out of 20 went through each of the five lists. Reaction time was used as the dependent variable. Both monolinguals and bilinguals were informed of the categories used in the experiment prior to their participation.

CHAPTER VI

RESULTS OF EXPERIMENT 2

Positive responses

Appendix 5 contains the mean RTs for different conditions for the two groups of subjects. However the main analysis of the experiment focused on the facilitation and inhibition effects. The difference scores were used as a measure of those effects. They were obtained by subtracting RTs of primed conditions from RTs of neutral conditions. Since for bilinguals half of the neutral conditions were in Spanish and half in English, the Spanish neutral conditions were used for Spanish probes and English neutral conditions were used for English probes. The same pattern followed for monolinguals even though all conditions were in English. The difference scores would be expected to be positive for related conditions if facilitation takes place, and negative for unrelated conditions if inhibition takes place.

Identical probes. Separate analyses were done on monolinguals and bilinguals. The analysis of monolinguals showed a significant effect of relatedness, $F(1,19)=11.07$, $p < .005$ (Table 4). The t-tests showed that difference scores for the related conditions were significantly greater than zero, $t=2.60$, $\alpha = .05$, showing a facilitation effect, whereas the difference scores for unrelated condition were significantly less than zero, $t=2.16$, $\alpha = .05$, showing an inhibition effect. This supports the prediction that subjects tended to respond significanlty faster to related primes than to neutral ones,

Table 4

Relatedness by Same versus Different Language Interaction:
Experiment 2, Difference Scores[1]

Identical Probes	Primes		
	Related	Unrelated	Mean
Monolinguals	25.24	-20.24	2.5
Bilinguals			
Same Language	24.05	-1.93	11.07
Different Language	10.73	-38.64	-13.96
Mean	17.39	-20.38	

Different Probes	Primes		
	Related	Unrelated	Mean
Monolinguals	110.59	-49.12	30.73
Bilinguals			
Same Language	77.45	-68.87	4.29
Different Language	91.34	-51.44	19.95
Mean	84.40	-60.16	

[1]The difference scores were obtained by subtracting RTs of primed conditions from RTs of neutral conditions.

and significantly slower to unrelated primes as compared with neutral ones.

An analysis done on bilinguals showed also an effect of relatedness, $F(1,19)=13.7$, $p < .005$ (Table 4). Just as for monolinguals, the difference scores for related condition were significantly greater than zero, $t=2.41$, $\alpha = .05$, showing facilitation, and difference scores for unrelated conditions were significantly less than zero, $t=2.82$, $\alpha = .05$, showing inhibition. The pattern of results for bilinguals thus followed the pattern found in monolinguals. There was also a main effect of same versus different language variable, $F(1,19)=9.28$, $p < .005$ (Table 4).

For same language condition there was facilitation but no inhibition, whereas for the different language condition the opposite was true (apparent facilitation of 10.73 was not significantly different from zero; $t=1.34$). This might be caused by the fact that on different language trials, subjects had to switch back and forth from reading rules in one language to the other language (language was randomized). Therefore, in same language condition facilitation of not having to switch to the rules of another language strengthened the overall facilitation effect and weakened the overall inhibition effect. In the different language condition on the other hand the inhibitory effect of a language rules switch weakened the overall facilitation effect and strengthened the overall inhibition effect. This interpretation is supported by the fact that there was no significant interaction of same versus different language condition with relatedness,

$F(1,19)=2.11$, $p > .162$. The effect of SOA interval was nonsignificant, $F(2,38)=.1016$, $p > .904$, suggesting that facilitation and inhibition effects occur even at the shortest time interval.

Different probes. The mean RTs for different conditions (using difference scores) for monolinguals and bilinguals are presented in Tables 4 and 5. The analysis done on monolinguals showed first a main effect of relatedness, $F(1,19)=78.31$, $p < .001$. The t-tests showed that the difference score for the related condition was significantly greater than zero, $t=8.67$, $\alpha = .01$, showing facilitation, whereas the difference score for unrelated condition was significantly less than zero, $t=3.85$, $\alpha = .01$, showing inhibition. Main effect of SOA interval, $F(2,38)=3.71$, $p < .05$, and the SOA by relatedness interaction, $F(2,38)=3.28$, $p < .05$, were also significant. Figure 1 shows that at the shortest SOA there was the smallest amount of inhibition and the largest effect of facilitation, whereas for the longest SOA inhibition is at its highest and facilitation at its lowest.

Analysis of variance done on bilinguals showed a significant effect of relatedness, $F(1,19)=91.78$, $p < .001$ (Table 5). The t-tests showed that difference scores for the related condition were significantly greater than zero, $t=7.92$, $\alpha = .01$, showing facilitation, and difference scores for unrelated condition were significantly less than zero, $t=5.65$, $\alpha = .01$, showing an inhibitory effect. Again then the relatedness effect found in monolinguals was also found in bilinguals. There was no significant interaction found between same versus different language condition and relatedness, $F(1,19)=.029$, $p > .866$, which

Table 5

SOA by Relatedness Interaction for Different Probes:

Experiment 2, Difference Scores[1]

Monolinguals

SOA	Primes Related	Unrelated	Mean
250	178.44	-33.27	72.58
500	111.32	-39.11	36.10
2000	42.02	-74.97	-16.47
Mean	110.59	-49.12	30.735

Bilinguals

SOA	Primes Related	Unrelated	Mean
250	50.74	-88.23	-18.745
500	107.05	-37.47	34.79
2000	95.45	-54.77	20.34
Mean	84.41	-60.16	12.125

[1]The difference scores were obtained by subtracting RTs of primed conditions from RTs of neutral conditions.

supports the prediction that semantic activation spreads just as much across two languages as within one language. The SOA by relatedness interaction was nonsignificant, $F(2,38)=.03$, $p > .866$, supporting the prediction that relatedness effect will occur even at the shortest time interval. There was a significant interaction of day by relatedness by cue language, $F(1,19)=5.57$, $p < .05$. Figures 3 and 4 show that there were no interpretable differences found between bilinguals' performance on two days of testing.

Negative responses

Mean reaction times for negative responses for three SOAs and three levels of relatedness are presented in Table 6 for monolinguals and bilinguals. Monolinguals were on the average 318.54 m sec faster than bilinguals. Facilitation and inhibition scores obtained in the way described for positive responses were used in the analysis of variance. However the effect of relatedness was nonsignificant, $F(1,38)=.068$, $p > .0795$. There were a number of significant effects found for which no interpretation can be offered at this time: relatedness by cue language interaction, $F(1,38)=27.49$, $p < .001$ (Table 7); same versus different language condition by groups interaction, $F(1,38)=21.62$, $p < .001$ (Table 8); cue language by same versus different language conditions by group interaction, $F(1,38)=6.26$, $p < .01$ (Table 9).

Neutrals

Mean reaction times for neutral conditions for the three SOAs are

Table 6

Mean RTs for Negative Responses: Experiment 2

Monolinguals

Prime	250	SOA 500	2000	Mean
Neutral	1130	1179	1251	1186
Related	1131	1171	1253	1185
Unrelated	1128	1183	1242	1184
Mean	1130	1177	1248	1185

Bilinguals

Prime	250	SOA 500	2000	Mean
Neutral	1467	1428	1567	1487
Related	1485	1471	1596	1517
Unrelated	1480	1487	1553	1507
Mean	1477	1462	1572	1504

Table 7

Relatedness by Cue Language Interaction for Negative Responses:

Experiment 2, Difference Scores

Cue	Related	Unrelated
English	3.39	37.53
Spanish	15.44	-25.25

Table 8

Same Language versus Different Language by Groups Interaction for

Negative Responses: Experiment 2, Difference Scores

	Monolinguals	Bilinguals
Same Language	-32.16	54.73
Different Language	28.83	14.52

Table 9

Cue Language by Same versus Different Language by Groups Interaction,

Negative Responses: Experiment 2, Difference Scores

Cue Language	Monolinguals		Bilinguals	
	Same Language	Different Language	Same Language	Different Language
English	7.19	23.48	7.49	43.68
Spanish	-71.52	34.175	32.37	-14.65

presented in Table 10 for monolinguals and bilinguals for identical and different probes. Monolinguals were on the average 200.23 msec faster than bilinguals. An analysis of variance treating monolinguals and bilinguals as a between subject variable found first of all a significant effect of SOA interval, $F(2,76)=7.25$, $p < .001$. Reaction time increased with the SOA interval (Table 10). Secondly, there was a significant interaction of SOA and probe language, $F(2,76)=3.13$, $p < .05$. Figure 5 shows that for bilinguals the reaction times to Spanish probes were in general slower than to English ones but this difference decreased as SOA interval increased. This effect (of slower RTs to Spanish probes) tended to exist also for non-neutral conditions. The reason for it might lie in the fact that even though all subjects were balanced bilinguals, their native language was Spanish and the fact that the task required a switch from reading rules in one language to the other language. They may have been set to English because the experiment took place in an American university and the experimenter used only English in communicating with subjects.

There was a main effect of the type of probe (identical versus different) with the difference in mean RT of 388.69 msec. A significant interaction of the type of probe with group, $F(1,38)=10.31$, $p < .005$, showed that bilinguals were in general slower than monolinguals, but that difference was larger for different probes than for identical ones (Figure 6). There was also a significant interaction of SOA interval, type of probe and group $F(2,76)=4.65$, $p < .01$ (Table 10) but no interpretation can be offered at this time.

Table 10

SOA by Probe by Groups Interaction for Positive Responses to Neutral Primes: Experiment 2

SOA	Monolinguals		Bilinguals	
	Identical	Different	Identical	Different
250	714	1105	860	1279
500	741	1064	864	1346
2000	796	1102	941	1416
Mean	751	1085	888	1347

Errors

The mean number of errors for all conditions for positive responses for different probes is shown in Table 11 and Figures 1 and 2 for monolinguals and bilinguals. There was no difference in the mean number of errors between the two groups. The pattern of the change in error rate between different conditions follows the pattern of changes in reaction time. Correlations of .74 and .81 were found for monolinguals and bilinguals respectively between the reaction times and error rates for corresponding conditions. The analysis of errors for identical probes showed very low error rates for all conditions for both groups (less than 2%).

The analysis of errors of negative responses (Table 12) showed first of all that subjects did not make on the average more errors in negative conditions than in positive ones (monolinguals: .0618 versus .0707; bilinguals: .06385 versus .767). Second of all, subjects tended to make fewer errors in the unrelated and neutral conditions than in the related conditions.

Table 11

Mean Error Rates for Positive Trials: Experiment 2

Monolinguals

Prime	SOA 200	500	2000	Mean
Neutral	.0665	.075	.066	.0692
Related	.03325	.0207	.0207	.02488
Unrelated	.104	.1789	.0704	.1178
Mean	.0679	.0915	.0524	.0707

Bilinguals

Prime	SOA 200	500	2000	Mean
Neutral	.079	.0624	.0873	.0762
Related	.0645	.0393	.0499	.0512
Unrelated	.0935	.0957	.0185	.10257
Mean	.079	.0658	.0852	.0767

Table 12

Mean Error Rates for Negative Trials: Experiment 2

Monolinguals

Prime	SOA			
	200	500	2000	Mean
Neutral	.04145	.04145	.025	.03597
Related	.133	.10405	.083	.1067
Unrelated	.04125	.0375	.050	.043
Mean	.0719	.061	.0527	.0618

Bilinguals

Prime	SOA			
	200	500	2000	Mean
Neutral	.03325	.025	.0625	.04025
Related	.123	.0895	.0979	.1035
Unrelated	.0562	.052	.0707	.04785
Mean	.07085	.0555	.06525	.06385

CHAPTER VII

DISCUSSION OF EXPERIMENT 2

The results support most of the predictions. The first major finding was the effect of relatedness. In a priming experiment where subjects' task was to decide whether or not two probe words presented simultaneously belong to the same natural category as each other, their 'yes' responses were the fastest when they were shown the name of the appropriate category prior to the probe words. They were slowed down when the probe words were incorrectly primed. When the prime was neutral (nonword) the reaction times fell somewhere between the reaction times to appropriately and inappropriately primed probes. That effect held true for both different probes (i.e., two different words belonging to the same category) and identical probes (i.e., same word presented twice).

The second major finding has to do with bilingualism and the effect of relatedness. Bilinguals did tend to have longer reaction times but the relatedness effect followed the pattern found in monolinguals. The relatedness by same versus different language condition interaction was nonsignificant for both identical probes, $F(1,38)=2.11$, $p < .162$, value of 95% confidence interval was 23.4 ± 33.7, and different probes, $F(1,38)=.03$, value of 95% confidence interval was 3.54 ± 43.5. Equal amounts of facilitation and inhibition were found within a language and between two languages. Even though bilinguals tended to

take longer to respond to longer SOAs, the effect of relatedness did exist at the short SOA of 250 msec. This shows that the spread of activation found in monolinguals within one language also takes place in bilinguals between as well as within languages. The time necessary for this activation to take place is the same within a language as between two languages.

For both positive and negative responses the RTs to two short SOAs were on the average similar but they were much longer to SOAs of 2 sec. It seems that there is an optimum SOA at which people's performance is at its fastest and that SOA is obviously less than 2 sec. This has been shown previously in a much simpler task (letter matching) by Posner and Boies (1971) who found the best performance at SOA of 500 msec.

A third finding showed support for another prediction. In the first experiment it was found that bilinguals showed twice as large an effect of relatedness than monolinguals. It was then argued that the reason for this effect might lie in the nature of nonwords used and that this effect should disappear in the second experiment. The differences found between conditions in this experiment were slightly less for bilinguals but not enough to reach any level of significance, and therefore the prediction is supported (Neutral-Related for monolinguals=67.675, for bilinguals=52.415; Unrelated-Neutral for monolinguals=39.455, for bilinguals=39.085; Unrelated-Related for monolinguals=107.13, for bilinguals=91.5).

The priming effects found in this experiment do not quite follow

the pattern of Rosch's (1975) findings. She obtained priming effects when her primes were either appropriate or neutral (Experiment 2) but she lost all of the priming effects when she used inappropriate primes on one third of the trials (Experiment 3). The interpretation she gave for this pattern of results was that when misleading primes are introduced subjects tend to disregard the prime completely to avoid getting confused. However the design of the present experiment differed from that of Rosch's in that the prime and the stimuli were presented in the same modality (visually) whereas in Rosch's experiments they were presented in two different modalities (prime as auditory, stimuli visually). Moreover, in the present experiment though subjects tended to respond more slowly at 2 sec SOA the relatedness effect did not change with time, that is, it remained even at SOAs of 250 msec. Those results indicate that spreading of activation is an automatic process and it takes place at a very early stage of processing words. For negative responses there were no differences found between neutral, related and unrelated conditions.

However, the largest percentage of errors was found for the condition where prime was related to one of the probe words following it. Those unsuspected results found for negative responses might be partially explained by the nature of the task involved. What subjects' decision was actually based on was the two probe words and they could in fact disregard the prime completely. However, since they were asked to pay attention to the prime they often at first reported being confused and they tended to make decisions as to whether the two items belong to

the primed category instead of the same category as each other. In all conditions (except for identical probes) the task involved retrieving a superordinate category of the two probe words and checking whether they were the same or not. For positive responses, when a prime was related to the probe words the reaction time was faster than when it was neutral or inappropriate because the category had been already activated and therefore it was easier to retrieve it. For negative responses again one would predict that with a related prime it would be easier to retrieve at least one of the categories involved and therefore it should take less time to make a decision than in the unrelated or neutral condition. I think that it is true that one category is retrieved faster but since the pattern of semantic activation follows that of a related positive condition the subjects' first impulse is to respond 'yes' (that is why there are more errors in related negative condition than unrelated and neutral) and they have to in some way suppress that in order to respond 'no' which slows them down. A somewhat similar interpretation has been proposed by Neely (1977) who suggested that expectancy plays a large role in verification of negative conditions in a lexical decision task.

CHAPTER VIII

CONCLUSION

Two experiments have been presented which used a priming technique in two types of tasks: a lexical decision task and a category judgement task. Both of these experiments showed support for the main prediction of the present study, that even coordinate bilinguals have one semantic system for their two languages. For some time now researchers have been concerned with what mechanisms are involved in a lexical decision task and what role semantics plays in it (Landauer and Freedman, 1968; Meyer and Ellis, 1970; Rubinstein, Garfield and Millikan, 1970; Meyer, Schvaneveldt and Ruddy, 1972; and others). Most of those studies showed that semantic relatedness can help in recognizing words as words and it was therefore concluded that lexical store might be organized according to semantic meaning. However, the first experiment involved in this study seems to be the first one to show the effect of semantic distance on lexical decision. It is also one of the first ones to show an equal amount of semantic priming within as well as between the two languages of a bilingual person. Experiment 2 might have provided information as to the level of processing at which semantic relatedness affects lexical decision tasks.

In Experiment 2 a relatedness effect was found for both 'different' and 'identical' probes for positive responses. According to Rosch (1975) there are two stages involved in a category judgement task. The first is the encoding stage and the second is the category

retrieval and comparison stage. For the identical probes the second stage never has to be reached for the decision to be made and reaction time to identical probes is much faster than to different probes. Rosch's argument is mainly supported by the fact that she obtained the effect of priming on identical probes (as well as different probes) when the prime preceeded the probes, but there was no priming effect for identical probes when the prime was presented simultaneously with probe items while the priming effect remained for different probes (Experiment 4). Priming has a different effect on the two stages, namely a time interval between the prime and the stimuli is necessary for facilitation (or inhibition) or encoding but no such time interval is necessary for priming effects to exist at the second stage (comparison). The second experiment involved in this study did not use a simultaneous presentation, so it does not give direct evidence for the two stage model. However, the existence of priming effect in identical probe condition is consistent with the two stage model.

The major finding of the two experiments has to do with bilingual semantic processing. They have shown that whatever semantic activation takes place within a language, it spreads just as fast and just as much between the two languages of a bilingual person as within one language. It has been argued that only compound bilinguals might have one semantic store, whereas coordinates should have two. Since the population of compound bilinguals was not available at the location where this study was conducted, both experiments used coordinate but balanced

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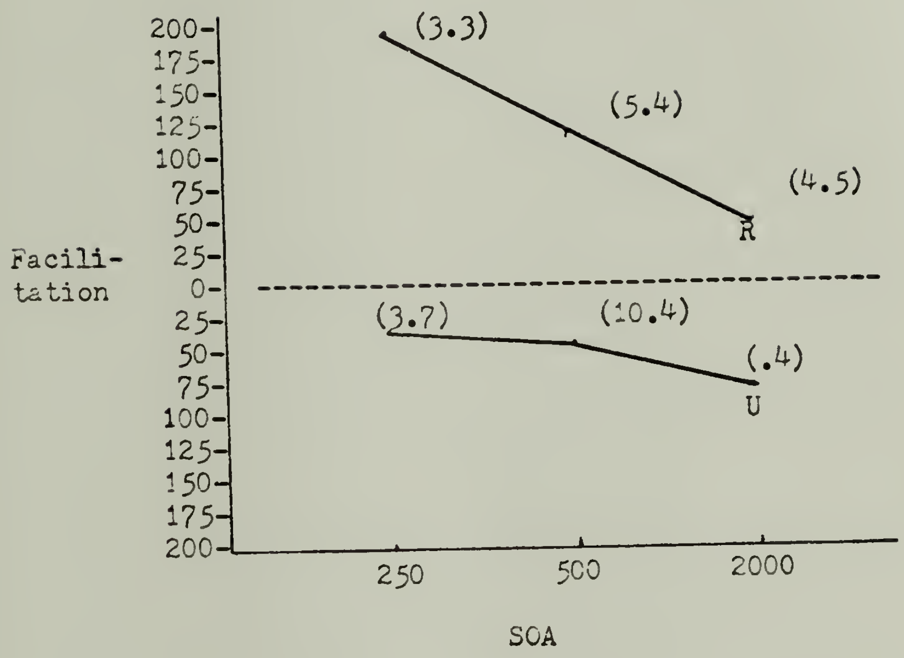
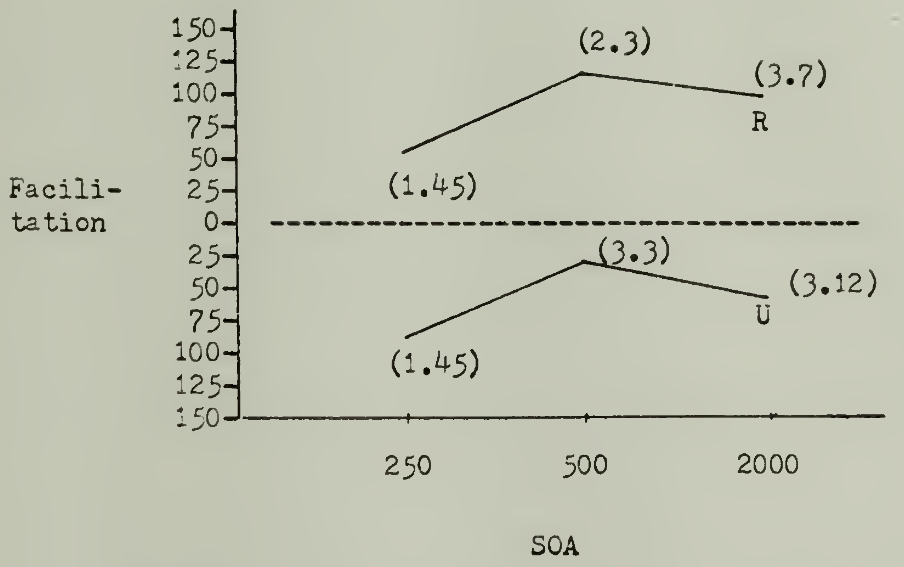
Figure 1



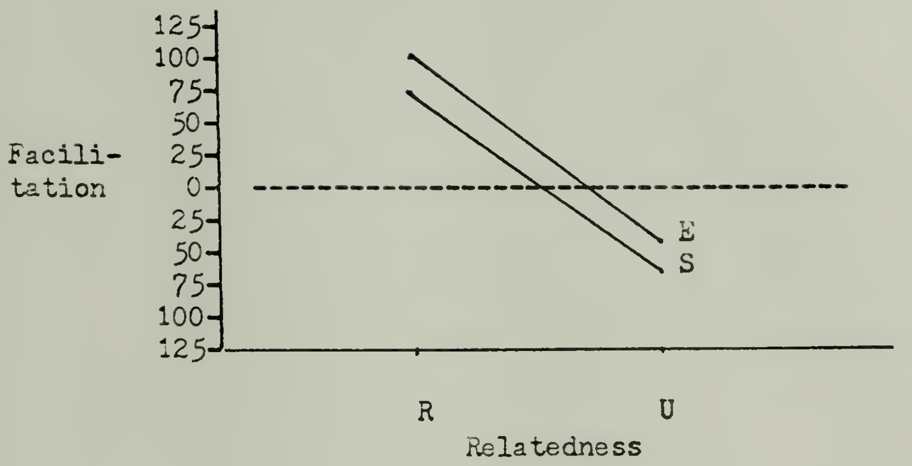
SOA by Relatedness Interaction for Monolinguals

Figure 2



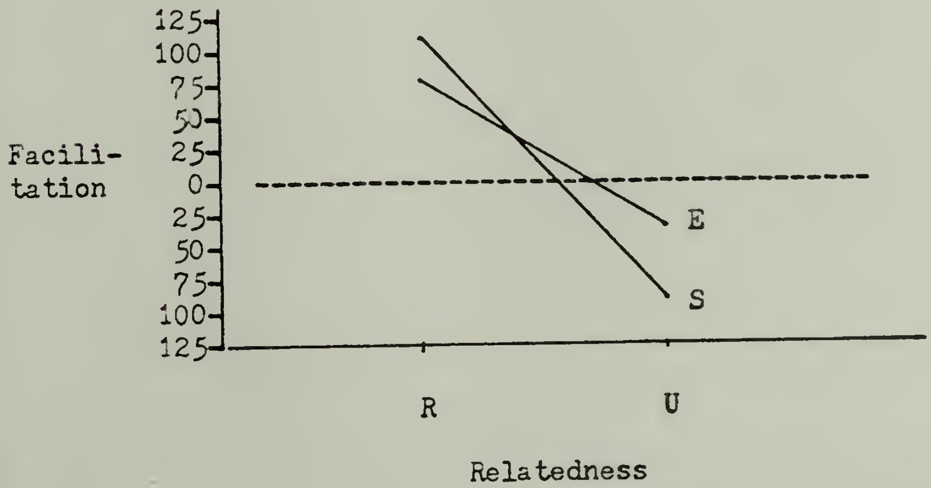
SOA by Relatedness Interaction for Bilinguals

Figure 3



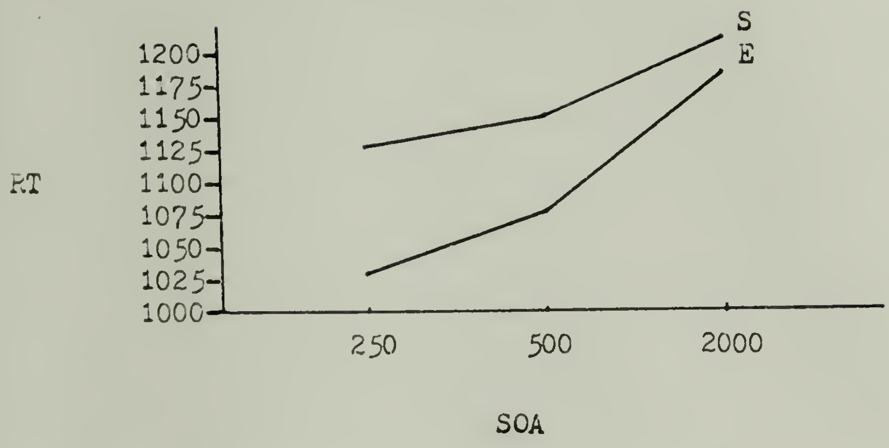
Relatedness by Cue Language Interaction for Bilinguals--Day 1

Figure 4



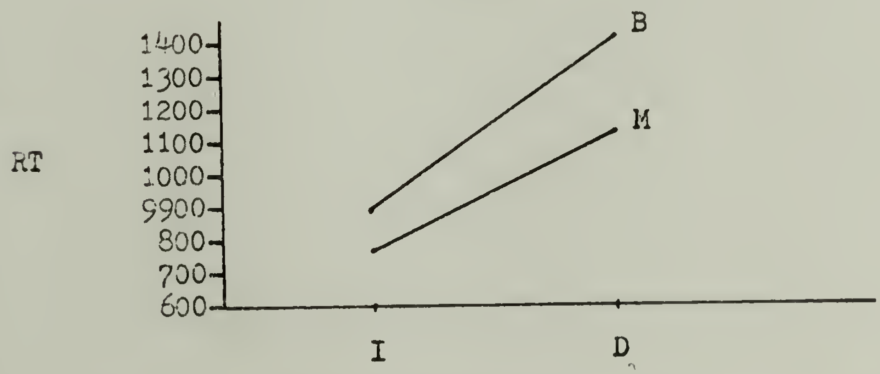
Relatedness by Cue Language Interaction for Bilinguals--Day 2

Figure 5



SOA by Probe Language Interaction for Neutral Positive Responses for Bilinguals

Figure 6



Identical vs Different Probes by Groups Interaction for Neutral Primes

APPENDIX I

HIERARCHIES USED IN EXPERIMENT 1

Superordinate	Subordinate	Instance (Example)
animal	bird	canary
	fish	tuna
food	fruit	apple
	vegetable	carrot
	spice	nutmeg
furniture	living room	sofa
	kitchen	refrigerator
	bedroom	bed
professions	religious	priest
	nonreligious	banker
buildings	dwellings	cave
	churches	chapel
kitchen utensils	cooking	pan
	eating	plate
measures	distance	mile
	time	second

APPENDIX II

	LESA				BORDERLINE	NON-LESA	
	0	1	2	3	4	5	6
UNDERSTANDING	Has no comprehension of the 2nd language.	Understand only some isolated words or familiar phrases when spoken slowly and with frequent repetition.	Cannot be said to understand even simple conversational English.	Has great difficulty following what is said. Understands only "social conversation" spoken slowly and with frequent repetition	Understands most of what is said at slower-than-normal speed with repetitions.	Understands almost everything at normal speed, although occasional repetition may be necessary.	Appears to understand everything without difficulty.
PRONUNCIATION	Has no pronunciation ability in the 2nd language.	Pronunciation problem limits person from attempting to speak in 2nd language.	Pronunciation problems so acute as to make speech virtually incomprehensible.	Very difficult to understand because of pronunciation problems.	Pronunciation problems necessitate concentrated listening which sometimes leads to misunderstanding.	Always intelligible, though one is conscious of a definite accent.	Has few traces of foreign accent.
GRAMMAR	Has no grammar skills in the 2nd language.	Grammatical structure of 2nd language cannot be tested because person will not attempt to speak in 2nd language at any time.	Errors in grammar and word order so severe as to make speech virtually incomprehensible.	Grammar and word order make understanding difficult. Must often rephrase sentences and/or restrict himself to basic patterns.	Makes frequent grammar and word order errors which sometimes obscures meaning.	Occasionally makes grammatical and/or word-order errors which do not, however, obscure meaning.	Makes few (if any) noticeable errors of grammar and word order.
VOCABULARY	Has no vocabulary skills in 2nd language.	Vocabulary is so limited that person will not attempt to speak in second language.	Vocabulary is so limited that conversation in 2nd language is virtually impossible.	Misuse of words and extremely limited vocabulary makes conversation quite difficult.	Uses wrong words frequently; conversation somewhat limited because of inadequate vocabulary.	Sometimes uses inappropriate terms and/or must rephrase ideas because of lexical inadequacies.	Use of vocabulary and idioms is virtually that of a native speaker.
FLUENCY	Has no fluency in the 2nd language.	Conversation in 2nd language is impossible because answers or responses will always be given in 1st language.	Speech is so halting and fragmented as to interfere with communication.	Hesistant, often forced into silence by language limitations.	Speed and fluency are rather strongly affected by language difficulty.	Speed of speech seems to be slightly affected by language difficulties. Appears to communicate suc-	Speech as fluent and effortless as that of a native speaker.

APPENDIX III

CATEGORIES USED IN EXPERIMENT 2

1. Professions
2. Furniture
3. Buildings
4. Fruits
5. Vegetables
6. Spices
7. Birds
8. Clothing
9. Kitchenware
10. Insects
11. Diseases
12. Relatives
13. Crimes
14. Body part
15. Weapon
16. Flowers
17. Weather
18. Vehicles
19. Furry animals
20. Clergy
21. Gems
22. Colors
23. Measures
24. House parts
25. Topography

APPENDIX IV

EXAMPLES OF DIFFERENT CONDITIONS

Examples for 'yes' responses

Condition	Prime	Probe
Appropriate category, different words	Bird	Pigeon Sparrow
Inappropriate category, different words	Fruit	Pigeon Sparrow
Neutral category, different words	Jagoda	Pigeon Sparrow
Appropriate category, same word	Bird	Pigeon Pigeon
Inappropriate category, same word	Fruit	Pigeon Pigeon
Neutral category, same word	Jagoda	Pigeon Pigeon

Examples for 'no' responses

Condition	Prime	Probe
Appropriate category, case 1	Bird	Pigeon Orange
Appropriate category, case 2	Bird	Orange Pigeon
Unrelated category	Furniture	Pigeon Orange
Neutral category	Jagoda	Pigeon Orange

APPENDIX V

MEAN RTs FOR POSITIVE RESPONSES: EXPERIMENT 2

Monolinguals

Prime	Probe	SOA 250	500	2000	Mean
Neutral	Identical	714	741	796	750
	Different	1105	1046	1102	1084
Related	Identical	704	706	766	725
	Different	927	935	1060	974
Unrelated	Identical	726	762	824	771
	Different	1139	1113	1176	1143
Mean		886	884	954	908

Bilinguals--Same language

Prime	Probe	250	500	2000	Mean
Neutral	Identical	864	860	942	888
	Different	1279	1346	1416	1347
Related	Identical	832	832	929	864
	Different	1237	1236	1320	1264
Unrelated	Identical	857	880	934	890
	Different	1363	1393	1475	1410
Mean		1072	1091	1169	1111

APPENDIX V (continued)

Bilinguals--Different languages

Prime	Probe	SOA			
		250	500	2000	Mean
Neutral	Identical	864	860	941	888
	Different	1279	1346	1416	1347
Related	Identical	869	860	904	877
	Different	1220	1243	1303	1255
Unrelated	Identical	897	898	987	927
	Different	1372	1392	1433	1399
Mean		1083	1100	1163	1115