SEMANTIC PROCESSING IN BILINGUALS

Helen Vasos

A Thesis

in

The Department

of

Psychology

Presented in Partial Fulfillment of the Requirements
for the degree of Doctor of Philosophy at
Concordia University
Montreal, Quebec, Canada

August, 1983

ABSTRACT

Semantic Processing in Bilinguals

Helen Vasos
Concordia University, 1983

Most bilinguals possess one fully developed language system and a second system which is relatively less well developed than the first. Studies have shown that even when bilinguals are familiar with translation equivalents of words in their two languages, meaning appears to be decoded more slowly in the second than in the first language. The present study examined whether taxonomic category labels in the bilingual's second langauge might not only evoke meaning more slowly but also evoke a more restricted meaning than their translation equivalents. In Experiment 1 monolingual speakers of English and monolingual speakers of French rated drawings with respect to how closely each drawing (e.g. a chair; a clock) represented their idea of an exemplar taxonomic category (e.g. Furniture). Drawings rated as either high or low in prototypicality by both groups were selected <u>for</u> use in subsequent experiments. In Experiment 2, native speakers of English who were fluent in French participated in a category judgment task. A taxonomic category prime either in French or in English preceded a pair of drawings at one of three stimulus onset asynchronies (SOA). Subjects responded <u>same</u> to pairs of stimuli which were physically identical (e.g.

chair-chair) or instances of the same category (e.g. chair-table) and <u>different</u> to pairs of stimuli from different categories (e.g. chair-hammer). Results are interpreted as suggesting no between-language differences in the information activated by the category primes nor in the speed of processing such information in the case of fluent bilinguals. In Experiment 3 the same task was administered to native speakers of English who were of intermediate fluency in French. Because an unequivocal interpretation of results was not possible, between-language differences were explored further in a final experiment with subjects at the same level of fluency in French as those participating in Experiment 3. Experiment 4 consisted of a lag study where a same-category trial was followed after zero, one or two intervening different category trials by a second same category trial. Half the subjects were tested at a short SOA; half at a long SOA. Results are interpreted as suggesting that a taxonomic category prime in a weaker language can evoke a more restricted meaning than its native language translation equivalent.

ACKNOWLEDGEMENTS

I wish to extend my sincere gratitude to Dr. Norman Segalowitz for his advice and constant support, to Dr. Tannis Arbuckle-Maag and Dr. Mel Komoda for their helpful suggestions and to Henri, Katherine and Kristina for their encouragement and patience.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

LIST OF APPENDICES

INTRODUCTION

In the broader perspective, being bilingual is generally considered a clearly positive condition with obvious cultural, economic and political advantages. Becoming bilingual, particularly when achieved at possible cost to some area of psychological or educational functioning, has received qualified support. In many parts of the world, thousands of individuals are becoming bilingual by working or studying in a second language. For some, earning their living or acquiring an education in a weaker language is a necessity, for others, it is a matter of choice.

The recent trend in Canada to study school subjects such as social studies and mathematics in a non-dominant language is one example of voluntary immersion in a second language. Generally, participants in these second language programs have compared favorably to individuals in regular first language programs in cognitive development and cognitive flexibility (Cummins & Gulutsan, 1974; Liedke & Nelson, 1968; Peel & Lambert, 1972; Scott, note 1) in first and second language achievement (Barik & Swain, 1977; Barik, Swain & Gardino, 1976; Genesee, 1983; Lambert & Tucker, 1972) and in broader aspects of cognitive functioning such as mastery of course content (Bruck, Lambert & Tucker, 1974; Genesee & Chaplin, note 2; Swain & Barik, 1976). There is some evidence (cf. Swain, 1978) that students who may not have attained a certain "threshold" level (Cummins, 1978; 1982) in their second language are less able to deal with mathematical and scientific concepts than are students who are instructed through their first language. The nature of these investigations and the fact that the students were following specific school subjects in only one language precluded cross-language comparisons within individuals. Yet, it is only when comparisons are made between the bilingual's two languages that specific problems in information processing in the weaker language can be examined.

Second language users frequently report difficulty in following the meaning of a lecture or a written passage. Generally, the cause is attributed to inadequate knowledge of vocabulary or syntactic structures. However, when the troublesome passage is carefully analysed, it is often clear that translation is not a problem and that something other than ignorance of vocabulary or syntactic structures is involved (Macnamara, 1967). Two hypotheses may be put forward in an attempt to understand such difficulties.

First, a word in the second language may evoke meaning more slowly than in the first, retarding or impeding the processing of other parts of the message. The slower semantic decoding of second language words has been used to explain between-language differences in some of the early bilingual studies (Macnamara, 1967; Nott & Lambert, 1968).

Second, a word in the weaker language might generate a more restricted meaning than that generated by the translation equivalent, evoking fewer associates and, possibly, interfering with full comprehension of the message. In some instances, restriction of meaning may simply be the result of learning a language by directly translating words from the first to the second language. For example, the knowledge that 'couper' denotes more than 'cut', given certain contexts, might not be available to those who have learned French through the translation methods of the second language classroom. In another sense, restriction of meaning might refer to the situation where the meaning of a word and its translation are actually equivalent but the word in the second language evokes fewer associations than does its translation. For example, the word 'meuble' might evoke fewer associates than the word 'furniture". It is to this latter notion of restricted meaning that this investigation is addressed.

It may be that the full meaning of a word in a second language can be evoked only after that word has been associated with numerous experiences and has been used in a variety of contexts. A child learns the full meaning of words in his first language through a variety of verbal and, more importantly, nonverbal experiences. On the other hand, a youngster learning a second language in a school setting would probably overlearn limited associations to or examples of words resulting in a restricted meaning for certain words. To date, there appears to be no experimental study which has explored this possibility.

The between-language differences in either the speed or breadth of activation referred to above may become obvious only when words are processed in situations where time constraints preclude or limit translation to the stronger language. Such constraints can be imposed in experimentally manipulated reaction time tasks (Macnamara, 1967), or conceivably can exist in a situation such as a lecture where the normal rapid pace of speech limits the second language listener's opportunity to translate troublesome words into the dominant language.

The idea that the processing of a word might be affected by the processing of previously occurring words has a long history. William James (1890) suggested that a word received a double awakening; once from the lips of the speaker and prior to that from within, by processes "irradiating" from related words used previously in the conversation. For example, the meaning of the word 'girl' would be more readily available if 'girl' were preceded by 'boy' rather than by 'tractor'. Semantic priming is the term currently used to refer to the activation of a word or phrase by prior processing of semantically related information. Semantic facilitation effects have been demonstrated in a variety of cognitive tasks such as naming (Jacobson, 1973; Stanovich & West, 1981, 1983; Stanovich, West & Feeman, 1981; Warren, 1970; West & Stanovich, 1978, 1980), category judgment (Caramazza & Brones, 1980; Lorch, 1982; Myer & Lorch, 1980), sentence verification (Ashcroft, 1978; Collins & Quillian, 1970, 1972; Glass & Holyoak, 1975; Holyoak & Glass, 1975; Lorch, 1981; Rips et al., 1973), and, most frequently, lexical decision (Antos, 1979; Becker, 1980; Massaro et al., 1978; Meyer & Schvaneveldt, 1971; Neely, 1976, 1977; Posner & Snyder, 1975; Scarborough et al., 1977; Schuberth & Eimas, 1977; Schvaneveldt & McDonald, 1981; Tweedy et al., 1977).

The prime in the present study was the name of a taxonomic category and the task, a category judgment task where subjects had to decide whether drawings did or did not represent items that were members of the category named by the prime. Two types of bilinguals, referred to as fluent and moderately fluent, were used as subjects. (In the present investigation the term fluent refers to bilinguals who were rated and who rated themselves as fluent in both their languages but somewhat more fluent in their first than in their second language. The term moderately fluent bilinguals refers to subjects who rated themselves and were rated as moderately fluent in their second language and fluent in their first).

The present study investigated the effects of priming with concrete category labels in each of the bilinguals' two languages. The two hypotheses investigated were that (1) retrieval of word meaning is slower in the second language than in the first, (2) the meaning evoked by a second language word is more restricted than that evoked by the equivalent word in the first language.

REVIEW OF THE LITERATURE

In the first section of the review, theories and studies in bilingualism relevant to the investigation of the two hypotheses are reviewed. This is followed by the discussion of two major theoretical views of the structure of semantic memory. A third section considers the priming paradigm as one way of investigating semantic memory. A final section deals with the structure of interest, the category, and an investigation of the processing of category information in memory. Implications for the processing of category information in bilinguals are considered within the context of a category judgment task. The final section concludes with a brief statement of the problem.

Bilingualism and the Problem of Second Language Access

The meaning evoked by a word in one language does not always correspond precisely to that evoked by the translation equivalent. Fluent bilinguals who have mastered relatively subtle features of their two languages would be sensitive to the difference in the semantic value of certain words and their so-called translation equivalents. For them the meaning of words in each of their languages would correspond to the meaning of these words for monolingual speakers of the language. For bilinguals who have had limited contact with the second language community or who have learned their second language through the translation methods of a typical second language classroom it may be, as Taylor (1974) has suggested, that the first language concept persists in the new language and is activated with all its connotations when the second language concept is evoked.

The fluent bilingual's sensitivity to each language was revealed in a study of associational response diversity by Lambert and Moore (1966). The investigators developed word association norms for English and French Canadian monolingual students and Canadian English-French bilingual students responding in English and French. The results were compared with published norms for American English and European French students. The responses of the English Canadian monolinguals resembled the more stereotyped American pattern. The French Canadian monolinguals were more diverse in their associations resembling the French students from France. Lambert and Moore reported a modification in response stereotypy as the Canadian English-French bilinguals changed their language. The bilingual subjects placed between the English and French Canadian monolingual groups when responding in English and between the French Canadian and French-French groups when responding in French. The investigators suggested that the bilinguals' intermediate degree of response similarity could contribute to making them effective linguistic mediators.

Kolers (1963, 1968) reported between-language similarities and differences in associations to translation equivalents and attributed this to differences in bilinguals' experiences with the referents of words. Working with students whose first language was other than English but who considered themselves fluent in English, Kolers found that words referring to concrete objects (i.e. thorn, tree) were more likely to elicit similar associations in the bilinguals' two languages than were abstract words (i.e. democracy, justice) or words referring to feelings (i.e. love, jealousy). Kolers attributed the greater overlap in associations to concrete words to a commonality of experience associated with each member of the translation pair. Because, for example, a chair and a table tend to occur together in the same environment, the association between words for these two objects might come to be established independently in the two languages of the bilingual. On the other hand, the abstract word 'democracy' although a translation of the German 'demokratie' might not elicit the same associations because of the different contexts in which these words were learned. Kolers suggested that some information was stored in such a way that it was readily accessible in the two languages; other information was closely tied to the language in which it was stored. His conclusion appeared to support both sides of a major theoretical controversy regarding two views of the bilingual mind, whether bilinguals store information in one common semantic store or in two separate stores, one for each language (Ervin & Osgood, 1954).

In the common store view, knowledge is represented in some common abstract manner and the bilingual person has access to the common body of knowledge through either language. A separate store suggests that knowledge is linked to the language of acquisition. Knowledge acquired through one language would not necessarily be available in the other language except through translation. Evidence from studies using primarily free recall and transfer-type paradigms appears to be overwhelmingly in support of the common store hypothesis (cf. McCormack, 1977; Segalowitz, 1977).

Recently, Paivio and Desrochers (1980) have proposed a separate store position that allows for certain processing mechanisms reflecting a common representational system. They have argued that some information can be stored in a supralinguistic (i.e. imaginal) form and other information in one of two language specific forms. Reactions to the separate languages can be mediated by shared connections with the image system as well as through direct links between translation equivalents. They reinterpreted Koler's findings within their own dual-coding (verbal-nonverbal), dual-store framework. They suggested that associations to the concrete words used by Kolers were mediated by referent images common to the translation equivalents in each verbal system. Associates to abstract words were determined, for the most part, by the structure of the verbal association network of each of the bilingual's languages. As yet, the model has received little direct testing, but was given some support in a recent study

(Paivio & Lambert, 1981).

Paivio and Lambert (1981) conducted two experiments investigating the effects of verbal-nonverbal and bilingual dual coding on recall. The experimental tasks ensured verbal-nonverbal coding in the case of picture-labeling and word-imaging tasks and bilingual (verbal) coding in the case of tasks requiring translation. They reported that in both experiments item recall increased significantly from unilingual to bilingual to verbal-nonverbal dual coding. This supported their predictions that representations in one system would activate those in another and that nonverbal (imaginal) and verbal meaning codes aroused directly by words and pictures or indirectly through imagery and by verbal encoding tasks would have additive effects on item recall.

Although most theories and investigations have attempted to seek generalizations about bilinguals (McCormack, 1977), one line of thinking distinguishes between two types of bilinguals, compounds and coordinates (Weinreich, 1953) and suggests that the bilingual's language acquisition history can lead to either a separate or a common semantic store (Ervin & Osgood, 1954). In compound bilingualism acquisition of two languages occurs in a situation where both have been spoken interchangeably such as in a bilingual home or through teaching methods involving translation. This presumably leads to the development of a common fused semantic system. In such a system identical meanings are attributed to corresponding words and expressions in the two languages. In coordinate bilingualism words are acquired in different contexts (i.e. home and school; country x and country y) and/or sequentially and are assumed to lead to the development of a separate store for each language.

Numerous studies investigating predictions stemming from the theory have attempted to find evidence to support the compound-coordinate distinction. While some studies failed to support the predictions (Dillon et al., 1973; Olton, note 3), other investigations, a number of which require subjects to pay close attention to meaning (Ervin, 1964; Jacobovits & Lambert, 1961; Lambert, Havelka & Crosby, 1958; Lambert, Ignatow & Krauthammer, 1969; Lambert & Rawlings, 1969; Segalowitz & Lambert, 1969) did provide some evidence for the distinction. One study (Lambert, Havelka & Crosby, 1958) is particularly relevant to the present research. This study revealed that translation equivalents of even simple, concrete words could evoke different associations in the two languages. The investigators had compound and coordinate French-English bilinguals rate a series of French and English words such as 'église' and 'church' on semantic differential scales. They found that those who had learned their second language in a separate context provided more dissimilar responses than those who had learned it in mixed contexts. These differences were even more pronounced for those who had learned English in culturally distinct contexts as compared to those who had learned the language in a culturally fused environment.

One reason why studies in this area seem contradictory may be due to inconsistencies in the way subjects have been classified as compounds and coordinates (Macnamara, 1967; 1970). Despite criticisms of the various attempts to define the categories (Paradis, 1978; Shaffer, 1976) and to identify them in practice (Diller, 1970) there seems to be enough experimental support to retain some form of the distinction.

No matter how one chooses to operationally define compound and coordinate bilinguals, the majority of bilinguals would fall outside of these two extreme categories. It may be more useful, as suggested by Paivio and Desrochers (1980), to think of the compound-coordinate distinction as a difference in degree rather than in kind. The variety of nonlinguistic and linguistic experiences encountered by individuals as they acquire a second language could lead to differences in the number and strengths of direct associations between translation equivalents. This would suggest that there could be differences both between and within individuals, as to the extent to which words and expressions considered to be translation equivalents would have the same, different or partially different meanings.

Some fluent bilinguals, such as the ones used as subjects in the present study, could be classified as coordinate bilinguals on the basis of the age of beginning second language acquisition (e.g. age 6) and the separate context in which second language acquisition took place (e.g. French school system). Yet, more careful examination of what is acquired during the second langauge experience would suggest elements characteristic of compound bilingualism. The school provides a special set of experiences with vocabulary and concepts that are specialized, particularly as one advances through the system. Because of this, certain commonly used second language words might rarely be encountered in the school setting and the concepts associated with these words not explored through the medium of the second language. Consequently, such words, when they are encountered, might not evoke meaning as completely as do their translations in the bilingual's first language. It may be then, that for any one individual, the learning of certain first and second language equivalents in mixed contexts leads to language use which is characteristic of a "compound bilingual" and the learning of other translation equivalents in separate contexts leads to language use which is characteristic of a "coordinate bilingual".

Even where words seem to evoke the same meaning, there is evidence that the meaning may be decoded more slowly in the nondominant language. During the past twenty-five years, a number of studies have reported between-language differences in the speed with which bilinguals could perform certain verbal decoding tasks. These differences seemed to persist even when high frequency words were used with bilinguals who had a number of years of experience with their second language. For example, Lambert (1955) presented simple instructions such as "Push the key painted blue" in two languages and found that response time was directly related to linguistic proficiency. In decoding tasks which required simple responses to instructions which designated items by position, shape, color and direction Dornic (1978) and Rao (1964) found slower reaction times in the non-dominant language, particularly when task difficulty was increased.

A number of investigators have reported that reading was slower in the weaker language (Kolers, 1966; Lambert, Havelka & Gardner, 1959; Kellaghan & Macnamara, 1967). In attempting to explain an earlier finding that bilinguals took longer to solve problems in their weaker language (Macnamara, 1966), Kellaghan and Macnamara (1967) presented arithmetical problems in both Irish and English to a large sample of school boys whose first language was English. Half the children had been taught their subjects in English; half in Irish. The children read each problem aloud three times and the time taken to read the problems was recorded. For both groups the first reading of the Irish version of the problem took significantly longer than the reading of the English version. The investigators suggested that the poorer reading in the second language could be attributed to difficulty in processing input at any particular level (e.g., orthographic, syntactic, semantic). For example, in investigating processes linked to knowledge of the orthographic redundances of a language, Favreau, Komoda and Segalowitz (1980) found that fluent bilinguals showed a smaller word superiority effect in their second as compared to their first language in a visual detection task. The investigators concluded that the subjects were less able to utilize orthographic redundancies in their second language.

The slower reading of a word in a second language might also be a function of a more complex cognitive activity, that of semantic decoding or retrieval of word meaning from long term memory. In tasks where meaning is important, it seems that the semantic value of words is decoded more slowly in the weaker language. For example, Nott and Lambert (1968) using groups of English dominant and French dominant bilinguals found that, with category lists, recall and category clustering were consistently lower in the weaker language. They suggested that nonfluent bilinguals were at a disadvantage in their second language because, in a task where meaning had to be determined, speed of semantic decoding was slowed and there was less time to rehearse the organization of the list.

In another study Macnamara (1967) found that subjects who were dominant in English could match a familiar printed, concrete word with a drawing significantly faster in English than in French. He attributed this to differences in the speed of semantic decoding. Unlike the Nott and Lambert (1968) study which did not control for other factors specific to the reading process, Macnamara measured the perceptual threshold for words in each language. He found no significant difference between French and English words. Because there was repetition of the same eight words, he suggested that a difference in perceptual threshold may have been obscured by a considerable familiarity factor. Apparently, the factor investigated (semantic decoding) was sufficiently robust to withstand the effect of this familiarity.

In summary, most of the literature on bilingualism has focused on the interaction between the bilingual's two languages. The issue of particular interest has been whether and to what degree the bilingual's two languages are independent or interdependent. A second area of research which has received considerably less attention has addressed the problem of how information processing is affected by the lower level of language skills that characterize the bilingual's use of the second language. It is to this issue that the present research is addressed.

Theoretical Views of the Structure of Semantic Memory

Semantic facilitation effects have been explained within the context of two major classes of semantic memory models -- set theoretic (Meyer, 1970; Schaeffer & Wallace, 1970; Smith, Shoben & Rips, 1974) and network (Anderson, 1976; Collins & Quillian, 1969; Collins and Loftus, 1975). Set theoretic models make few assumptions about the kinds of relations represented in semantic memory, emphasizing the role of comparison processes in the processing of information. Network models assume that various types of semantic relations are represented in semantic memory, stressing the importance of retrieval operations. In this section one influential model from each major class of models is described and its implications for bilingual semantic memory are discussed. In addition a recent conceptual distinction between two components of processing which underlie priming effects (Posner & Snyder, 1975) is discussed.

The Feature Comparison Model

Of the set theoretic models, the feature comparison model (Smith et al., 1974) has been referred to most frequently in the priming literature (Collins & Loftus, 1975; Glass & Holyoak, 1975). In this model, concepts are represented as features corresponding to properties of the concepts. For example, the concept 'bird' would be represented in semantic memory by features such as feathers, wings, two-legged, able to fly and so on. Only property relations are stored in memory. Other relations (e.g. superordinate-subordinate) must be calculated from information provided by the features.

Smith, Shoben and Rips (1974) proposed a two-stage process to explain the effects of relatedness in a category verification task. The first stage consists of a global comparison of the features of the two concepts presented in the task. The global comparison involves a comparison of defining as well as of characteristic features. Defining features are those that a concept must possess in order to be a member of a category. Characteristic features are those which are commonly associated with the concept but are not necessary for category membership. For example, 'feathers' might be considered a defining and 'flying' a characteristic feature of the concept 'bird'. If there is a large proportion of common features or properties, then relatedness is judged to be high and the decision for a positive (true, same) response can be quickly made. If there is a small proportion of common features, relatedness is judged to be very low and the decision for a negative (false, different) response, again, can be quickly made. If, however, the proportion of shared features is neither high nor low then a second, more analytical stage of processing is executed. This stage is based on a comparison of defining features only.

The model predicts that reaction times in tasks which demand only the first stage of processing would be faster than those in tasks which implicate the second processing stage. A comparison of 'a robin is a bird' or 'a tulip is a bird' would involve only stage 1 processing and a relatively fast true or false response. Determining whether 'a bat is a bird' would involve stage 2 processing and would result in slower reaction times. Glass and Holyoak (1975), elaborating the model, have suggested that semantic relatedness (i.e. number of common features) should affect the outcome of stage one only and category size (i.e. the number of features that define a category) should affect the duration of stage two only.

The common and separate semantic store hypotheses of bilingual memory can be explored within the context of a feature comparison model of lexical representation. In a separate bilingual representational system where each language would have its own set of feature lists, it could be possible that the feature list associated with a particular word in the nondominant language is shorter than that of its translation equivalent. If superordinate-subordinate relations are calculated from information provided by the features, then between-language differences in reaction times might be attributed to differences in the size of the feature list for words in each language. In a common representational system the two languages would presumably share the same network with translation equivalents having relatively distinct feature lists. In the case of the nonfluent bilingual, for example, 'furniture' and 'meuble' would activate the same meaning system but the number of features which define the category furniture could be greater than those defining the category meuble.

The Spreading Activation Model

One of the most influential of the network theories, that of Collins and Quillian (1969), has been extended and reformulated in 'quasi-neurological terms' to accommodate a theory of semantic processing. This 'spreading activation' model of semantic processing (Collins & Loftus, 1975; Collins

& Quillian, 1972) is, to date, the most popular attempt to explain the mechanism that underlies facilitation effects.

Within the spreading activation model semantic memory is seen as composed of a hierarchy of cognitive nodes (or alternatively, cognitive units). Hypothetically, concepts are represented in memory as nodes and relations among concepts as associative pathways connecting these nodes. These associative pathways or links can extend from one node to other nodes which are, in turn, linked to more distant nodes. Collins and Loftus (1975) maintain that it is primarily the number of links in the hierarchy and/or the distance between these links which determine the strength of the relationship, although they also claim that differences can exist in the strength of the various bonds. According to the original theory there are five different kinds of links, one of them is the superordinate-subordinate link characteristic of category-membership relationships. According to the model the cognitive nodes representing, for example, VEHICLE and CAR are directly and closely connected; those representing VEHICLE and FIRE ENGINE are directly connected but the distance between nodes is longer, whereas the node representing VEHICLE would be linked indirectly to VOLKSWAGON through the node CAR.

The processing implications of this spreading activation model for priming would be as follows. When a stimulus word is presented the corresponding node in memory is accessed and the activation of nodes associated with the priming node is initiated. This temporarily enhances the accessibility of the related nodes. As activation spreads from the target word, an intersection between the two related nodes is found and a response is executed. Thus, retrieval of a concept represented by one of the related nodes is presumably facilitated by the preactivation (or priming) it has already received. This preactivation provides the basis for explaining the facilitation produced when a prime and a target are semantically related.

Given the semantic structure outlined above, the model would predict that the closer (i.e. distance) two concepts are in the network and/or the more closely related (i.e. number of links or strength of bond) the faster the connective path can be found. Retrieval time is hypothesized to decrease as relation strength increases (e.g. 'robin' would be verified faster as a 'bird' than would 'turkey'). Although network models have emphasized this relationship strength interpretation, there is another correlated factor which is hypothesized to determine retrieval time. Collins and Loftus (1975) have suggested that in addition to relationship strength, the extent to which the two concepts share certain features should speed retrieval time (e.g. 'feathers', 'flying', 'worm eating' are common to robin and bird but not to turkey and bird). Collins and Loftus (1975) concede that this process is similar to that proposed by Smith, Shoben and Rips (1974) but disagree that this is the only way all categorization judgments are made. They argue that people make use of all types of evidence including superordinate-subordinate links. In addition they hypothesize that the longer the activation process continues, the more features will be compared.

The two bilingual storage hypotheses can be explored within the context of the spreading activation model of semantic memory. In a separate system, each system would have its own network of nodes representing the concepts underlying the translation equivalents. In the case of a nondominant language, it might be that the distances between nodes associated with a particular concept in the network are greater and/or the paths less numerous compared to the dominant language. For example, the distance between the nodes representing 'moyen de transport' and 'traineau' might be greater than that between 'vehicle' and 'sleigh' when French is the nondominant language. In a common representational system, the translation equivalents could share the same meaning system with primes possibly activating relatively distinct representations within that system.

There are three local processing assumptions in the extended theory (Collins & Loftus, 1975) which are particularly relevant to the present research. First, entering the network at a certain point is assumed to activate pathways in all directions. An example of this processing assumption is the case of BIRD activating the high frequency nodes WINGS, FEATHERS and BEAK at the same time. Some evidence for this type of parallel rather than serial processing has been provided by Freedman and Loftus (1971).

Subjects were asked to produce an instance of a category which began with a specific letter of the alphabet. The investigators hypothesized that a serial search would take longer, the larger the category to be searched. Subjects took no longer to produce a correct high frequency instance from a larger than from a smaller category thus providing some support for parallel processing. An alternative hypothesis is that high frequency items are at the top of the list whether the list is long for a larger category or short for a smaller category. Consequently, the lack of a difference in reaction times does not necessarily indicate parallel processing but rather serial processing of the same number of items. To distinguish between alternative hypotheses it is important to determine the number of high frequency items in each category.

In the case of bilingual processing, it might be that the prime in the nondominant language would activate fewer high frequency nodes than would a dominant language prime. In a category verification case, this could result in a between-language difference in reaction-time with, possibly, no facilitation effects for second language trials.

A second processing assumption within the extended model is that units have thresholds which must be exceeded in order for activation to take place. When activation from two nodes summates at some point of intersection and this summation exceeds threshold, the path in the network producing the activation will be evaluated. Given a subthreshold prime or too little processing time the threshold might not be reached resulting in no facilitation effect. On the other hand, more processing time could allow distant nodes to be activated. Consequently, the amount of facilitation produced by a prime should be constrained not only by the semantic relationship between prime and target words but also by the time available for activation to spread. This assumption has received some support in a study by Myers & Lorch (1980). They found that, when target words were primed by a category member (e.g. TURKEY), the facilitation effect was significantly greater for low dominant items (e.g. TURKEY-BIRD) at the long SOA (stimulus onset asynchrony) than at the short. In regard to processing in the bilingual context, it could be that nodes representing concepts within a second language system or intersections between these nodes have higher thresholds. Alternatively, it takes longer for activation to spread through the system, presumably because pathways are longer or less numerous than in the first language system.

The third assumption within the extended model states that the activation of a unit decays gradually over time and/or intervening activity. Evidence for such decay over time has been provided by Loftus (1973) in a lag study which revealed that both time and intervening activity diminished the effects of facilitation from the prime. This study is described in more detail in a subsequent section. In the bilingual situation, a node might be less activated within the second language system and, consequently, decay more rapidly over time than its first-language counterpart. Alternatively, if fewer nodes are activated, as could be the case in either a common or separate store, then one would expect to observe an earlier diminution of facilitation effect in the second as compared to the first language.

A mental lexicon organized in such a way that spreading activation can operate is an essential feature of an influential two-factor model of attention (Posner & Snyder, 1975) which has attempted to explain both the facilitation and the inhibition effects of primes. (In contrast to facilitation, inhibition occurs where the prime interferes with the processing of the probes slowing reaction times). The model is not concerned with semantic organization or retrieval operations but with attentional processes involved in facilitation and inhibition.

Posner and Snyder (1975) have provided a conceptual distinction between an automatic and a controlled (conscious, attentional, strategic) processing of the prime. The automatic component is described as fast-acting, occurring without conscious control. This component is equivalent to the notion of spreading activation and leads only to the facilitation of items related to the prime. Controlled processing is described as operating slowly, with intention, and as being characterized by limited resources. It can produce both facilitation and inhibition effects. This model has important implications for the present investigation in that it makes use of spreading activation as the basic mechanism to account for priming while providing a mechanism to account for the nonfacilitative effects of the prime. Although the automatic-controlled distinction has been recently criticized in its application to the item-recognition paradigm (Ryan, 1983), it has received substantial empirical support in the literature on priming of words and sentences. This literature, which includes some recent work on bilingual processing, is reviewed in the following section.

Investigating Semantic Memory - the Priming Paradigm

The results of studies of semantic priming have generally been interpreted as reflecting the organization of semantic memory. One prediction that is shared by most theories of semantic memory is that the nearer two concepts are in memory or, alternatively, the more properties they have in common, the more mutually facilitative they will be. The results of priming investigations have revealed that letter strings can be more quickly detected as words (Meyer & Schvaneveldt, 1971; Neely, 1976, 1977; Posner & Snyder, 1975) or named (Jacobson, 1973; Warren, 1972, 1977) if preceded by a related rather than an unrelated word. In addition, it apparently takes less time to retrieve a category instance (Loftus, 1973; Loftus & Loftus, 1974) or to verify category membership (Caramazza & Brones, 1980; Fischler & Goodman, 1978; Lorch, 1982; Myers & Lorch, 1980; Rosch, 1973, 1975) if the target stimulus (probe) is preceded by a related rather than an unrelated word. These same investigations have also reported that words that are more closely associated to the prime are detected more quickly than words that are more distantly associated.

According to the spreading activation model activation takes time to spread through the semantic network. Some of the recent priming investigations have explored the time course of activation by varying the length of the interval between prime and probe. Facilitation effects of the prime were found at intervals as short as 40 msec. (Fischler & Goodman, 1978) and were reported as increasing with increases in SOA (Antos, 1979; Fischler & Goodman, 1978; Lorch, 1982; Neely, 1976; Ratcliffe & McKoon, 1981).

Only a few published studies have investigated the decay of semantic activation over time and with intervening activity predicted by the spreading activation model. Three studies (Gough et al., 1981; Kirsner & Smith, 1974; Warren, 1972) found no significant effect of prime except at the zero lag (a priming word followed directly by a related target word with no intervening filler items). For example, Gough, Alford and Holley-Wilcox (1981) manipulated the lag in a lexical decision task. Each of 80 target words was preceded by a primed word at one of seven lags varying from 0 to 32 intervening items. The occurrence of a related word just prior to the target word (0 lag) resulted in a facilitation effect thus reducing reaction time. The introduction of only one intervening item eliminated this effect.

Other studies (Brown & Block, 1980; Davelaar & Coltheart, 1975; Forbach et al., 1974; Loftus, 1973; Loftus & Loftus, 1974; Scarborough et al., 1977; Schvaneveldt & Meyer, 1973) reported priming effects that were undiminished over a number of lags. In one typical priming experiment Loftus (1973) paired a category name with the initial letter of the most frequently given instance and with the initial letter of the third most frequently given instance based on published sets of category norms. Half the subjects saw the high dominance stimulus [e.g. color - B (for blue)] before the low [e.g. color - G (for green)] and half saw the stimuli in reverse order. The initial presentation of the critical category-letter stimulus was followed, after 0, 1 or 2 intervening filler items, by the presentation of the same category with a different letter. Loftus reported that the time to generate the name of an exemplar of a given category was reduced if subjects had just named another exemplar of the same category. This reduction occurred even when the low dominance stimuli were presented before the high dominance. In addition, she found that the facilitating effect of repeating the category name decreased as the number of items (1 or 2) intervened between two appearances of that category name. The difference in reaction time between the initial presentations (baseline data) and the presentation at each lag (0, 1 and 2 intervening items) was significant. Her results supported the idea that memory locations can be temporarily activated by a category word making information retrieval easier the second time that category is presented and that the accessibility of these memory locations decayed gradually over time.

Recent priming investigations have supported the distinction between automatic and controlled processing provided by Posner and Snyder (1975). In interpreting the results of their lexical decision task, Fischler and Goodman (1978) suggested that the facilitation effect of priming could be attributed to an early automatic spread of activation and a slower acting, controlled processing component. They found that a prime could produce a facilitation effect within a 40 msec SOA (stimulus onset asynchrony) and again at an SOA of 150 msec. The absence of facilitation at an SOA of 90 msec was attributed to the dissipation of the fast-acting automatic component of processing and a brief delay prior to the involvement of the slower, controlled component.

The most convincing empirical support for the distinction between the two processes has been provided by Neely (1977) in a lexical decision task (deciding whether a string of letters is or is not a word) which used semantic category word primes (e.g. Bird) and a critical condition which made use of a miscue. In the critical condition subjects were led to expect that the category name would usually be followed by a member of a different category, for example 'Bird' followed by a member of the category 'Building'. When the category name was followed by a member of the expected category (e.g. Bird-Window) conscious attention would facilitate performance but automatic activation (which activated associates of the category BIRD) would not. When the priming word (e.g. Bird) was followed unexpectedly by a member of the bird category (e.g. canary), the automatic activation would facilitate performance but since this probe was unexpected, the conscious component would interfere with performance. In order to distinguish between the two processes, Neely varied the interval between prime and probe so that at the shortest interval (250 msec) no effect of attention was found because conscious processes had insufficient time to operate.

In a recent study, Favreau & Segalowitz (in press) used a paradigm similar to Neely's in order to compare the performance of two groups of fluent bilinguals who were distinguished by their level of reading skills. They found that at an SOA of 200 msec, the pattern of reaction times produced by bilinguals who had equivalent reading rates in their two languages suggested automatic processing in both languages. On the other hand, the reaction times produced by those bilinguals with the slower second language reading rate suggested the involvement of automatic processes in their first language only.

In contrast to Neely's and Favreau and Segalowitz's data, a few studies (Antos, 1979; Myers & Lorch, 1980) have reported interference effects at SOAs of 200 and 250 msec respectively. Myers and Lorch (1980) used a semantic verification task where trials included high and low dominant member-category pairs (e.g. robin-Bird OR turkey-Bird) preceded at an SOA of 250 or 1250 msec by an identical prime (e.g. Turkey), an unrelated prime (e.g. Chair) or a neutral prime ('Blank'). The pair of words used as probes were presented at the same time. Subjects were asked to determine whether the top word was a member of the category designated by the bottom word by inserting "is a" between the two words to make a sentence. Subjects were also instructed to use the word cue to prepare for the pair of word probes by trying to think of categories to which the cue word belonged. One-third of the these trials involved a miscue in the sense that the cue word (the prime) was unrelated to either word in the subsequently presented pair. An interference effect at the small SOA was observed for three of the four dominance (high, low) by truth (true, false) conditions. In effect, there was no interference in the high dominance, true condition (e.g. Chair:: robin-Bird) whereas there was in the high dominance false condition (e.g. Chair:: robin-Clothing); in the low dominance true condition (e.g. Stool:: turkey-Bird) and in the low dominance false condition (e.g. Stool:: turkey-Clothing). The authors suggest that the answer for this pattern of interference effects lies in the rate at which associates of the unrelated cue are activated relative to the rate at which associates of the probes are activated. In the high dominance condition, the two probe words are so strongly associated that information relevant to the evaluation of the word pairs is activated before associations of the cue are sufficiently active to interfere with the evaluation process. On the other hand, evaluation of low dominant items and false items take more time, allowing activation from the cue word to interfere with their processing.

It is possible then that interference, as a manifestation of conscious processing, might not be as slow-acting as originally suggested. The speed with which controlled processing is involved might be dependent upon the amount of processing that is required (Myers & Lorch, 1980). It might be that tasks requiring semantic categorization or judgments of category membership make more processing demands than do lexical decision or naming tasks possibly resulting in an earlier involvement of controlled processes.

Semantic Categorization and the Processing of Category Information

On the one hand, bilingual research has explored two major hypotheses concerning the way bilinguals store linguistic information, has provided an important distinction between compound and coordinate bilingualism, and has revealed assymetries in the processing of information in the two languages. On the other hand, semantic memory research with monolinguals has provided theoretical approaches pertaining to the organization of a semantic memory system. The priming paradigm has been the major experimental method used to study such a system. The present investigation has used some of the theoretical assumptions of monolingual semantic memory research within the bilingual context. Possible between-language differences in the processing of category information by bilinguals have been investigated by means of a priming paradigm similar to that used by Eleanor Rosch (1975) in the investigation of semantic processing in monolinguals.

Rosch and her colleagues (Rosch, 1973, 1975; Rosch & Mervis, 1975; Rosch et al., 1976), in investigating the nature of the cognitive representation of semantic categories, have addressed two major issues: (1) the internal structure of a category, and (2) the effect of internal structure on cognitive processing of the category. Since both of these issues are of particular relevance to the present investigation, they are presented in some detail below.

According to Rosch (Rosch et al., 1976) categories exist at different levels of abstraction. The more inclusive categories are referred to as superordinate (e.g. Furniture) and the less inclusive as subordinate (e.g. French Provincial). In addition, there is an intermediate level of categorization called the basic level (e.g. chair) which is considered to be the most informative level. Sometimes, depending, in part, upon the specialized knowledge of the person doing the categorizing, the subordinate level may be the most informative. Members of any of the three levels of categories are referred to as instances and instances are composed of attributes. For example, chair would be an instance of the superordinate category furniture, with attributes such as legs, flat surfaces and angles. Categories with a large number of discriminating attributes are more informative than those with fewer attributes and have, according to Rosch, high "cue validity". Basic level categories which contain objects in the real world (e.g. table, chair, fan) would have high cue validity because they would consist of attributes that reoccur and that are most clearly predictive of membership in a category. The broader superordinate category (e.g. Furniture) would be much more inclusive and less discriminating (e.g. is used, has flat surfaces) and the subordinate category (e.g. French Provincial) could contain attributes (e.g. curved legs, molding) at a level of discrimination appreciated by relatively few individuals. Each member of a category (at any level) does not possess all the defining attributes of that category but there is sufficient overlap so that separate instances can all be considered as members of a particular category. The category members which possess more defining attributes than others are considered to be most prototypical. For example, chair, table and bed would be considered more prototypical of the category Furniture than would fan, rug and clock.

Recently, Murphy (1982) has argued that cue validity can only increase for more inclusive categories and is therefore unable to pick out the basic level. He is in agreement with Rosch that basic levels may be the more useful category because, among other things, they are highly differentiated, have many features in common to members, and are defined perceptually rather than functionally. Unlike Rosch, Murphy has suggested that cue validity measures something different from category differentiation and might be proportional to the "certainty of classification". In his example, a distant flying object should be classified with more certainty as a physical object than as an animal and with more certainty as an animal than as a bird. As Murphy has pointed out, whether, in reality, classification confidence follows his rational rule remains to be proven.

Rosch has explored the internal structure and cognitive processing of semantic categories with the following results:

(1) Prototypes and reliable gradients of category membership exist for semantic categories in the sense that subjects (American college students) considered it a meaningful task to rate members of such categories according to how well they fitted the subjects' idea or image of the meaning of the category name. There was very high agreement among subjects for these ratings (Rosch & Mervis, 1975).

(2) Members of categories which were considered most prototypical were those with most attributes (features) in common with other members of the category and least attributes in common with other categories. This family resemblance hypothesis was explored through a series of rating experiments (Rosch & Mervis, 1975) and was proposed as an alternative

explanation to the definition of categories in terms of critical features.

(3) The prototypic structure of a category was used in the cognitive processing of a category. The evidence that natural categories are processed in terms of prototype and distance from the prototype was based on two types of studies of retrieval from semantic memory. In the first set of studies, Rosch (1973) asked subjects to judge statements (an x is a y) about category membership. Results showed that it took longer for subjects to respond "true" to the true statements of category membership when member x was a relatively poor member of category y. No such difference occurred for false statements which indicated that the poor members (low typicality) of a category were not in and of themselves difficult to process.

Earlier research (Berlin & Kay, 1969; Heider, 1971, 1972; Mervis, Catlin & Rosch, 1975; Rosch, 1974) has demonstrated that in domains where prototypes are biologically given (e.g. color), categories are formed around the salient prototypes and have elements of content as well as principles of formation which are universal. Unlike color coding, not all categories have an obvious perceptual basis. As Rosch pointed out, it would be unreasonable to assume that humans come equipped with natural prototypes for categories such as Furniture, Fruit and Vehicle. For categories such as these, the content of the categories and the nature of the prototypes can be expected to vary across cultures but the principles of category formation and of the development of prototypes are expected to be universal.

A recent study (Favreau & Segalowitz, Note 4) has provided some evidence for cross cultural similarities and differences in category membership norms. The investigators provided norms for 30 semantic categories collected from 300 native speakers of English and 300 native speakers of French residing in Montreal, Quebec. Subjects were asked to write, in order of preference, the four items which, in their view, best represented the semantic category. Responses under each category were consistent within each linguistic group. Correlations between the first ten responses in each language group revealed some differences in the way English and French speakers defined the category. These differences were attributed to both cultural and linguistic factors.

To date, no study has investigated semantic category membership in bilinguals. If results from word association studies (Dalrymple-Alford & Aamiry, 1970; Kolers, 1963; Lambert & Moore, 1966) are any indication, one would expect to find some differences in the way bilinguals define semantic categories in each language and differences between their definitions and those of monolingual speakers of each language.

Rosch (1975) used a category judgment task to investigate her second major issue, the extent to which the mental representations generated by a category name affected the perceptual encoding of category members. Since both the design of her investigation and her results are pertinent to the present study, they are reported in some detail. Implications of her findings for an investigation of a bilingual's two languages are presented.

Rosch's subjects were shown two category members of either high, medium or low prototypicality. They were to press the same key if the members of the pair belonged to the same category and the different key if the members belonged to a different category. In some experiments (Experiments 2, 3, 7) an orally presented priming stimulus preceded the pairs of pictures or words by an interstimulus interval of 2000 msec. This priming stimulus was a superordinate category name such as WEAPON or VEGETABLE which accurately predicted the same-category membership of stimulus pairs on half the trials. In Experiment 4, the prime was presented (orally) simultaneously with the probes. In Experiment 5, the prime was again the taxonomic category label but subjects were given physically identical rather than same category instructions and were told to press the same key if the two items were physically identical and the different key if they were not. Results, summarized under each of the three conditions, are presented below:

(1) For physically identical pairs, there was a significant interaction between effects of priming and prototypicality. For highly prototypical pairs (e.g. apple-apple), primed trials were significantly faster than unprimed trials; for items of low prototypicality (e.g. nut-nut), primed responses

were significantly slower than unprimed; for pairs of intermediate prototypicality (e.g. cherries-cherries), differences between primed and unprimed trials were not significant. Rosch concluded that the prime facilitated the reaction time to good members because it contained some of the information used to perceive or encode those members. The prime depressed the reaction to low prototypical members because it was sufficiently unlike these members so as to interfere with their perception. The prime influenced the reaction time to physically identical item pairs only when it was presented in advance of the pairs where it could affect encoding. Since in the physically identical condition there was no necessity to make a decision about category membership, the advance prime affected only the encoding stage and not both the encoding and verification stages as in the same and different category conditions. It was this selective effect of prime on the encoding of physically identical items that was of particular interest to Rosch because it provided seemingly unequivocal support for her main thesis.

Rosch investigated the effects of a taxonomic category prime on judgments of physical identity only for monolinguals. One can speculate about the implications of using a similar paradigm to investigate bilingual semantic processing. In the case where category instances in the two languages of the bilingual are being processed, between-language differences, if they exist, could be a function of differences in the semantic representation generated by first and second language category primes. If the second language prime activates fewer associates to the category in comparison to first language primes, this could result in little or no facilitation for high prototypical pairs and little or no inhibition for low prototypical pairs. In this context facilitation means significantly faster responding in language-primed than neutral trials; inhibition means significantly slower responding in language than neutral-primed trials. Alternatively, if the second language prime activates associates more slowly than does the first language prime, this could result in no facilitation of high prototypical pairs at a short SOA and facilitation at a long SOA.

(2) For same category pairs in Rosch's experiment, advance priming facilitated responding in general and was as helpful for intermediate and for low as it was for high prototypical pairs. Rosch explained how the prime differentially affected the encoding and the verification stages resulting in equal facilitation to good and poor members of a category. In the same category case, it can be inferred that at least part of the relevant information in the prime acted on decision processes regarding the stimulus after the stimulus had been made available to the subject. However, due to some inconsistent findings, Rosch was unable to fit the same process model to all her data.

If, in the bilingual situation, the second language prime activates the associates to the category more slowly or activates a more restricted set of associates, between language differences in reaction times would be predicted for low and possibly high prototypicality trials. Where the prime is presented in advance of the probe, at an SOA that is short enough for between-language differences in speed of processing to be manifested, there might be greater facilitation effects for first language trials than for second language trials at high and low prototypicality. If, on the other hand, there is a between-language difference in the number of associates evoked by the prime, then even at an SOA long enough for all associates to be activated, between-language differences in facilitation effects would still be manifested at low and possibly at high prototypicality.

(3) For the different category pairs in Rosch's study, advance priming resulted in facilitation at all levels of goodness-of-example. As was the case with the same category results, Rosch was unable to fit one process model to the data in experiments 2 and 4.

Since the effects on encoding and verification of using a different category prime were unclear in Rosch's results, no predictions are made for the bilingual situation.

A search of the published literature has produced only one study (Caramazza & Brones, 1980) which has used a category judgment task in a bilingual context. The purpose of the study was to determine whether Spanish-English bilinguals had shared or separate semantic memory stores. Three category labels, furniture, fruit and vegetable and their Spanish equivalents were used as primes and six instances (three high and three low prototypical words) in each category comprised the probes. Instances were selected from norms developed by Rosch (1975). A native Spanish speaker confirmed the correspondence in prototypicality between the English and Spanish instances. There were 576 trials with same and different language conditions and high and low prototypicality items randomly assigned to four blocks of trials. Ten subjects were asked to decide whether the instance (e.g. chair) was the same or different from the category prime (e.g. Furniture). The first experiment used an SOA of 2000 msec. The second experiment using eight subjects and simultaneous presentation of prime and probe was performed in order to rule out the possibility of translation within the 2000 msec interval in the first study. Although overall reaction times were faster in the first study, results were similar. As expected there were strong prototypicality effects in both language conditions (same and mixed). More importantly, there were no reaction time differences between the same and mixed language condition in either experiment, thus supporting the hypothesis of shared semantic memory.

There are some similarities between the Caramazza and Brones study and the present research. Like the fluent bilinguals in Experiment 2 of the present investigation, the Caramazza and Brones' subjects were dominant in their first language, having learned their second somewhat later, probably in a school setting. High and low prototypicality items in the Caramazza and Brones study were based on Rosch's norms and were primed by the name of a taxonomic category. The SOA in their first experiment was similar to the long SOA used in the present investigation. Unfortunately the investigators did not report a between-language analysis of results. The 'same' language condition included data from both of the language trials. Differences in reaction times between the stronger and the weaker language would have been compatible with the result of no difference between the same and mixed language condition. Had a between-language analysis been reported, it could have provided evidence for possible between-language differences in speed of processing information.

The purpose of the present study was to investigate whether a taxonomic category prime in the bilingual's second language evoked a more restricted number of associates and whether it evoked associates more slowly than did the prime in the first language. Taxonomic category primes representing common superordinate categories such as Furniture, Toy and so on are ideal for such an investigation. Not only are category instances easily depicted in drawings but subjects are more likely to be familiar with instances (concepts) associated with these categories than they are with concepts labelled by more abstract words.

EXPERIMENT 1

Before attempting to investigate the effects of prime on decisions about category membership, it was necessary to establish subjects' typicality ratings of the drawings with respect to their idea of the meaning of the category name. The categories and many of the items selected were similar to those used by Rosch (1975). Although Rosch used drawings in her experiments, her normative data were gathered on subjects' ratings of words which were only subsequently represented by line drawings. In this study data were gathered on the drawings used as the experimental probes in subsequent experiments.

(In retrospect, obtaining reaction times to picture recognition so as to equate high and low prototypicality items for general latency would have provided a further control. If, for example, reaction times to the recognition of low prototypical pictures were more variable than to the recognition of high prototypical pictures, this would provide an additional source of variability where prototypicality interacted with other factors. Although this precaution has not been taken, to date, in the priming literature, it is one which should be considered in future studies.)

Because of the nature of the investigation, it was necessary to gather normative data from both an English and a French population and to select drawings, from within each of the eight categories, which were given similar ratings by the two linguistic groups.

Method

Subjects:

Twenty English-speaking undergraduate students who indicated very poor comprehension of French and twenty French-speaking undergraduate students who indicated very poor comprehension of English were selected for the study. The subjects, consisting of an equal number of males and females in each group and ranging in age from nineteen to twenty-eight, were paid $1.50 for participating in a thirty-minute testing session.

Materials:

The eight categories (FURNITURE, WEAPON, TOOL, CLOTHING, TOY, VEHICLE, VEGETABLE, BIRD) were selected from among the ten concrete categories used and described by Rosch in her 1975 publication. The categories SPORT and FRUIT were eliminated because the category labels (Fruit-Fruits; Sport-Sports) were similar in the two languages. Since words were to be used as primes in the subsequent experiments, it would have been impossible to determine which language system was being primed. The high and low prototypicality items selected for this study were those used by Rosch (1975). This basic set was extended using Battig and Montague (1969) norms. Only members with very high or very low production frequencies were selected. Simple line drawings representing each of these items were produced on 8.5 x 11 sheets and then photostated. Sample drawings are provided in Appendix A.

In order to ensure nonambiguous membership in a category, a small sorting study was carried out using six subjects who did not participate in the final rating task. Drawings from all the categories were shuffled and subjects were asked to sort the drawings into the eight categories. A few drawings, for example, a roller skate and a blimp, which were assigned as frequently to the category TOY as to the category VEHICLE, were eliminated from the set of stimuli.

In the actual normative study, the results of testing the first eight subjects from each of the language groups revealed that a few items (for example, hockey stick and work-bench) were rated and ranked very differently by the males and females in the sample. In addition, a few items (for example, nail and drill) which were listed as highly prototypical words by Rosch did not behave that way when represented as drawings. Adjustments were made to the original drawings and to the displays and new subjects were selected for the study.

Procedure:

Drawings representing high and low prototypical members of each category were randomly displayed on shelves beneath a sign bearing the appropriate category name. Subjects were tested in groups of no more than three. Each group of subjects received a different random order of categories and of drawings within each category. English subjects were instructed and tested in English; French subjects, in French.

Subjects were asked to complete two tasks with respect to the drawings displayed under each category. They were instructed to rank each set of drawings from most typical to least typical of the meaning of the category term. In addition, they were asked to rate, on a seven-point scale, the extent to which each item represented their idea of the category meaning. A _1_ on the scale indicated a very good representation; a _7_, a very poor representation. The category FRUIT and eight appropriate exemplars of the category were provided for practice in order to determine whether instructions were understood. Subjects then proceeded to rank and then rate the drawings displayed under each category word using a response sheet provided in the appropriate language.

Results and Discussion

The mean rank and mean rating obtained on each drawing selected for use in the priming experiments are listed in Table 1. Results are presented separately for each language group and are further classified by category (Clothing, Furniture, Tool, Toy, Weapon, Bird, Vegetable, Vehicle) and prototypicality (high, low). Assignment to each level of prototypicality was based on results of mean ratings with highest-rated items (closest to 1) placed under high

TABLE 1

Ranking and Rating of Drawings
by English and French Monolinguals

For 20 English Ss			For 20 French Ss		
ITEMS	Mean Rank	Mean Rating	ITEMS	Mean Rank	Mean Rating
CLOTHING					
High			High		
Trousers	1	1.21	Trousers	1	1.45
Dress	2	1.26	Dress	2	1.15
Shirt	3	1.21	Skirt	3	1.45
Skirt	4	1.68	Shirt	4	1.55
Socks	5	2.84	Socks	5	2.20
Shoes	6	4.05	Shoes	7	3.05
Low			Low		
Apron	8	4.32	Apron	8	4.05
Earmuffs	9	6.05	Purse	9	4.80
Purse	10	5.79	Towel	10	5.45
Watch	11	6.68	Watch	11	5.60
Towel	12	6.21	Earmuffs	12	5.35
Ring	13	6.68	Ring	13	6.60
FURNITURE					
High			High		
Chair	1	1.25	Bed	1	1.30
Table	2	1.35	Table	2	1.70
Dresser	3	1.55	Dresser	3	1.75
Bed	4.5	1.30	Sofa	4	1.95
Sofa	4.5	1.30	Chair	5	2.25
Cabinet	6	3.70	Cabinet	7	3.05
Low			Low		
Clock	8	4.80	Clock	8	4.30
Rug	9	5.10	Rug	9	5.15
Picture	10	5.80	Vase	10	5.85
Fan	11	6.45	Picture	11	5.95
Vase	12	6.60	Fan	12	6.30
Shade	13	6.40	Shade	13	6.35

TABLE 1 (Continued)

TOOL

High			High		
Hammer	1	1.05	Hammer	1	1.20
Saw	2	1.50	Saw	2	1.45
Wrench	3	2.10	Screwdriver	3	1.60
Screwdriver	4	1.40	Wrench	4	2.05
Drill	5	2.45	Drill	6	2.30
Sold. Iron	6	3.60	Sold. Iron	7	3.15
Low			Low		
Anvil	7	4.80	Anvil	5	2.85
Nails	8	5.10	Nails	9	3.95
Stapler	9	5.05	Scissors	8	4.10
Paint Br.	10	5.80	Paint Br.	10	4.35
Scissors	11	5.45	Ladder	12	4.95
Ladder	13	5.70	Stapler	13	4.85

TOY

High			High		
Blocks	1	1.45	Blocks	1	2.10
Doll	2	1.55	Doll	2	2.45
T. Bear	3	1.55	T. Bear	3	2.35
Animals	4	1.65	Skip. Rope	4	2.20
Skip. Rope	5	2.90	Animals	5	2.40
Balloon	6	3.45	Balloon	6	3.65
Low			Low		
Football	7	4.20	Football	8	3.90
Swing	9	4.65	Swing	9	3.90
Book	10	5.40	Book	10	4.75
Cards	11	5.90	T. Racket	11	4.60
T. Racket	12	5.80	Cards	12	5.50
Guitar	13	6.70	Guitar	13	5.65

TABLE 1 (Continued)

VEGETABLE

High			High		
Carrots	1	1.05	Carrots	1	1.00
Peas	2	1.95	Peas	3	1.70
Beans	3	2.37	Beans	4	1.85
Corn	4	2.60	Corn	5	2.15
Low			**Low**		
Celery	5	3.10	Celery	2	1.95
Onions	6	3.42	Onions	6	3.10
Mushrooms	7	4.55	Mushrooms	7	3.65
Pumpkin	8	6.45	Pumpkin	8	5.20

VEHICLE

High			High		
Car	1	1.00	Car	1	1.30
Truck	2	1.70	Bus	2	1.40
Bus	3	1.60	Truck	3	2.30
Motorcycle	4	1.70	Motorcycle	4	2.45
Ambulance	5	2.55	Ambulance	5	2.50
Low			**Low**		
Tractor	6	4.10	Tractor	6	3.45
Canoe	7	5.15	Canoe	7	3.20
Wagon	8	4.70	Wagon	8	4.40
Sled	9	5.70	Sled	9	4.65

TABLE 1 (Continued)

WEAPON

High			High		
Pistol	1	1.45	Pistol	1	2.00
Rifle	2	1.40	Rifle	2	1.95
Knife	3	1.90	Knife	3	1.55
Mach. Gun	4	2.50	Mach. Gun	4	2.60
Cannon	6	3.55	Sword	6	3.15
Sword	7	3.40	Cannon	8	3.60
Low			Low		
Whip	9	4.25	Slingshot	7	3.55
Slingshot	10	4.90	Whip	9	3.85
Bottle	11	4.60	Rope	11	4.80
Fist	12	5.05	Fist	12	4.60
Poison	13	5.85	Bottle	13	5.00
Rope	14	5.90	Poison	14	5.35

prototypicality and lowest-rated items (closest to 7) placed under low. Generally, there was good correspondence between the ranking and rating of an item within a language group. There was also strong agreement between language groups on mean ranking and mean rating of items. In the few instances where the mean rating of an item for the English group differed sufficiently from that for the French group so as to make prototypicality assignments somewhat difficult, the decision was based both on the relative size of the difference between ratings of the item by each language group and on the rank. There were only two instances of this within the categories subsequently used in experimental trials. The first was the categorizing of 'soldering iron' and 'anvil' as high and low prototypical tools; the second, the categorization of 'cannon' and 'sling shot' as high and low prototypical weapons. The final decision as to placement of these items was not considered critical given that, in the first two priming experiments, the two bottom items in the high prototypicality list for each category and the two top items in the low prototypicality list were used in warm-up trials only.

Pearson product-moment correlations of mean ratings were obtained (for the English group and for the French group) between halves of the samples of subjects divided randomly. For all categories used in the experimental trials, correlations were above .90.

EXPERIMENT 2

The second experiment was concerned with the investigation of whether, for fluent English-French bilinguals (1) a French taxonomic category word activated semantic associates (associated category members) more slowly than did an English category prime and (2) a French taxonomic category prime activated fewer associates than did the English category prime.

To test these two hypotheses a paradigm similar to that described by Rosch (1975) was used. Trials consisted of neutrally-primed, English-primed and French-primed physically identical, same and different category probes at high and low levels of prototypicality. The eight English taxonomic category labels and their French translation equivalents identified in Experiment 1 were used as primes. The eight French words are familiar to most persons who have even a beginner's knowledge of the language. Unlike Rosch's study where category words were presented orally, the primes in this experiment were presented visually. Drawings rather than words were used as probes because the French names for some of the low prototypical items would be familiar to only the most fluent bilinguals. The experimental trials were presented at three different SOA (stimulus onset asynchrony): 200, 500 and 1650 msec.

Evidence in support of the hypothesis that the French prime activates semantic associates more slowly than an

English prime would be indicated by a between-language difference in facilitation effects (language trials faster than neutral trials) as a function of SOA. Because for all bilingual subjects English was the dominant language, facilitation effects would be predicted for English but not French trials at the short SOA. With increase in SOA and more time for the French prime to activate associates a facilitation effect equivalent to that for English trials would be predicted for high and possibly low prototypical same-category trials. A similar pattern would be predicted for physically identical high prototypical pairs. For physically identical low prototypicality targets no inhibition effects (language trials slower than neutral trials) would be predicted for French-primed trials at the short SOA since there would be insufficient time to activate the representation that would presumably result in such inhibition.

Evidence in support of the second hypothesis that the second language category prime activates fewer associates than does the first language category prime would be indicated by a facilitation for targets at first but not second language primed trials, at each SOA, for at least the low prototypicality same category pairs. If the prime affected the number of associates evoked rather than the speed at which these associates are evoked then an increase in SOA would not be expected to result in an increase in facilitation. For the physically identical condition, evidence that the English but not the French prime activates high prototypical associates would be reflected in facilitation for high prototypical targets for English trials but not for French trials.

Method

Subjects:

Subjects were eighteen native speakers of English who were fluent in French. They were university students who had responded to an advertisement inviting participation in a language experiment.

All students who presented themselves were paid $2.00 to participate in a screening procedure taking a maximum of thirty minutes. Initial selection was based on responses to a brief language background questionnaire and a self-rating scale. Subjects rated their own comprehension, reading and speaking skills in English and in French on a scale of 1 to 7. Subjects who indicated that they had completed at least elementary school in French and for whom there was no more than a two point difference between ratings on English and French skills were tested further.

The second stage of screening consisted of a voice comparison task (Segalowitz, 1977) and a task in French oral expression. In the first task, subjects were asked to read, silently, a one-page story written in English. They then listened to a recording of three native speakers of English attempting to tell the same story in French. Each excerpt had been previously judged by native speakers of French as representing a distinct, non-overlapping level of ability to express ideas in French -- poor expressive ability, expression with hesitancy and expression with the ease of a native speaker. At the end of each excerpt subjects were asked to judge whether their own production, given a similiar situation, would be equivalent to, better or worse than each of the taped speakers. To assess oral proficiency subjects were then asked to describe in French, a sequence of events depicted in a set of cartoons. Their productions were taped and subsequently submitted to a French language specialist who evaluated oral proficiency on a seven point scale where 7 indicated native-like proficiency. Subjects who rated themselves as equivalent to or better than the most advanced taped speaker and who were rated at least 6 with respect to native-like proficiency were retained for the experiment.

Eighteen subjects (9 males, 9 females) who ranged in age from 18 to 26 with a mean age of 20 received $8.00 for participating in the experiment which lasted approximately two and one-half hours.

Materials:

Two types of stimuli, words and line drawings, were used in this experiment. English concrete category words and their French translation equivalents, constituted the language primes; drawings presented in pairs, constituted the probes or targets. These were the drawings which had been previously rated as to prototypicality in Experiment 1. The stimuli used in the experimental condition differed from those used in the practice condition.

Experimental Stimuli: In order to keep the testing session below two and one half hours, only five ~~of the eight~~ categories were tested. The experimental set consisted of 360 word-picture (prime-probe) pairs. The set of primes consisted of five English words (Clothing, Furniture, Tool, Toy, Weapon), five French words (Vêtement, Meuble, Outil, Jouet, Arme) and the nonsense word Bzzz. In addition, four high prototypical and four low prototypical drawings based on each of five categories were used as the experimental probes. These categories and the drawings depicting four high and four low prototypical members of each category were: CLOTHING (trousers, dress, shirt, skirt; earmuffs, watch, towel, ring); FURNITURE (table, dresser, bed, sofa; picture, fan, vase, shade); TOOL (hammer, saw, wrench, screwdriver; stapler, paintbrush, scissors, ladder); TOY (blocks, doll, teddy bear, stuffed animals; book, cards, tennis racket, guitar); and WEAPON (pistol, rifle, knife, machine gun; bottle, fist, poison, rope).

The set of stimuli consisted of 360 prime-probe pairs. There were 120 English category word primes, 120 French category word primes and 120 primes with the nonsense word Bzzz. The probes consisted of paired drawings depicting two items of high or two items of low prototypicality. One quarter of the drawings consisted of physically identical pairs (e.g. table-table) and one quarter consisted of drawings which belonged to the same category but which were not physically identical (e.g. table-bed). The balance of the drawings (half the total pairs) contained items belonging to different categories (e.g. table-doll).

<u>Practice Stimuli</u>: The practice set contained 36 prime-probe pairs which did not appear in the experimental set. Four high prototypicality and four low prototypicality drawings were selected from the category BIRD (sparrow, canary, robin, pigeon, chicken, turkey, peacock, penguin), VEGETABLE (carrots, peas, beans, corn, celery, onions, mushrooms, pumpkin) and VEHICLE (car, bus, truck, motorcycle, tractor, canoe, wagon, sled). There were equal numbers of English, French and neutral primes and equal numbers of same (physically identical and same category) and different category probe pairs.

Each experimental and practice stimulus word was typed in upper case, executive letters and was photographed using a fixed camera so that the word would occupy the middle third of the developed film segment. Each film segment was mounted on a plastic slide. Drawings were photographed in pairs in such a way that each drawing would be centred on the appropriate half of the finished slide.

Design:

The experiment used a 3x3x2 design with within-subject factors of SOA (200, 500, 1650), Prime (English, French, Neutral) and Prototypicality (high, low). The 360 trials were blocked by SOA resulting in six blocks of sixty trials each. Each subject was provided with a different random order of presentation with the constraint that no two consecutive blocks would be presented at the same SOA. Within each of the six blocks, the type of primed trial (English, French, neutral) was presented randomly with no one type of primed trial appearing more than three times in a row. Each block consisted of an equal number of English, French and neutral primes and an equal number of high and low prototypical probes. The same pairs of drawings were exposed at each of the three SOAs and for each of the three primes. Slides were so arranged in a pseudorandom order such that no particular response (hence "same" or "different") was required more than three consecutive times.

Each block was preceded by six warm-up trials consisting of items which were members of the experimental categories but which were not used in the experimental trials. Generally, these drawings were the two bottom members on each high prototypical category list and the two top members on each low prototypical list. Results from these trials were not included in the analysis.

Procedure:

Each of the eighteen subjects was exposed to the same experimental conditions and procedures with the exception of the order of presentation of the six blocks of trials, as explained in the previous section.

Subjects were tested individually in a quiet room. They were informed of the general nature of the reaction time task and the type of response expected of them. They were provided with the names of the eight categories in English and in French. Subjects were informed that their task was to read silently the printed word (English category word, French category word or nonsense word, Bzzz) and to respond to a pair of drawings by pressing the right panel to indicate <u>same</u> if the two items depicted in the drawings belonged to the same category or by pressing the left panel to indicate <u>different</u> if the two items belonged to different categories. Physically identical items were to be considered <u>same</u>. Subjects were instructed to use the fingers of their dominant hand to respond and to rest their hand on the board between the panels after each response. Slides were projected using a three channel projection tachistoscope with shutters controlled by an Apple II microcomputer which also collected reaction times. Slides were advanced manually. Subjects were seated at a fixed distance of four feet from the viewing screen. A thirty-six trial practice session allowed subjects to become familiar with the apparatus and the nature of the judgment expected of them.

The stimulus presentation was as follows. Subjects were given a verbal "ready" signal at the beginning of each block only. The sounds generated by the experimenter's starter key and the shifting of the trays on the projector signaled the onset of each new trial. Subjects viewed a centrally positioned fixation cross for 1500 msec followed by a stimulus word exposed for 150 msec. After an interval of 50, 350 or 1500 msec a pair of drawings appeared on the screen and remained there until the subject terminated the trial by pressing the response key. Subjects' reaction times were recorded from onset of the target pair. Subjects rested between each block as the experimenter changed slide trays and were given a twenty minute break half way through the experiment. A brief interview was conducted at the end of the experiment to inquire into the subjects' strategies and interpretations.

Results

The overall error rate was 3.37% in the English language condition and 3.68% in the French.

Reaction times were subjected to a three-way, repeated measures analysis of variance. Within-subject factors were Prime (neutral, English, French), Prototypicality (high, low) and SOA (200, 500 and 1650 msec). Separate analyses were conducted for physically identical, same category and different category data. A table of means for data in Experiment 2 is found in Appendix B and analysis of variance summary tables are in Appendices C, D and E.

Analysis of data for physically identical stimuli revealed two significant main effects, that of Prototypicality

[F(1,17)=37.23, p<.00] and Prime [F(2,34)=6.11, p<.006]. High prototypical stimuli resulted in significantly faster reaction times than low prototypical stimuli (747 vs. 883 msec). Post-hoc Newman-Keuls tests revealed that neutral primed trials were significantly faster than French-primed (799 vs. 831 msec, p<.01), but not faster than English-primed trials (799 vs. 815 msec, p>.10). The difference between English- and French-primed trials was not significant. These main effects were qualified by a significant two-way Prototypicality by Prime interaction [F(2,34)=21.88, p<.001] depicted in Figure 1. Post-hoc Newman-Keuls tests revealed that with high prototypicality, reaction times to English- and French-primed trials were significantly faster than to neutral trials (729 vs. 771 msec, p<.05 and 740 vs. 771 msec, p<.05) and, conversely, at low prototypicality, reaction times to neutral trials were significantly faster than to English- and French-primed trials (826 vs. 901 msec, p<.01 and 826 vs. 921 msec, p<.01). There was no significant effect of SOA either alone or in interaction with the other variables.

Analysis of data for same category stimuli revealed two significant main effects. Prototypicality was highly significant [F(1,17)=76.73, p<.001] with reaction times to high prototypicality pairs faster than to low prototypicality pairs (944 vs. 1458 msec). The main effect for Prime was also significant [F(2,34)=45.21, p<.001]. Post-hoc Newman-Keuls tests revealed a significant difference between neutrally-primed trials and English-primed trials (1348 vs.

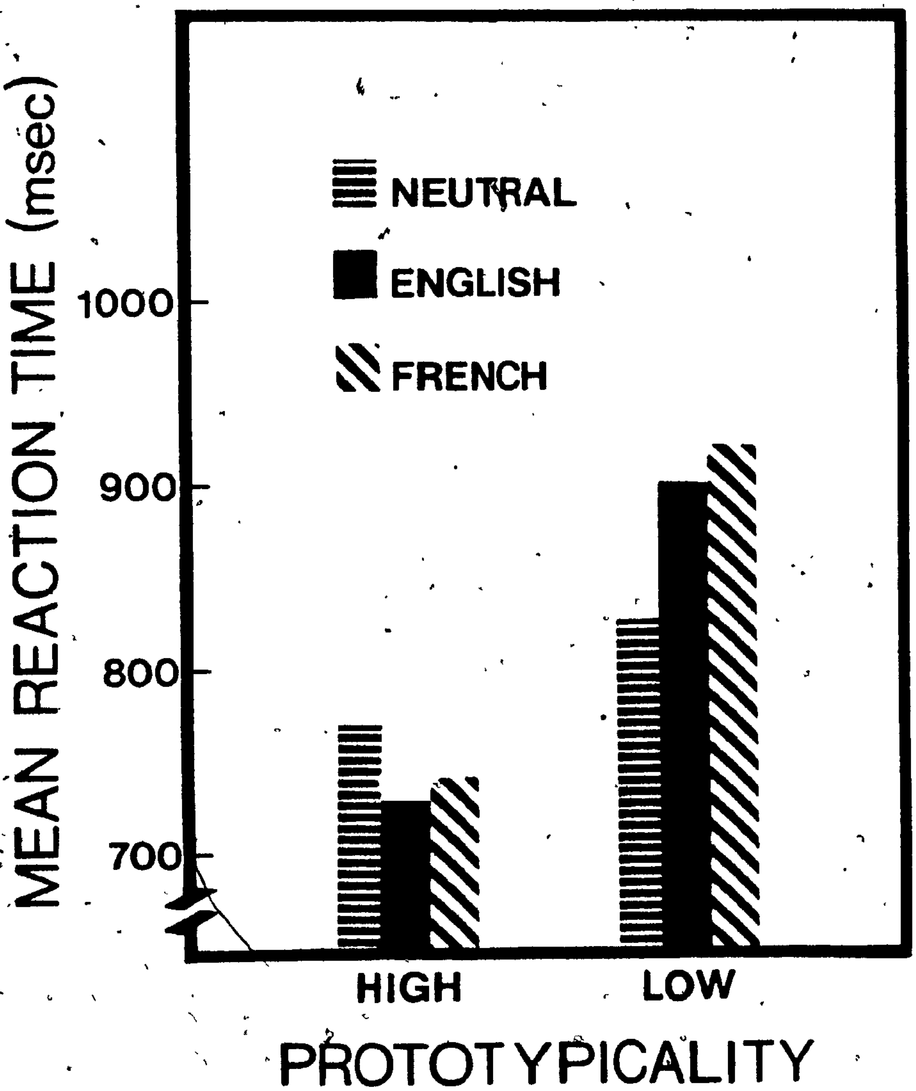


Figure 1. Mean reaction times for physically identical items as a function of prime and prototypicality in Experiment 2.

1150, p<.01) and between neutrally-primed trials and French-primed trials (1348 vs. 1181 msec, p<.01). The main effect for prime was qualified by one significant interaction, SOA by Prime, [F(4,68)=2.74, p<.04]. As may be seen in Figure 2, SOA differently affected type of prime. Whereas for English-primed trials post-hoc Newman-Keuls tests revealed that none of the differences between means for SOA reached significance (1115 vs. 1134 vs. 1163 msec, p>.10), for French-primed trials reaction times at 500 SOA were significantly faster than at 1650 (1116 vs. 1230 msec, p<.05) and at 200 (1116 vs. 1196 msec, p<.05). In addition, for neutrally-primed trials, reaction times at 200 SOA were significantly faster than at 500 SOA (1279 vs. 1373, p<.05) and at 1650 SOA (1279 vs. 1391 msec, p<.05). Post-hoc analyses of reaction times at each SOA revealed a difference, significant at least at .05, between English and neutral and between French and neutral trials. There was no significant difference between English- and French-primed trials at each of the SOAs.

For different category pairs the ANOVA yielded only one significant main effect, Prototypicality [F(1,17)=24.84, p<.001], where responses to high prototypical pairs were faster than to low (1224 vs. 1505 msec). None of the interactions reached significance.

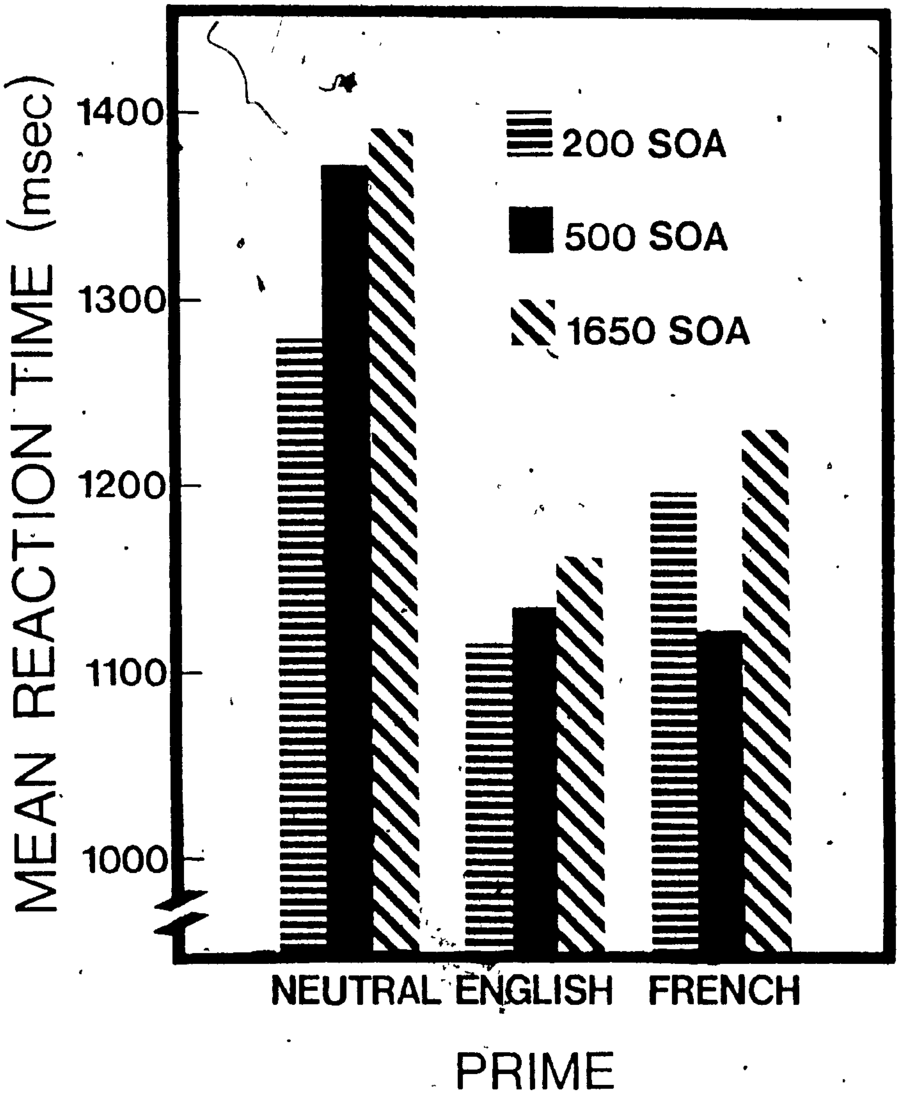


Figure 2. Mean reaction times for same category items as a function of SOA and prime in Experiment 2.

Discussion

The most important result of this experiment was that, for physically identical, same category and different category conditions in a category judgment task, the effect of priming with a French taxonomic category label was similar to that obtained when priming with an English translation equivalent. In effect, the data did not reveal any between-language differences which could be attributed to factors proposed in the two hypotheses specified in the general introduction and in the introduction to this experiment. The results of this experiment, which are discussed below, replicated those reported by Rosch (1975) in investigations with monolingual speakers of English and extended her findings to the second language of the fluent English-French bilingual.

The main results for the physically identical condition are depicted in Figure 1. Priming, whether with an English or a French category word, facilitated responses to items of high prototypicality and inhibited responses to items of low prototypicality. Evidence for facilitation at high prototypicality was indicated by the result that reaction times to language-primed trials were significantly faster than to neutral trials. Conversely, at low prototypicality, an inhibition effect was indicated by the finding that reaction times to neutral trials were significantly faster than either to English-primed or to French-primed trials. The differential effect of the prime on physically identical stimuli would seem to lend support to an interpretation by Rosch (1975) that the representation of a superordinate semantic category contains information that is more like the high than the low prototypical members of the category. An alternative interpretation for these and similar findings in the third experiment is developed in the final chapter.

For same category pairs, priming facilitated responding in general and French language primes were as helpful to high and low prototypcality pairs as were English language primes. The size of the facilitation effect (the difference between language-primed and neutral trials) was over four times as great for same category high prototypical pairs as compared to physically identical high prototypical pairs. A similar comparison can be made for low prototypical pairs. In the case of physically identical pairs, the facilitation effects of the related prime have been attributed to effects at encoding (Rosch, 1975). For same category pairs, the substantial facilitation could be attributed to effects on encoding as well as on post-encoding processes.

Another result for same category pairs which requires explanation is the SOA by Priming interaction depicted in Figure 2. The fact that for English-primed trials there were no significant reaction time differences between SOAs, coupled with the finding that the English prime was equally facilitating at all SOAs for high and low prototypical items, would seem to indicate that equivalent processing was in effect at all SOAs. For neutral trials, the significantly slower reaction times at the two longer SOAs compared to the short SOA would seem to indicate that the neutral prime did generate certain expectations which, given sufficient time, tended to slow overall reaction time. Although none of the differences reached significance, a trend to slowing of reaction time with each increase in SOA was evident for physically identical, same category and different category results for language and neutral trials. This could be interpreted as reflecting the increasing involvement of strategic processes with strategic processes more fully operative at the longest SOA. The one major exception was the French-primed same category condition where reaction time at the intermediate SOA was significantly faster than at either the longest or the shortest SOA. No explanation of this result can be suggested at this time.

For the different category conditions, responses to high prototypicality pairs were faster than to low prototypicality pairs. This result was consistent with that found by Rosch (1975). One would expect that verification (in the case of language-primed trials) and retrieval (in the case of neutral trials) would be faster for items which could be readily identified as members of other categories than for items whose category affiliation was more difficult to ascertain.

The most important conclusions based on the results of Experiment 2 can be summarized as follows. For fluent English-French bilinguals, associates activated by French category primes were similar to those activated by English category primes in the sense that there was equal facilitation in the encoding and verification of category members in a category judgment task. In addition, failure to find an interaction between the language condition and either prototypicality or SOA would seem to indicate that there was no between-language difference in the number of associates activated nor in the speed with which these associates were activated. In effect, neither of the hypotheses put forward at the beginning of the experiment were upheld. If the structure of semantic memory does influence the processing of information in this category judgment task, then there appears to be no between-language differences in the structure of concrete category information in the semantic memory of fluent bilinguals.

It might be possible to reveal between-language differences by using as subjects moderately fluent bilinguals who have learned their second language through the translation methods of the second language classroom and who have had limited experience with the language outside the school situation. If, as suggested by Taylor (1974), learning a second language through translation methods can result in associates to the first language concept becoming activated when the second language concept is evoked, then one might predict no between-language differences in reaction-times, at least at the longest SOA. If, as suggested by Kolers (1963), similar experiences with concepts in the two languages evoke similar associations, then one might predict, for individuals who have limited experience with the second language, between-language differences in reaction times and in facilitation/inhibition effects which might be attributed to differences in the number of associates activated and/or to the speed of activation.

EXPERIMENT 3

This experiment attempted to determine whether the predictions made for the more fluent bilinguals in Experiment 2 would apply to individuals whose dominant language was English but who were less fluent in French than the subjects who participated in Experiment 2. Subjects at this level of fluency probably represent the most typical bilingual in North American society. Their initial second language learning took place in a classroom, probably through a program emphasizing direct translation and drill. At their present level the subjects perceived themselves as having mastered the "basics" and as needing to develop a more extended vocabulary and to improve syntax. (In fact, in a brief questionnaire administered at the end of this experiment, most subjects were confident that they had produced a balanced performance on what they perceived as a simple bilingual task.) Although simple skills tend to be neglected as learners and instructors focus on more complex language operations, it is the simple decoding and encoding operations which are the real "basics". If, for example, nonfluent bilinguals cannot decode quickly in their second language, this has implications for trying to follow a normal conversation or even a simple lecture.

Method

Subjects:

Subjects who participated in this experiment were English first language university students whose level of French fluency was substantially below that of subjects selected for the previous experiment. The selection procedure was similar to that used in Experiment 2. Subjects were paid $2.00 for participating in the screening procedure and were selected on the basis of the following criteria. (1) schooling in French as a Second Language (FSL) consisting of approximately forty minutes a day from grade four to secondary five and no more than three post high school French courses; (2) a discrepancy of either 3 or 4 points between self ratings of English and French language skills; (3) ability to express ideas in French perceived equivalent to that of the intermediate speaker on the story telling sequence and; (4) a rating of 3 or 4 on the seven point scale of French expression.

Eighteen subjects ranging in age from 18 to 27 with an average age of 21 were retained for the experiment. Each received $8.00 for approximately two and one-half hours of participation.

Materials:

The stimuli and presentation order were the same as used in Experiment 2.

Design:

The same 3x3x2 design was used in this study as was used in Experiment 2.

Procedure:

The procedure was the same as that followed in the second experiment.

Results

The error rate was 3.56% for the English language condition and 4.78% for the French language condition.

Reaction times were subjected to a three-way, repeated measures analysis of variance. Within-subject factors were Prime (neutral, English, French), Prototypicality (high, low) and SOA (200, 500, 1650 msec). Separate analyses were conducted for physically identical, same category and different category pairs. A table of means can be found in Appendix F and summary ANOVA tables in Appendices G, H and I.

Analysis of data for physically identical stimuli revealed a significant main effect for Prototypicality [$F(1,17)=48.49$, $p<.0001$], with reaction times to items of high prototypicality faster than to items of low (790 vs. 898 msec). The main effect for SOA was just short of significance [$F(2,34)=3.22$, $p=.052$]. The main effect for Prototypicality was qualified by a significant interaction between Prototypicality and Prime [$F(2,34)=11.66$, $p<.001$] which is depicted in Figure 3. For high prototypical items post-hoc Newman-Keuls tests revealed that reaction times to neutrally-primed stimuli were significantly slower than to English-primed (821 vs. 767, $p<.05$) and to French-primed (821 vs. 782, $p<.05$) stimuli. At low prototypicality, the order of reaction times was reversed with reaction times to French-primed stimuli significantly slower than to neutral stimuli (924 vs. 861, $p<.01$), and with reaction times to English-primed stimuli intermediate as to speed and significantly different from neutral trials (908 vs. 861, $p<.05$).

The main effect for Prototypicality was further qualified by a second interaction, that of Prototypicality by SOA depicted in Figure 4 was also significant [$F(2,34)=4.36$, $p<.025$]. The Newman-Keuls test revealed that for highly prototypical items, the mean reaction time at 1650 SOA was significantly slower than that at 500 SOA (820 vs. 765, $p<.05$). Other tested comparisons at high prototypicality did not reach significance. For low prototypicality items, the Newman-Keuls test revealed a significant difference between each paired comparison. Mean reaction time at 200 SOA was significantly faster than that at 500 (844 vs. 894, $p<.05$) and at 1650 SOA (844 vs. 954, $p<.01$). The difference between reaction times at 500 and 1650 SOA was also significant (894 vs. 954, $p<.01$) as was the difference ($p<.01$) between high and low prototypicality pairs at 200 (784 vs. 844 msec), at 500 (765 vs. 894 msec) and at 1650 (820 vs. 954 msec).

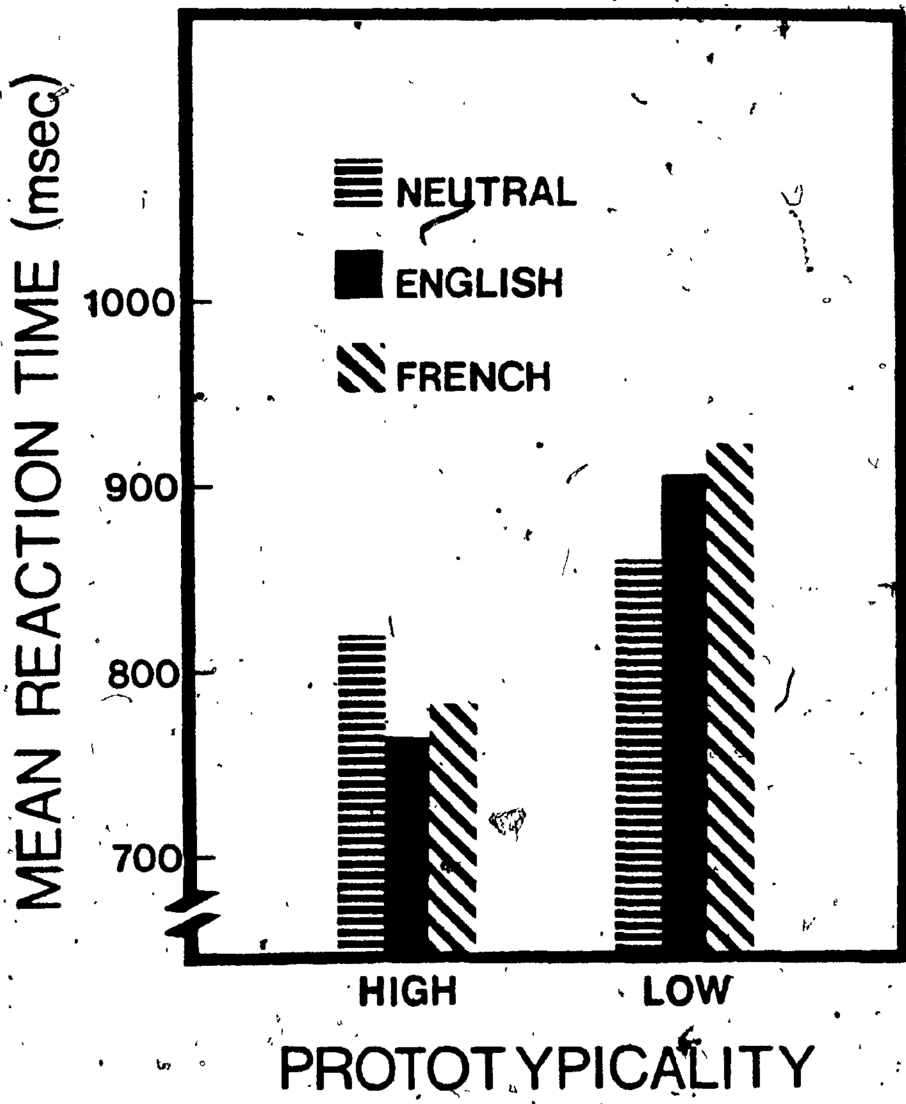


Figure 3. Mean reaction times for physically identical items as a function of prime and prototypicality in Experiment 3.

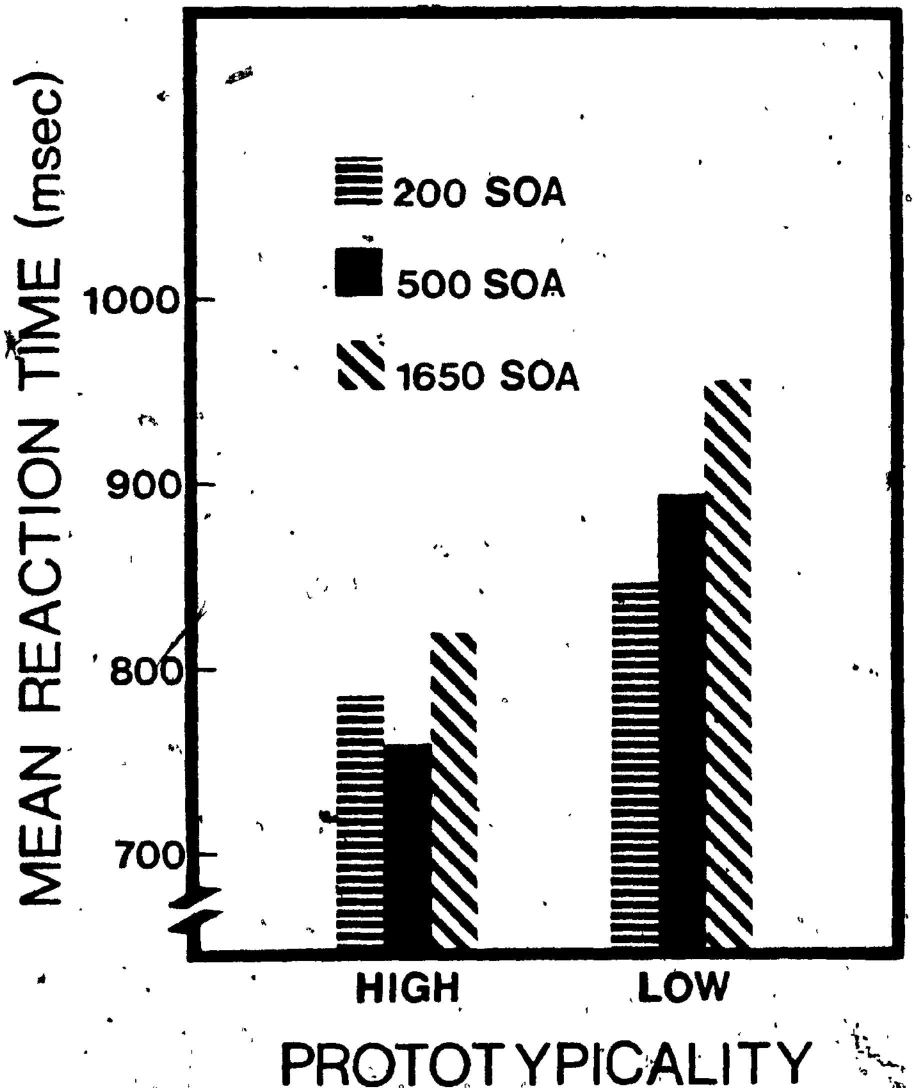


Figure 4. Mean reaction times for physically identical items as a function of SOA and prototypicality in Experiment 3.

The analysis of data for same category stimuli yielded two significant main effects, that of Prototypicality [$F(1,17)=42.45$, $p<.001$] and Prime [$F(2,34)=35.93$, $p<.001$]. The post-hoc Newman-Keuls revealed that the differences in mean reaction time between total neutral trials and both total English trials (1386 vs. 1137) and total French trials (1386 vs. 1255) were significant ($p<.01$). Also significant was the difference between English-primed and French-primed trials (1255 vs. 1137, $p<.01$). The two main effects were qualified by one significant interaction, that of Prototypicality by Prime [$F(2,34)=4.30$, $p<.025$], depicted in Figure 5. For high prototypical items, post-hoc Newman-Keuls tests revealed that reaction times to English- and French-primed stimuli were significantly faster then to neutral stimuli (924 vs. 1150, $p<.01$; 956 vs. 1150, $p<.01$, respectively). The difference in reaction time between language-primed trials was not statistically significant. At low prototypicality, the Newman-Keuls procedure revealed a significant difference between English and French trials (1350 vs. 1553, $p<.01$) and between English and neutral trials (1350 vs. 1623, $p<.01$). At this level, and unlike the results at high prototypicality, the difference between neutral and French trials was not significant. The difference in reaction time between high and low prototypical trials for each prime, Neutral (1150 vs. 1623 msec), English (924 vs. 1350 msec) and French (957 vs. 1553 msec) was significant ($p<.01$).

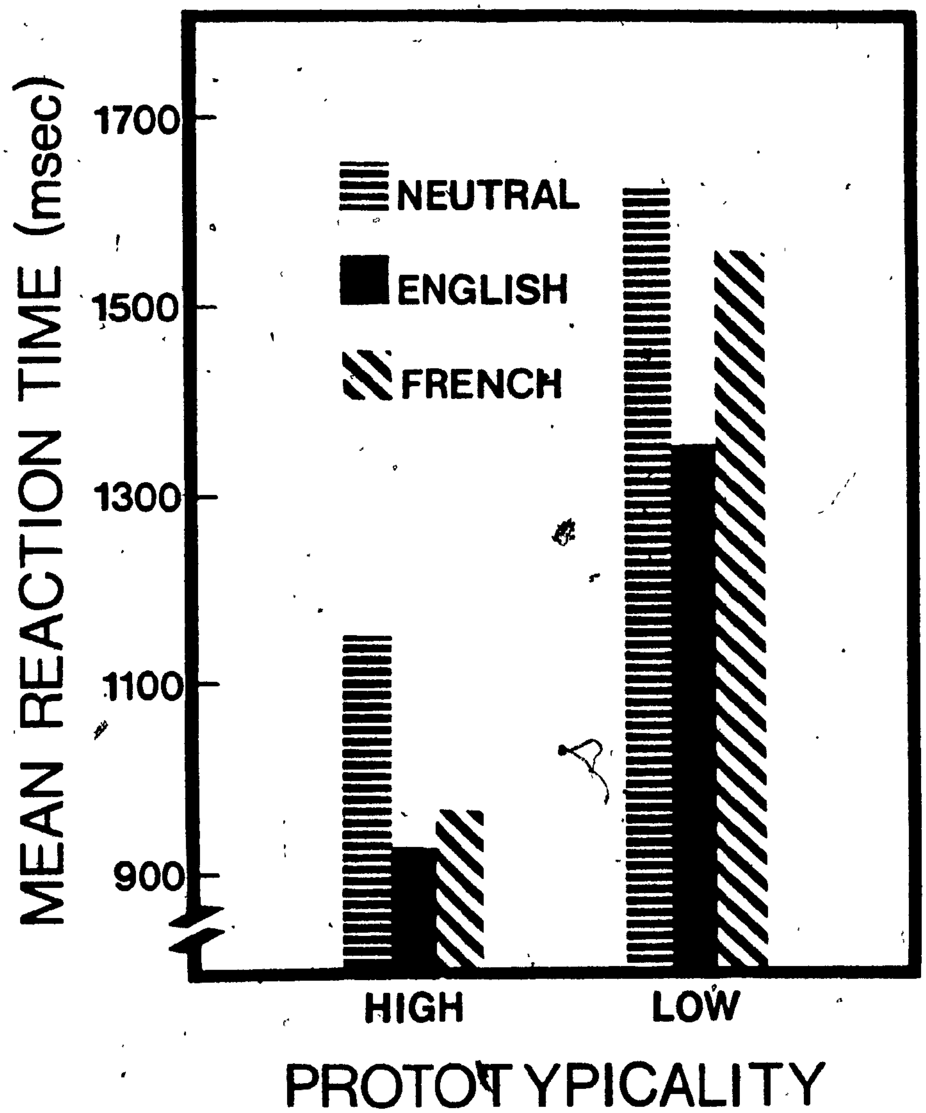


Figure 5. Mean reaction times for same category items as a function of prime and prototypicality in Experiment 3.

For different category pairs, the ANOVA yielded a significant main effect for Prototypicality [$F(1,17)=89.12$, $p<.001$] with reaction times to high prototypical pairs faster than to low prototypical pairs (1210 vs. 1469 msec). The only other significant result was that of the main effect for Prime [$F(2,34)=4.81$, $p<.02$] where neutral trials were significantly slower than English trials (1373 vs. 1301 msec, $p<.05$).

Discussion

In this experiment, the most important result was that obtained for the same category condition. In brief, the effect of priming with a French category word was similar to that obtained with an English prime at high prototypicality but not at low. The result at low prototypicality, a facilitation effect for English-primed but not for French-primed trials, differed from that obtained in Experiment 2 and provided evidence which was interpreted as support for a between-language difference in either the speed at which associates of the prime were activated or the number of associates activated by the prime. For the different category condition, facilitation occurred for English but not for French-primed trials. This result differed from that in Experiment 2 where the difference in reaction time between each language condition and the neutral condition was large (although just short of significance). In the physically identical condition, results, for the most part, paralleled those obtained in Experiment 2.

For physically identical trials, the result of major interest, the Prototypicality by Prime interaction, is depicted in Figure 3. Both English and French trials produced a facilitation effect for items at high prototypicality and an inhibition effect at low prototypicality. This pattern was similar to that obtained in Experiment 2 and to that in the investigation by Rosch (1975). These results will be considered at length in a final, general discussion.

The significant Prototypicality by SOA interaction for physically identical pairs depicted in Figure 4 added a new dimension to the interpretation of results. As revealed in Figure 4, reaction times tended to increase as a function of SOA and the difference between reaction times at low prototypicality was greater than the difference at high. In other words, the longer the time interval between prime and probe, the slower the reaction time, with slowing more evident at low than at high prototypicality. The slower reaction times at the longer SOA could reflect the greater involvement of strategic processes. The more time between presentation of prime and presentation of probes, the more time available for expectations to operate.

It is possible that the faster reaction times observed at the shortest SOA reflect the effect of automatic processing of the prime. Although the difference in reaction time between high and low prototypical trials was significant at each SOA, the difference was less marked at 200 SOA. This result and the overall faster reaction times at the shortest SOA could reflect the automatic component of processing. This SOA by Prototypicality interaction had a parallel in the results of Experiment 2, although the interaction fell short of significance.

In the different category condition, the significantly faster reaction times to high prototypicality items compared with low was similar to the result obtained in Experiment 2 and to that reported by Rosch (1975). A result which differed from that obtained in Experiment 2 and which required explanation was that English-primed but not French-primed trials were significantly faster than neutral trials. In effect, there was facilitation for English but not for French trials. Although Rosch did find that a language prime facilitated decisions in the case of different category probes, given that she was unable to separate the effect on encoding and postencoding processes, she did not pursue these results.

The most important result for the same category condition is depicted in Figure 5. In the case of high prototypical pairs, there was equal facilitation for English and French-primed trials. At low prototypicality, it took significantly longer to verify category membership for French compared to English-primed trials. It is this lack of facilitation which requires explanation.

It is possible that, unlike the English language prime, the French prime did not activate the associates required to provide a savings in retrieval time at low prototypicality or that more time was required between the presentation of prime and probe in order to generate these associates. Given that the French prime activated high prototypicality associates as quickly as did the English prime even at the shortest SOA, it would appear unlikely that the longest SOA did not provide enough time for activation from the prime to spread along relational paths. Although at this point evidence is not clear cut, one explanation for the between-language difference could be that more associates are activated by the word Furniture than by the word Meuble resulting in faster convergence with associates activated by the unit representing a low prototypicality probe. Clearly, additional evidence is needed here.

The between-language difference in error rate was small. It could be, however, that the design of the experiment reduced the possibility of error while at the same time slowing reaction times to French-primed trials. In same category trials, when one of the item probes could be identified as a member of the category given by the word prime, the second item was necessarily a member of that same category. In the same way, for different category trials, where one of the items of the pair was identified as a nonmember, the other item was necessarily a member of a different category. Consequently, when there was some indecision about the category membership of one of the items, the verification of the second item with the category prime was sufficient for deciding on a correct response. Such slowing of verification may have occurred more frequently for French-primed trials (presumably because the French category would be comprised of a different or more restricted set of low prototypicality members) resulting in longer verification times but little difference in error rate. The design used in Experiment 4 precluded the possibility of such a check.

In summary, the major findings of this experiment are based on results for the same category condition. For English-French bilinguals who are moderately fluent in their second language, French primes activated semantic associates which appeared to correspond to the high prototypical associates activated by corresponding English primes. With regard to between-language differences on low prototypical trials, there was no strong evidence to distinguish whether the French primes activated fewer associates than English primes or whether they activated associates similar to those of English primes but did so more slowly. Experiment 4 was designed to investigate further the questions related to these issues.

EXPERIMENT 4

In Experiment 3, facilitation effects were obtained for high but not low prototypical same category stimuli. The results were interpreted as indicating that the French prime activated as many high prototypical associates as did the English prime and did so with equivalent speed. For low prototypical stimuli, priming with a French prime did not produce a facilitation effect at even the largest SOA. A result of facilitation at the largest but not the smallest SOA would have been interpreted as suggesting a between-language difference in the speed at which associates of the prime were processed but no difference in the number of associates activated by the prime. The obtained result did not permit such a distinction. Experiment 4 was designed to replicate Experiment 3 using a different paradigm and an extended set of high and low prototypical items. In addition, the design permitted investigation of two new hypotheses based on assumptions of the extended spreading activation model.

Experiment 4 used a category judgment task where critical stimuli were presented at three lags, that is, an initial presentation of a same category prime-probe pair was followed after 0, 1 or 2 intervening filler different category pairs by the presentation of the second critical same category prime-probe pair. The purpose of this experiment was to investigate whether (1) the French category word activated associates to the prime more slowly than did the English category word, (2) the French concrete category contained fewer associates than did the English concrete category, (3) the presentation of a category name in a second language would increase accessibility of the more distant memory locations making information retrieval easier when the category name was repeated in a subsequent trial, (4) the decline in facilitation over time would be more rapid for French than for English trials.

The experiment consisted of a same and different category condition. In the same condition, a category word in either French or English was paired with one drawing depicting an item which was either a high or a low prototypical category member. For example, the category label Furniture was paired with a drawing of a table in the high prototypicality condition and with a drawing of a fan in the low. In the different condition, the item was not a member of the category with which it was paired. The category label Furniture, for example, was paired with a drawing of a dress in the high condition and with a ring in the low. All the different category trials served as the filler trials between same category presentations at each lag. Subjects were randomly assigned to two SOA conditions -- 200 and 1650 msec.

The design of the experiment eliminated the possibility of using the checking strategy referred to in Experiment 3 and reduced the number of trials to which the subject was exposed. In addition, enlarging the set of high prototypical items to include items that were rated as more intermediate in prototypicality could result in revealing the between-language differences in the facilitating effect of the prime that the use of the very highly prototypical items in Experiment 3 could not.

Evidence in support of the first hypothesis that the French category prime activated associates more slowly than did the English prime would be revealed by a significant difference between language trials at 200 but not at 1650 SOA. Evidence in support of the second hypothesis that a French prime activated a more restricted meaning (hence fewer associates) than did an English prime would be indicated by a between-language difference in reaction time for high as well as for low prototypicality trials. Evidence in support of the third hypothesis, that information retrieval from memory locations would be easier following the repetition of a French category name, would be indicated by a facilitation effect where mean reaction time at the shortest lag would be significantly faster than baseline (initial presentation). Evidence in support of the fourth hypothesis specifying a more rapid decline in facilitation of French compared to English trials would be indicated by a between-language difference in the effect of lag.

Method

Subjects:

The subjects were thirty-six university students whose first language was English and whose command of French was equivalent to students at an intermediate level of fluency. In fact, twenty-one of the thirty-six subjects were in the process of taking an intermediate level course in French as a second language and the balance had completed the course in a previous semester. Students who responded to the advertisement for subjects were paid $2.00 for participating in the screening session. The procedure for selecting the subjects was similar to that used in the first two experiments.

The subjects (18 females, 18 males) ranged in age from 18 to 25 with a mean age of 20. All received $5.00 for their participation, which lasted for about one and one-half hours.

Materials:

For the most part the stimuli used in this experiment were similar to those used in Experiments 2 and 3. The same concrete category labels were used as primes. Probes (targets) consisted of a single drawing rather than the pair of drawings used in the previous experiments. The design necessitated an increase in the pool of items used in the experimental trials. Consequently, drawings used in the warm up trials in Experiments 2 and 3 and for which prototypicality ratings were available were included in the experimental set and new drawings were generated for the practice set.

Experimental stimuli: The set of primes consisted of five English category words (CLOTHING, FURNITURE, TOOL, TOY, WEAPON) and their French equivalents (VETEMENT, MEUBLE, OUTIL, JOUET, ARME). Six high and six low prototypical drawings depicting members of the five experimental categories were used as probes. These categories and associated drawings were: CLOTHING (trousers, dress, shirt, skirt, socks, shoes; earmuffs, watch, towel, ring, apron, purse); FURNITURE (table, dresser, bed, sofa, chair, cabinet; picture, fan, vase, shade, clock, rug); TOOL (hammer, saw, wrench, screwdriver, drill, soldering iron; staples, paintbrush, scissors, ladder, anvil, nails); TOY (blocks, doll, teddy bear, stuffed animals, skipping rope, balloon; book, cards, tennis racket, guitar, football, swing) and WEAPON (pistol, rifle, knife, machine gun, cannon, sword, bottle, fist, poison, rope, whip, slingshot).

The set of stimuli consisted of 240 prime-probe pairs. Probes were primed equally frequently by English category labels and by French category labels. Half of the probes were drawings of high prototypicality, half of low. For one-half the prime-probe combinations, the drawing depicted an item that was a member of the category labelled by the prime (e.g. Furniture-table); for the other half, the drawing depicted an item that was a member of another category (e.g. Furniture-dress).

Practice Stimuli: The practice set contained 12 prime-probe pairs from the three categories which did not form part of the experimental set. There was an equal number of English and French category words. Two high and two low prototypical items were randomly selected from the category BIRD (robin, canary, penguin, turkey), VEGETABLE (peas, corn, celery, mushrooms) and VEHICLE (bus, car, ambulance, canoe).

Design:

The experiment used a 2x2x4x2 design with within subject factors of Prime (English, French), Prototypicality (high, low) and Presentation (Baseline, lag 0, lag 1, lag 2) and SOA (200, 1650 msec) as a between-subject factor. The experimental stimuli were presented in five blocks of 48 trials per block. There was an equal number of same and different response trials. The same category trials were presented in a special order within each block. The initial presentation of a taxonomic category label paired with its representative item was followed, after 0, 1 or 2 intervening filler items, by the presentation of the same category label as in the initial trial paired with an item at the same level of prototypicality. Reaction times to presentations of category words initiating the lag sequences served as baseline data against which reaction times at each lag were compared. Subjects received 60 baseline trials, 20 trials at each of the three lags and 120 filler trials for a total of 240 trials. The filler trials presented a pairing of a category word and a high or low prototypicality item which was not a member of the category and which were responded to as "different".

Six versions of each block were developed in order to ensure complete counterbalancing. Each item appeared in baseline trials, in all levels of lag, in all combinations of baseline and lag trials, and these combinations were the same for English and French trials. English and French primes were mixed within blocks. Language primes were not mixed across lags. Six subjects were assigned to each version. Since each version consisted of different paired combinations, it was necessary to test all six subjects before rearranging slides. Three subjects were randomly assigned to the 200 msec SOA condition and three to the 1650 msec SOA condition. Each subject received a different presentation order of the five blocks.

Each block was preceded by five warm-up trials which consisted of items which were members of the experimental categories but not used in the actual experiment nor included in the analysis of results.

Procedure:

Thirty-six subjects were randomly assigned to SOA conditions and to a random order of presentation within that condition as explained in the previous section.

The procedure followed at each testing session was consistent with that described in Experiment 2. Instructions to subjects were modified so as to accommodate the single picture presentation. In brief, the stimulus presentation was as follows: Subjects viewed the fixation point for 1500 msec followed by the stimulus word for 150 msec. An interval of either 50 or 1500 msec preceded the onset of the picture which remained exposed until subjects terminated the trial by pressing the response key. Reaction times were recorded from onset of target. Subjects were given a ten minute rest period between the third and fourth block presentation and were asked to respond to a few questions prior to debriefing.

Results

Overall error rate for the English language condition was 3.16% and for the French language condition 3.65%.

As explained in the design section, each same category sequence was initiated by the presentation of a category word and a representative probe. This trial was followed, as appropriate, by either two, one or no filler (different category) items and, finally, by the lag trial which was a pairing of the category word presented in the initial trial with a new picture probe. In effect, each lag trial was preceded (either immediately or after an interposition of one or two filler items) by its own initial presentation trial.

In order to determine whether there was a significant difference between initial presentation trials preceding each of the three lags, a one-way analysis of variance was performed at each SOA, for English and French trials separately at each level of prototypicality. None of the differences reached significance permitting pooling of the three initial presentation means at each level of prototypicality and language for each SOA group of eighteen subjects. These eight averages were used as the baseline data in subsequent analyses.

Reaction times for same category data were subjected to a four-way analysis of variance with three within-subject factors, Prime (English, French), Prototypicality (high, low) and Presentation (Baseline, Lag 0, Lag 1, Lag 2) and one between-subject factor, SOA (200, 1650 msec). Different category data were subjected to a three-way analysis of variance with two within-subject factors, Prime (English, French) and Prototypicality (high, low) and one between-subject factor, SOA (200, 1650 msec).

Analysis of data for same-category stimuli revealed three significant main effects. The main effect for Prototypicality [$F(1,34)=243.55$, $p<.001$] was significant in the expected direction of high faster than low (876 vs. 1131 msec). The main effect for Language was also significant [$F(1,34)=38.91$, $p<.001$] with English language trials faster than French (943 vs. 1064 msec). The third main effect, Presentation, was significant [$F(3,102)=29.24$, $p<.001$]. The Newman-Keuls procedure revealed that differences between each pair of means was significant at least at $p<.05$. The difference between reaction times at 200 and 1650 SOA did not reach statistical significance.

The three main effects, Prototypicality, Language and Presentation were qualified by four significant interactions. The Prototypicality by Language interaction [$F(1,34)=7.47$, $p<.01$] is depicted in Figure 6. The Newman-Keuls test revealed that the difference between English and French trials was significant at both high prototypicality (837 vs. 915 msec, $p<.01$) and low (1048 vs. 1213 msec, $p<.01$). As expected, the reaction time difference between high prototypicality and low for English-primed trials (837 vs. 1048 msec) and for French-primed trials (915 vs. 1213 msec) was significant ($p<.01$). Although all pairwise comparisons of means differed significantly, the results were non-parallel in the sense that the pattern for the two levels of the language factor differed at each level of the prototypicality factor.

A second significant interaction, Language by Presentation [$F(3,102)=2.88$, $p<.04$] is depicted in Figure 7. For English trials, application of the Newman-Keuls procedure resulted in six significant differences with four of the six significant at $p<.01$. Results of principal interest were as follows: Baseline (1021 msec) vs. Lag 0 (866 msec), $p<.01$; Baseline (1021 msec) vs. Lag 1 (912 msec), $p<.01$; Baseline (1021 msec) vs. Lag 2 (973), $p<.05$. In addition, the difference between Lag 2 and Lag 1 and between Lag 1 and Lag 0 was significant ($p<.01$). For French trials, a major result was the difference between Baseline (1106 msec) and Lag 0 (992 msec) which reached significance ($p<.01$). The mean reaction time for Baseline was close to that of Lag 2 and Lag 1 and

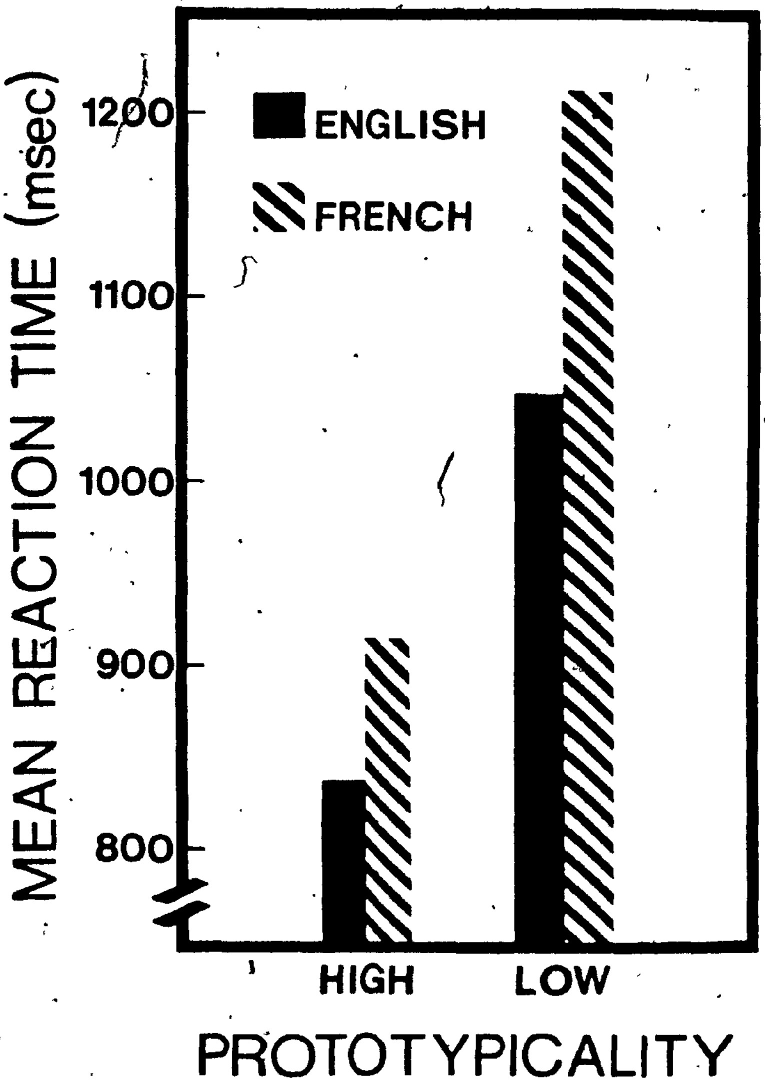


Figure 6. Mean reaction times for same category items as a function of prototypicality and language in Experiment 4.

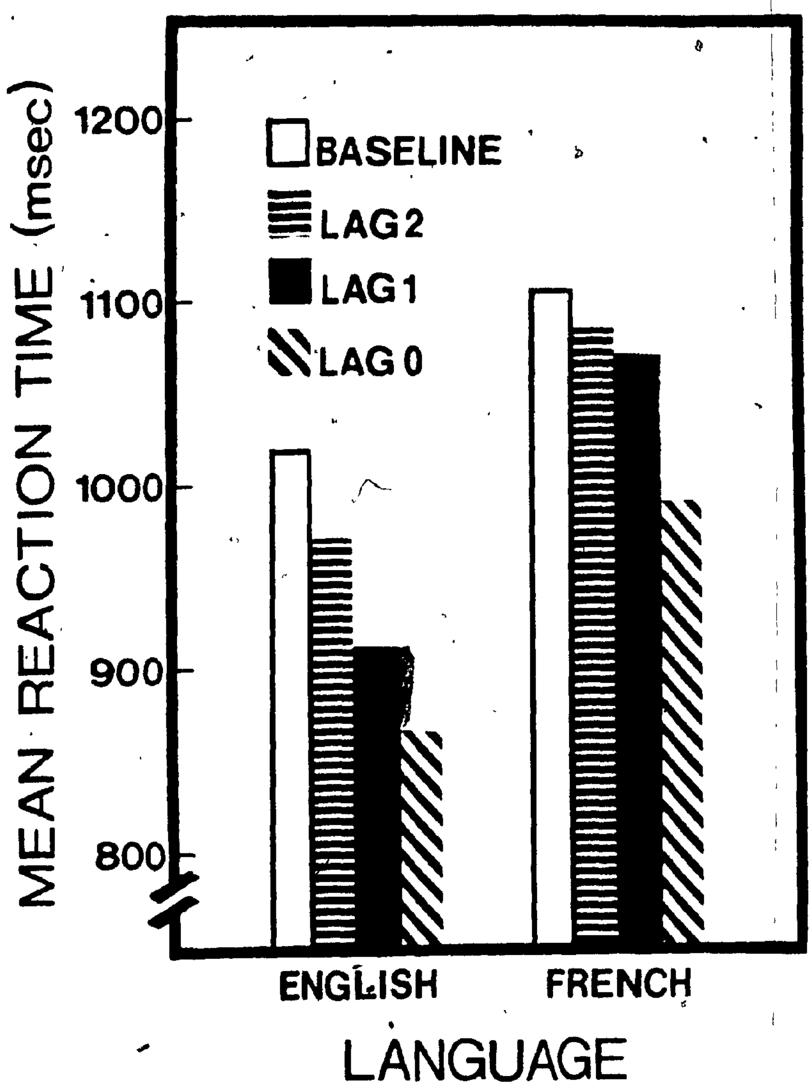


Figure 7. Mean reaction times for same category items as a function of language and presentation in Experiment 4.

differences did not reach significance. The difference between the mean reaction time at Lag 0 (992 msec) was significantly different (p<.01) from each of the other presentations, Baseline (1106 msec), Lag 2 (1085 msec) and Lag 1 (1072 msec). In addition, differences between English and French primed trials for Baseline (1021 vs. 1106 msec), Lag 0 (866 vs. 992 msec), Lag 1 (912 vs. 1072 msec) and Lag 2 (973 vs. 1086 msec) all reached significance (p<.01).

Although the main effect for SOA was not significant, two interactions with SOA did reach significance. The Presentation by SOA interaction [F(3,102)=4.14, p<.01] is depicted in Figure 8. Post-hoc tests performed between Presentation levels at 200 SOA revealed a significant difference between the mean at Baseline (1019 msec) and the mean at Lag 0 (914 msec) and at Lag 1 (927 msec) (p<.01) and between Baseline and Lag 2 (1019 vs. 972 msec, p<.05). A difference between Lag 2 (972 msec) and Lag 0 (914 msec) was also significant (p<.05). At 1650 SOA, the mean reaction time at Baseline was significantly different from that at Lag 0 (1108 vs. 944 msec, p<.01) and that at Lag 1 (1108 vs. 1056 msec, p<.05). Although the difference between Lag 2 and Lag 1 (1086 vs. 1056 msec) was not significant, that between Lag 2 and Lag 0 (1086 vs. 944 msec) and between Lag 1 and Lag 0 (1056 vs. 944 msec) was significant (p<.01). An important difference, that between Baseline and Lag 2 (1108 vs. 1086 msec), did not reach significance. The post hoc Newman-Keuls revealed that at Baseline, at Lag 2 and at Lag 1 the

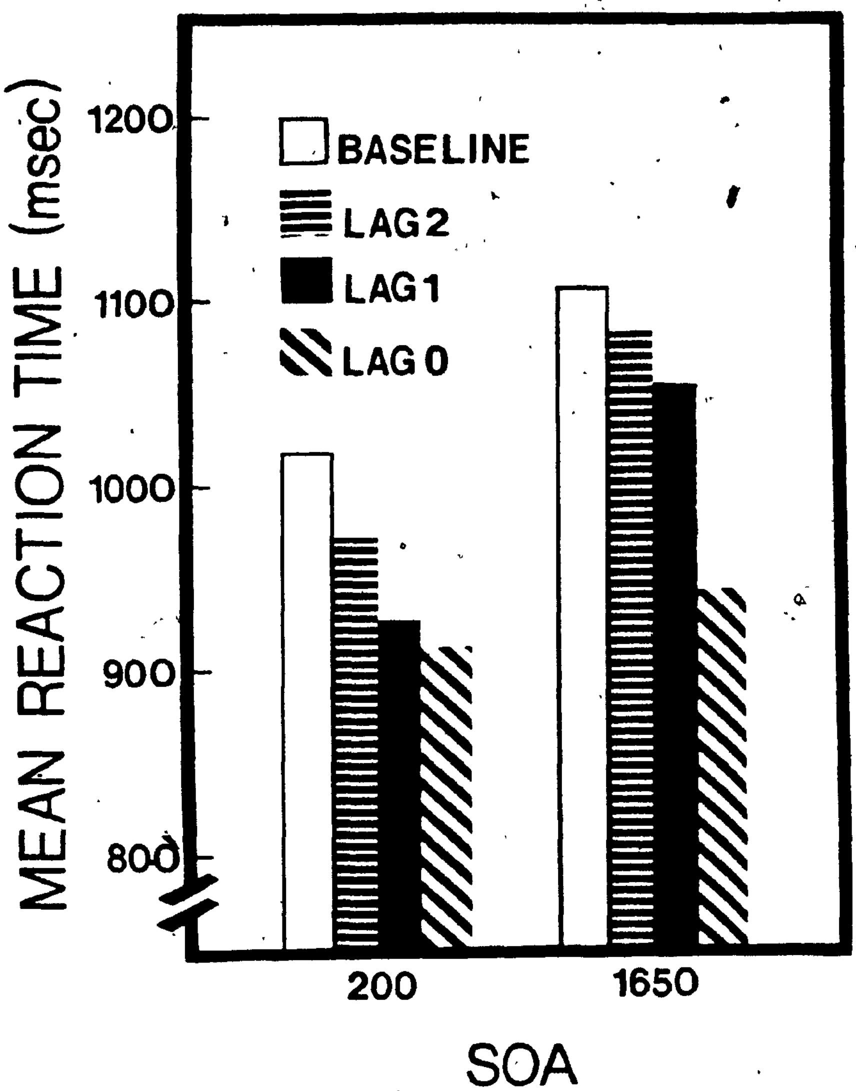


Figure 8. Mean reaction times for same category items as a function of SOA and presentation in Experiment 4.

difference between the mean reaction times at 200 SOA and at 1650 SOA was significant (p<.01) with the 200 SOA group consistently faster than the 1650 SOA group. At Lag 0, however, the difference between the two SOA groups was not significant. The interaction effect was seen in the difference between Baseline and Lag 2 and between Lag 1 and Lag 0 at each SOA. The difference for the former was significant at 200 SOA but not at 1650 whereas the difference for the latter was not significant at 200 SOA but was significant at 1650 SOA.

The interaction between Prototypicality and SOA [F(1,34)=6.19, p<.02] is depicted in Figure 9. For high prototypicality the Newman-Keuls test revealed that the mean reaction time for subjects responding to trials at 200 SOA was significantly faster than those responding at 1650 SOA (810 vs. 942 msec, p<.01). At low prototypicality, the difference between the 200 SOA and 1650 SOA just reached significance (1106 vs. 1156 msec, p<.05). The difference between high and low prototypicality for each language was significant (p<.01). Although all pairwise comparisons differed significantly, the pattern of results for the two levels of the SOA factor differed at each level of the prototypicality factor.

For different category stimuli, the analysis of variance yielded two significant main effects, Prototypicality and Prime. The mean reaction time for high prototypicality trials (1098 msec) was significantly faster than that for low (1209 msec), [F(1,34)=38.85, p<.001] and the mean reaction

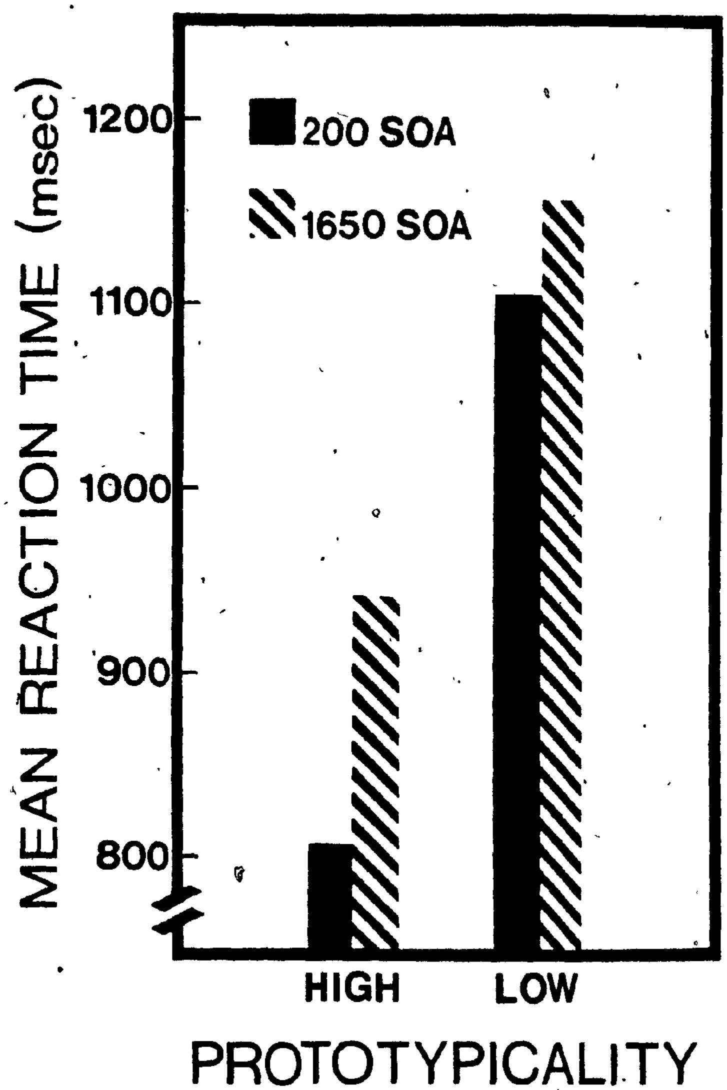


Figure 9. Mean reaction times for same category items as a function of prototypicality and SOA in Experiment 4.

time for English-primed trials (1132 msec) significantly faster than for French-primed trials (1174 msec), [$F(1,34)=5.10$, $p<.05$]. The main effect for SOA was short of significance [$F(1,34)=1.77$, $p>.05$].

Discussion

There are five major findings to be considered in the discussion of Experiment 4. The first of these relates to the between-language difference in error rate. The remaining four are depicted in the significant interactions in figures 6 through 9.

The error rate was very similar for each language condition and in line with error rates reported in other priming studies (Massaro et al., 1978; Rosch, 1975). It would seem, then, that altering the design so that subjects would necessarily have to make use of the prime to make decisions about category membership did not affect the accuracy of these judgments.

For the same category condition, some important findings are depicted in Figure 6. The significant difference between reaction times at high and low prototypicality for both first and second language trials replicated the results obtained in the previous experiment. At low prototypicality, responses to English language trials were significantly faster than to French trials, replicating the differential effect of language on reaction time obtained in Experiment 3.

A very important result is indicated in the significant difference between English and French trials at high prototypicality depicted in Figure 6. This difference, obtained in this but not the previous experiment, probably reflected the effect of the expansion of the high prototypical set of probes to include items rated somewhat less prototypical than those used in Experiments 2 and 3. The between-language difference in reaction time could be attributed to the inability of the French category word to activate as large a set as that activated by the English translation equivalent. Since there were no between-language differences as a function of SOA in Experiment 4, there was no evidence to attribute the difference in reaction time to a difference in the speed with which meaning was activated. The seeming inability of the French prime as compared to the English prime to activate the appropriate associates in the semantic network might also explain the between-language difference at low prototypicality, a difference which, as indicated by the interaction effect, was even greater at low than it was at high. Given that the inclusion of the less prototypical items in the high prototypical set slowed reaction time to French trials compared to English trials, an even greater difference would be expected at low prototypicality where probes would receive even less activation from the language prime.

A third result which requires explanation is revealed in the pattern of reaction times depicted in Figure 7. First, repetition of the English category prime produced a facilitation effect (trials at all lags were significantly faster than trials at baseline). This could be interpreted to mean that activation from the English word increased the access to the appropriate memory locations even when there were as many as two intervening trials between initial and second presentation of the category word. That there might be decay in this facilitation effect over time is revealed by the increase in reaction time with increase in the number of intervening items. In contrast to the English condition, repetition of the French category name produced a facilitation effect only at lag 0. It might be, then, that repetition of a French category name made additional memory associates available in the verification of category membership. This result, in conjunction with that obtained in Figure 6, could suggest that with repetition of a name there is activation of more associates to the prime rather than a speedier activation of the same associates. Given the differences in the pattern of results between lags for English as compared to French trials, it could also be that the memory locations activated by an English word decayed much less rapidly than did those activated by a French word.

The results depicted in Figure 8 indicate that the facilitation effect at lag was a function not only of the language of prime but also of SOA. The facilitation effect appeared to be more pervasive at the shorter SOA resulting in significant differences in the expected direction at all three lags compared to the two at the longer SOA. Although the decline in the facilitation effect was more evident at the long SOA, giving the impression that there was a more rapid decay in the memory trace, the total time elapsing from onset of baseline prime to onset of probe at Lag 2 must be considered. The total time (e.g. from onset of baseline trial to onset of probe at Lag 2) at the long SOA was approximately eight times as long as that at the short SOA. Although the facilitation effect at 1650 SOA had persisted over only two lags, this represented a period approximately four times the length covered by the three lags at 200 SOA. Unfortunately, the design of the experiment did not permit a test of the duration of the facilitation effect at the short SOA.

Another important result is revealed in Figure 8. Differences between SOAs at each presentation were significant with the exception of Lag 0. Here there was only a small difference in reaction time between trials at 200 and 1650 SOA. It appears that repetition of the category name was particularly effective at Lag 0 for the long SOA. The longer SOA may have allowed for activation of more associates making activation easier the second time around. The differences in reaction time between the two SOAs could be attributed to the degree of involvement of strategic processes.

Figure 9 depicts the differential effect of SOA on prototypicality. Although the difference in reaction time at each SOA was significant for high and for low prototypicality pairs, the difference was more marked at high than at low.

This result could be attributed to the more efficient operation of automatic processes at high than at low for the shorter SOA. The differences between SOAs at each level of prototypicality would be attributed to the greater involvement of strategic processes at the long SOA.

Different category results where reaction times were faster for high compared to low prototypicality pairs and for English compared to French trials were consistent with those obtained in Experiment 3.

In summary, the results of Experiment 4 provided support for only one of the two original hypotheses put forward in this study. Evidence revealed that the French category prime might not activate as many associates as the English prime. More simply, the results would seem to indicate that the French concrete category primes generated a more restricted meaning than did the English equivalents. In addition, repetition of a category name did make information retrieval easier for both language trials. In the case of English but not French trials, this facilitation effect persisted over two intervening trials, although the effect decreased with increase in intervening activity. This would seem to indicate that the memory locations activated by a French category prime decayed more rapidly than did those activated by an English word. Alternatively, it might be that the rate of decline was similar to that of English trials but the difference reflected the smaller number of memory locations activated in the French condition.

GENERAL DISCUSSION

In this section the major results of Experiments 2, 3 and 4 are summarized and discussed with respect to their implications for understanding how information about categories is processed by bilinguals. These findings are compared with those in relevant publications and some inconsistencies in interpretions are discussed.

Implications for Semantic Processing in Bilinguals

The investigation attempted to determine whether a familiar taxonomic category prime in a bilingual's second language could facilitate processing in the semantic network as completely and/or as quickly as could the translation equivalent in the dominant language. Between-language differences in reaction times were interpreted as suggesting a possible difference in either speed of processing the prime or in the number of associations generated by the prime within a specified time limit.

In the case of the fluent English- French bilinguals in Experiment 2 the principal results for the second language condition paralleled those for the first language. Overall reaction times and facilitation/inhibition effects in the second language were similar to those in the first for physically identical, same category and different category trials. If, as has been repeatedly suggested, the taxonomic category prime does facilitate retrieval of category information from semantic memory then a prime in the fluent bilingual's second language seemed to evoke similar associates to those evoked by the English translation equivalent in the present study. In addition, there appeared to be no difference in the speed with which each language prime evoked these associates.

Between-language differences in reaction times at an SOA of 200 msec. were found by Favreau and Segalowitz (in press) in a lexical decision task with bilingual subjects whose level of French fluency was similar to that of subjects used in Experiment 2. The authors attributed the results to automatic processing in the first but not in the second language. The lack of correspondence of these results with those of the present investigation at the shortest SOA might be attributed to a difference in the experimental paradigm -- a lexical decision task versus a category judgement task.

Equivalent reaction times in the first and second language condition for the fluent English-French bilinguals in Experiment 2 correspond to the results obtained by Caramazza and Brones (1980) for fluent Spanish-English bilinguals in a category judgment task. Unfortunately a between-language analysis of results which would have permitted comparisons with the findings of the present study was not reported.

The principal results for the second language of moderately fluent bilinguals in Experiment 3 paralleled those for the fluent bilinguals with two major exceptions. In the same category and different category conditions there were no facilitation effects for French-primed low prototypicality trials. Adding probes which were more intermediate in prototypicality (Experiment 4) to both the high and low prototypicality sets used in Experiments 2 and 3 resulted in significant between-language differences for both the high and the low prototypicality same category and different category trials. In addition, facilitation effects persisted over the three lags for English-primed but not for French-primed trials where only one difference, that at the first lag (lag 0), was significant.

These slower reaction times to the second as compared to the first language primes could conceivably be attributed to additional time required to translate from a weaker to a stronger language or to a difference in the speed of perceiving words in the two languages. The fact that there was no between-language difference for high prototypical trials (Experiment 3) precluded attributing between-language differences at low prototypicality to either of these explanations.

Unlike the study by Macnamara (1967) which investigated the speed with which English and French words were matched to a picture labelled by the word, there appeared to be no observable between-language differences which could be attributed to decoding speed. It is possible that a difference in decoding speed did exist and could have been manifested at SOAs which were shorter than those used in the present study. It is probable, however, that the nature of the task was such that decoding speed might not have been a factor contributing to a significant between-language difference at even the shortest SOAs. The same five French primes were repeated throughout the experiment reducing the liklihood of differences in speed of decoding.

Where in Macnamara's same category condition a basic level prime labelled (named) the concept depicted in a drawing, in the present investigation the concept labelled by the more abstract, taxonomic category prime presumably evoked a number of associates in preparation for making judgments as to the category membership of items depicted in the drawings. Results for the same category trials of Experiments 3 and 4 taken together were interpreted as indicating that the French language prime evoked a more restricted number of associates and, consequently, a more restricted meaning, than did the English prime, slowing judgments about category membership.

The second language prime activated associates as quickly as did the first language prime but appeared to activate fewer associates. The few associates which were activated corresponded to the high prototypical (dominant) instances of the category. According to the model (Collins & Loftus, 1975) the nodes corresponding to these associates would be situated near and/or be strongly bonded to and/or share common features with the nodes corresponding to the prime. Given the results at low prototypicality, the low prototypical associates of the French prime appeared to have relatively weaker bonds or fewer common features with or be relatively more distant from the prime than corresponding associates of the English prime. The first presentation of the second language prime (Experiment 4) seemed to lower the threshold for activation at lag 0 making the distant nodes more accessible to the second presentation of the prime and, consequently, resulting in a faster verification of the probe.

These results can be accommodated within two models of the way words and pictures are categorized. The first model suggests an abstract, modality-free representational system neutral for pictures and words (Chase & Clark, 1972). In this case, categorization might be based on a set of features which is common to an abstract representation of pictures and words. In a neutral or modality-free system a French prime might activate fewer features than the English prime.

Alternatively the results can be interpreted within the framework of a model which assumes a separate knowledge base for words and images as well as a separate representational system for each of the bilingual's two languages (Paivio & Desrochers, 1980). According to these investigators the two verbal systems are connected through representations corresponding to translation equivalents and through an image system which is specialized for processing nonverbal material. In the processing of words and pictures in the present study at least two possibilities emerge: (1) recoding information from words to pictures, (2) recoding information from pictures to words and accessing the first language system through translation. In the first instance, a prime might be converted to an image code in preparation for pictures. In this event, the second language prime would activate fewer associates within the second system. In the second form of recoding, a picture might be named and/or converted into a verbal code before categorization or verification. Such a conversion would be in line with the thinking of some investigators (Vygotsky, 1962; Bruner, Greenfield & Olver, 1966) who consider categorization to be primarily a verbal task. It is possible that the slow reaction times for low prototypicality French trials can be attributed to a strategy adopted by the nonfluent bilinguals. In Experiment 4, where only one probe was employed, subjects might use the French prime in verifying the category membership of only the high prototypical items. However, when a French prime did not activate a sufficient number of associates to interface with those activated by the probe, subjects might have translated the prime and verified low prototypical instances through the first language system. The adequacy of these models in regard to the processing of category information in a second language is a topic for future research.

Some Problems in the Interpretation of Results

Some of the principal results obtained for each of the three conditions (physically identical, same category, different category) were similar to those reported in other priming studies conducted with monolingual subjects. However, there was a lack of correspondence between certain important results in the present investigation and those of similar studies. This raises questions about the interpretation of results from this paradigm and has implications for understanding both monolingual and bilingual semantic processing.

Physically Identical Results

Consistent with results in similar paradigms (Beller, 1971; Posner, Boies, Eichelman & Taylor, 1969) overall reaction times were faster for physically identical pairs than for categorically identical or different pairs in Experiments 2 and 3. In addition, differential effects of prime similar to those of Rosch (1975) were obtained. Priming with a taxonomic category label, whether in English or in French, facilitated responses to high prototypical instances of the category and inhibited responses to low.

Rosch (1975) has explained facilitation and inhibition effects for physically identical stimuli by claiming that the representation generated by a superordinate category word contained information that was more like the high than the low prototypical member, thus facilitating the encoding of the former and interfering with the encoding of the latter. Although Rosch implied that activated instances (i.e. high prototypical instances) somehow laterally inhibited neighboring less activated instances (i.e. low prototypical instances), it was Loftus (1975) who interpreted Rosch's results within the framework of spreading activation. She suggested that when activation from the prime spread to highly prototypical instances, this somehow drew away from the low prototypical members. Although the use of this "hydraulic effect" accommodated the physically identical results in Rosch's investigations and in the present study, it was not a particularly compelling explanation since it involved introducing some inhibitory bonds into an otherwise excitatory model. This model has attributed the facilitation effect of a prime on both immediate and distant associates to an uninhibited spread of activation from one cognitive unit to another along relational paths (Collins & Quillian, 1969). An alternative interpretation of Rosch's results, one which suggests that the inhibition effect at low prototypicality might not be a function of interference at encoding and that both encoding and postencoding processes might be facilitated by an advance prime is developed below.

Recent evidence (Neely, 1976, 1977) has revealed that strategic processing was implicated in tasks where certain expectations were initiated by the presentation of the prime. Although there was no direct manipulation of expectancy effects in the present investigation, the nature of the task and the instructions to the subjects could provide participants with a set of expectations. Subjects would be expecting to make decisions about category membership because instructions emphasized the making of these decisions and because three quarters of the trials required a category membership rather than a physically identical decision. When subjects were instructed to make semantic level judgments and were faced with two identical items they were, as Posner (1978, p. 110) has suggested, in a "horserace between physical match of the two arrays and a match of these items to the category." High prototypical items did not only match each other but also matched the prime, whereas low prototypical items matched each other but did not as readily match the prime.

Although both Rosch (1975) and Loftus (1975) hypothesized that subjects perform a physical match before any retrieval of category information takes place, with priming influencing encoding time, there is no direct evidence that physical match does occur before retrieval of information about the superordinate category. Considering the possibility that category information is retrieved during the physically identical condition, Loftus (1975) hypothesized that the operations involved in physically matching the items might overlap with those involved in the retrieval of category information.

Developing this idea, one might suggest that for high prototypicality items where the prime is presented in advance of the probes and subjects are instructed to make category judgments, category match operations might precede physical identity operations. A prime presented simultaneously with physically identical probes might not initiate category matching operations. Rosch (1975) reported that when a prime was presented simultaneously with the probes it had no facilitation effect on high prototypical physically identical pairs. It did have a facilitative effect when presented in advance of the probes. She concluded that advance priming affected the encoding of physically identical pairs. If, as has been suggested, subjects are set to make category judgments, an advance prime might have facilitative effects on both encoding and category matching operations. Determining whether category matching operations do take place when a physical match is required would be a subject for a future investigation.

For primed low prototypicality, physically identical items, the items are not easily recognized as members of the primed category slowing the execution of a same response. The slowing of reaction time at low prototypicality can be explained as a function of both an instructional set which encouraged the determination of a category match and of a diminished benefit from the prime. This explanation could account for the unexpected same category result in Rosch's experiments when similar reaction times were obtained regardless whether the prime was presented in advance of or simultaneously with the probes. Rosch expected less facilitation for low prototypical items than high in the case of an advance prime because she predicted that, as with physically identical pairs, there should be inhibition at the encoding stage, thus increasing reaction time for low items. If the interpretation suggested above is correct, then there would be no inhibition in the encoding of low prototypical same category pairs and, possibly, equivalent facilitation at high and low prototypicality. The inhibition effect would occur only with physically identical low prototypical pairs for reasons discussed above.

Interpreting results as indicating that strategic processes did develop very quickly, in both the first and second language trials, at least within the shortest SOA (200 msec.) in Experiments 2 and 3, finds support in recent studies where evidence for the development of strategic processing has been reported at SOAs as short as 200 msec (Antos, 1979) and 250 msec (Myers & Lorch, 1980). This would also be in line with the suggestion (Posner, 1978) that strategic processing might develop much more rapidly after stimulus onset than the 350 msec originally proposed (Posner & Snyder, 1975).

Same Category Results

Several results in the present investigation were consistent with predictions from the general spreading activation model (Collins & Quillian, 1969; Collins & Loftus,

1975) and most of the available empirical evidence. The finding, for the same category condition of Experiments 2, 3 and 4, that reaction times were faster when prime-probe pairs were strongly associated than when they were weakly associated corresponds to the results of numerous studies (Becker, 1980; Fischler & Goodman, 1978; Lorch, 1981, 1982; Massaro et al., 1978; Myers & Lorch, 1980; Ratcliff & McKoon, 1981; Rosch, 1975). The general facilitative effect of a related prime relative to a neutral-prime or unrelated prime condition in the two priming studies (Experiments 2 and 3) is consistent with most findings in a wide variety of priming paradigms (Caramazza & Brones, 1980; Meyer & Schvaneveldt, 1971; Neely, 1976, 1977; Posner & Snyder, 1975; Rosch 1975). Finally, there was some evidence in support of the finding in Experiment 4 that the facilitative effect of the prime is reduced with time and intervening activity (Loftus, 1973; Scarborough et al., 1977).

Other principal results were not in line with predictions from the original model and were consistent with the findings of only some of the published studies. For the English and French-primed trials in Experiment 2 and for English-primed trials in Experiment 3, prototypicality (dominance) had no effect on the magnitude of priming facilitation even at the smallest SOA. This was supported by the results of some studies (Neely, 1977; Warren, 1977) but not others (Becker, 1980; Lorch, 1982; Ratcliff & McKoon, 1981). The latter group of studies reported results that were consistent with predictions from the spreading activation model (Collins & Quillian, 1969; Collins & Loftus, 1975) which specified more facilitation for high than for low dominance items. In addition, results in Experiments 2 and 3 revealed that priming facilitation did not increase with increase in SOA. These results were consistent with those of some investigations (Myers & Lorch, 1980; Neely, 1977) but not others (Antos, 1979; Fischler & Goodman, 1978; Neely, 1976; Ratcliff & McKoon, 1981), contradicting predictions that, with time, activation spreads (Collins & Loftus, 1975). Finally, the results for the English and French-primed trials of Experiment 2 and for the English-primed trials of Experiment 3 revealed that there was no interaction between dominance and SOA. The model would predict greater facilitation for high than low dominance items at the short SOA and a greater facilitation for low dominance items at the long than at the short SOA. The findings of the present study were supported by some investigations (Lorch, 1982; Neely, 1977; Ratcliff & McKoon, 1981, Experiment 1) but not others (Myers & Lorch, 1980; Ratcliff & McKoon, Experiment 2). The results of the present investigation which appear to be at variance with some experiments and with the model are considered further.

Lorch (1982) has attributed the lack of dominance effect on the magnitude of facilitation in the Neely (1977) lexical decision and the Warren (1977) naming latency tasks to their use of a median-split procedure to partition stimuli into those of high and low associative strength resulting, as he suggested, in a lack of statistical power. This explanation would not apply to the present investigation. First, the selection of the experimental stimuli was based on independent ratings of items as high or low in prototypicality. Second, unlike the Neely (1977) and Warren (1977) studies, there was a significant reaction time difference between high and low prototypical trials indicating a difference in associative strength between the prime and probes at each level. In the present investigation there is at least one possible interpretation for the finding that dominance does not affect the magnitude of facilitation.

The finding that dominance had no effect on the amount of facilitation might suggest that the prime had fully and completely activated all members of a category even at the shortest SOA. Such an interpretation would be appropriate for the Neely (1977) and Warren (1977) results where equivalent facilitation of high and low dominance items was coupled with the finding of no difference in reaction time between high and low dominance trials. In the present investigation (Experiment 2) equivalent facilitation of high and low prototypicality items and a significant difference in reaction time between high and low trials would preclude such an interpretation. A less elegant explanation, but one which better accommodates the data, follows.

The model (Collins & Quillian, 1969; Collins & Loftus, 1975) assumes that the retrieval of information from semantic memory consists of a two-stage process. Associates to the prime and probe are activated in what is assumed to be a parallel, intersecting activation process. When associates to the prime and probe are activated, the selection process evaluates these associates with respect to the target superordinate-subordinate relation. Prototypicality (dominance) would affect the duration of this evaluation process. For the same category condition of the present investigation and, in accordance with the model, the prime provides a headstart on the activation of associates so that when the probe is presented there is a savings in retrieval time. If there is enough time to activate the appropriate associates (as would be the case with high prototypicality trials) there would be additional savings in that the encoding of the probes would be facilitated. In addition, since the activation level of high prototypicality probes is very high, the evaluation process could be completed quickly resulting in fast reaction times and substantial facilitation of both encoding and postencoding processes. In the case of low prototypicality items results would suggest that an advance prime would have little or no facilitation effect on encoding. If information from an advance prime had helped in the encoding of low prototypical pairs, facilitation effects would have been obtained for these pairs in the physically identical condition (see discussion of physically identical condition in this section). In fact, there was no such benefit obtained. In interpreting same category results, Rosch (1975) and Loftus (1975) have suggested that the prime could be more beneficial to the evaluation of low than high prototypicality pairs because, as revealed in the neutral condition (see Figure 5), it is substantially more difficult to determine whether two low prototypical items are members of a category. It may be that for tasks that are assumed to make more processing demands than do naming or lexical decision tasks (Myers & Lorch, 1980) the prime differentially influences the encoding and postencoding operations at high and low prototypicality with the result of equal facilitation at each level of prototypicality. Although the assumption of differential effects of prime on the encoding and postencoding operations involved in processing high and low prototypical pairs is consistent with results obtained in the present investigation, the validity of this suggestion would require some direct evidence of the effect of a prime on each processing operation. Neither this investigation nor that of Rosch (1975) unambiguously demonstrates the effect of the prime on each processing operation because both encoding and postencoding operations are confounded within each condition of the experiments.

Two major results in the present investigation are not consistent with predictions of a model (Collins & Loftus, 1975) which assumes that activation spreads from more highly to less highly activated nodes and does so over time. The present investigation (Experiments 2 and 3) revealed that, for low prototypical items, facilitation was not greater at the longer than at the shorter SOA nor did facilitation increase with increase in SOA. One simple explanation might be that the smallest SOA (i.e. 200 msec.) was long enough to allow for a complete spread of activation. The inclusion of an even smaller SOA, for example 50 msec., and a subsequent comparison of facilitation effects might have revealed an increase in facilitation at 200 SOA. The most compelling argument against such an explanation of present results is based on the findings of a recent study (Lorch, 1982) which used a category judgment task similar to the one used in Experiments 2 and 3. Using SOAs of 150, 300, 450 or 600, the investigator reported an increase in facilitation with increase in SOA.

The present results are inconsistent with predictions from the original spreading activation model and can be explained by an alternative activation model (Wickelgren, 1976). This model differs from the original only in the proposal that the activation process is instantaneous. The model has received support in some investigations (Dosher, 1981; Ratcliff & McKoon, 1981; Wickelgren, 1976) and could be used to interpret the results of other studies (Myers & Lorch, 1980; Neely, 1977; Warren, 1977) which have failed to find an increase in facilitation with increase in SOA. In line with the alternative model, information is stored in a semantic network with strongly associated concepts closer together than weakly associated concepts. Activation from the prime (and eventually from the probe) spreads through the network at a very rapid rate (1 msec. per link). The activation process is not limited by the time between prime and probe (SOA) but rather by the proximity (or strength of the bond) between prime and probe. Probes that are closely associated to the prime would have a higher activation level and therefore would be processed more quickly than those more distantly associated. This model can explain the priming effects, the difference in reaction times between high and low prototypical trials and the similar facilitation effects across SOA found in the present study. It does not, however, explain the increases in reaction time with increase in SOA. As has been suggested previously, these differences might reflect the increasing involvement of strategic processes (Posner & Snyder, 1975) in a task where the subject must verify more than one type of relationship (e.g. physically identical and category membership). Alternatively, the pattern of reaction times might simply reveal a tendency for response times to vary with the rate of presentation of the stimuli when that rate remains constant within a block of trials.

Although the Wickelgren model (1976) appears to accommodate the data from this investigation, the question of why activation appears to spread in some situations but not others needs to be further investigated.

Different Category Results

The finding of overall slower reaction times for different as compared to same category results corresponds to those of Rosch (1975) and to numerous other studies (Caramazza & Brones, 1980); Collins & Quillian, 1972; Gellatly & Gregg, 1975; Glass et al., 1974; Myers & Lorch, 1980; Rips et al., 1973). Facilitation effects for high and low prototypicality English-primed trials correspond to the results of Rosch (1975) but not Myers and Lorch (1980). Like the present investigation both these studies used a category judgment task where negative responses were sought to items which were clearly unrelated (eg. Furniture -- wrench - dress).

Different category findings are more readily explained by feature comparison than by network models of semantic memory. The first of the two-stage comparison process hypothesized by the feature comparison model (Smith et al., 1974) suggests a quick, holistic comparison of the features of prime and probe where either a very large or very small overlap of features is quickly judged as same (positive response) or different (negative response). Although the network model (Collins & Quillian, 1969; Collins & Loftus, 1975) has mentioned both strength of relation and shared associations as factors contributing to relatedness effects, generally, relatedness has been interpreted (Anderson, 1976; Glass & Holyoak, 1975) to mean strength of relation between two concepts or nodes in the network. If relation strength is emphasized this leads to the prediction that reaction times would decrease with increase in relatedness for both same (true) and different (false) responses. For the present investigation where different category pairs are completely unrelated this would have meant much slower reaction times for different category results and consequently no facilitation at high and low prototypicality.

Holyoak and Glass (1975) and Lorch (1981) have suggested that the relatedness of false sentences in some experiments has been manipulated so as to maximize the influence of shared associations rather than the influence of strength effects. False (different) conditions are constructed by simply interchanging items used to construct the true (same) conditions. An explanation based on the extent of shared associates rather than distance might be more consistent with the results of the present investigation which has used a similar procedure to construct different category pairs. The facilitation effects for the different category stimuli would suggest a quick comparison made possible by the very small feature overlap between prime and probe in this condition.

The experiments reported above have revealed between-language assymetries in the processing of category information by moderately fluent bilinguals. Familiar French taxonomic category labels used as primes in a category judgment task facilitated the processing of only very highly prototypical instances of these categories. Results were interpreted as suggesting that category primes in the second language evoke fewer associates and, consequently, a more restricted meaning than do primes in the first language.

It is this inferior performance in basic operations in the second language which can contribute to deterioration in more complex operations such as comprehending a written or oral passage. In tasks such as studying from a text, where input speed can be controlled, an individual can compensate for slower or less complete decoding by rehearsing or translating to the dominant language. In a situation, such as listening to a lecture, where auditory presentation places great demands on short term memory and reasoning ability, a person who functions in a weaker language might be placed at a considerable disadvantage. When it is possible to rehearse or translate the decoded input for reorganization in the dominant language, long term negative effects on the quality of the information one acquires might be minimal. Where fast decoding of input is essential to full comprehension, the bilingual who is less than fluent in a second language would appear to face serious problems in performing some very basic information processing operations.

REFERENCE NOTES

1. Scott, S. The relation of divergent thinking to bilingualism: Cause or Effect. Unpublished manuscript, McGill University, Montreal, 1973.

2. Genesee, F., & Chaplin, S. Evaluation of the 1974-75 grade 11 French immersion class. Unpublished manuscript, McGill University, Montreal, 1976.

3. Olton, R.M. Semantic generalization between languages. M.A. thesis, McGill University, 1960.

4. Favreau, M., & Segalowitz, N. Semantic category norms for the French and English Quebec population. Paper presented at the American Psychological Association, Montreal, September, 1980.

REFERENCES

Anderson, J.R. Language, memory and thought. New York: Erlbaum, 1976.

Antos, S.J. Processing facilitation in a lexical decision task. Journal of Experimental Psychology: Human Perception and Performance, 1979, 5, 527-545.

Ashcroft, M.H. Property dominance and typicality effects in property statement verification. Journal of Verbal Learning and Verbal Behavior, 1978, 17, 155-164.

Barik, H.C., Swain, M., & Gardino, V. A Canadian experiment in bilingual education in the senior grades: The Peel study through grade 10. International Review of Applied Psychology, 1976, 25, 99-113.

Barik, H.C., & Swain, M. Bilingual Education Project: Evaluation of the 1975-1976 French Immersion Programs in Grades 3 to 5 (Ottawa and Carleton Board of Education). Toronto: Ontario Institute for Studies in Education, 1977.

Battig, W.F., & Montague, W.E. Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. Journal of Experimental Psychology Monograph, 1969, 80, (3 Pt. 2).

Becker, C.A. Semantic context effects on visual word recognition: An analysis of semantic strategies. Memory & Cognition, 1980, 8, 493-512.

Beller, H.K. Priming: Effects of advanced information on matching. Journal of Experimental Psychology, 1971, 87, 176-182.

Berlin, B., & Kay, P. Basic color terms: Their universality and evolution. Berkeley: University of Californis Press, 1969.

Brown, S.W., & Block, R.A. Contextual facilitation and disruption in word identification. Bulletin of the Psychonomic Society, 1980, 15, 242-244.

Bruck, M., Lambert, W.E., & Tucker, G.R. Bilingual schooling through the elementary grades: The St. Lambert project at grade seven. Language Learning, 1974, 24, 183-204.

Bruner, J.S., Greenfield, P.M., & Olver, R.R. Studies in cognitive growth. New York: Wiley, 1966.

Caramazza, A., & Brones, I. Semantic classification by bilinguals. Canadian Journal of Psychology, 1980, 34, 77-81.

Chase, W.G., & Clark, H.H. Mental operations in the comparisons of sentences and pictures. In L. Gregg (Ed.), Cognition in learning and memory. New York: Wiley, 1972.

Collins, A.M., & Loftus, E.F. A spreading activation theory of semantic processing. Psychological Review, 1975, 82, 407-428.

Collins, A.M., & Quillian, M.R. Retrieval time from semantic memory. Journal of Verbal Learning and Verbal Behavior, 1969, 8, 240-247.

Collins, A.M., & Quillian, M.R. Facilitating retrieval from semantic memory: The effect of repeating part of an inference. Acta Psychologica, 1970, 33, 304-314.

Collins, A.M., & Quillian, M.R. How to make a language user. In E. Tulving and W. Donaldson (Eds.), Organization of memory. New York: Academic Press, 1972.

Cummins, J. Educational implications of mother tongue maintenance in minority-language groups. The Canadian Modern Language Review, 1978, 34, 395-416.

Cummins, J. Bilingualism and cognitive functioning. In S.M. Shapson, V. D'Oyley and A. Lloyd (Eds.), Bilingualism and multiculturalism in Canadian education. Centre for the Study of Curriculum Education, University of British Columbia, 1982.

Cummins, J., & Gulutsan, M. Bilingual education and cognition. The Alberta Journal of Educational Research, 1974, 20, 259-269.

Dalrymple-Alford, E.C., & Aamiry, A. Word associations of bilinguals. Psychonomic Science, 1970, 21, 319-320.

Davelaar, E., & Coltheart, M. Effects of interpolated items on the association effect in lexical decision tasks. Bulletin of the Psychonomic Society, 1975, 6, 269-272.

Diller, K.C. "Compound" and "coordinate" bilingualism: A conceptual artifact. Word, 1970, 26, 254-261.

Dillon, R.F., McCormack, P.D., Petrusic, W.M., Cook, M., & Lafleur, L. Release from proactive interference in compound and coordinate bilinguals. Bulletin of the Psychonomic Society, 1973, 2, 293-294.

Dornic, S. The bilingual's performance: Language dominance, stress and individual differences. In D. Gerver and V. Sinaiko (Eds.), Proceedings from the interdisciplinary symposium on language, interpretation, and communication. New York: Plenum Press, 1978.

Dosher, B.A. The effects of delay and interference: A speed-accuracy study. Cognitive Psychology, 1981, 13, 551-582.

Ervin, S. Language and TAT content in bilinguals. Journal of Abnormal and Social Psychology, 1964, 68, 500-507.

Ervin, S.M., & Osgood, C.E. Second language learning and bilingualism. Journal of Abnormal and Social Psychology (supplement), 1954, 49, 139-146.

Favreau, M., Komoda, M.K., & Segalowitz, N. Second language reading: Implications of the word superiority effect in skilled bilinguals. Canadian Journal of Psychology, 1980, 34, 370-380.

Favreau, M., & Segalowitz, N. Automatic and controlled processes in the first and second language reading of fluent bilinguals. Memory & Cognition, (in press).

Fischler, I., & Goodman, G.O. Latency of associative activation in memory. Journal of Experimental Psychology: Human Perception and Performance, 1978, 4, 455-470.

Forbach, G., Stanners, R., & Hochaus, L. Repetition and practice effects in a lexical decision task. Memory & Cognition, 1974, 2, 337-339.

Friedman, J.L., & Loftus, E.F. Retrieval of words from long-term memory. Journal of Verbal Learning and Verbal Behavior, 1971, 10, 107-115.

Gellatly, A.R.H., & Gregg, V.H. The effects of negative relatedness upon word-picture and word-word comparisons and subsequent recall. British Journal of Pyschology, 1975, 66, 311-323.

Genesee, F. An invited article. Bilingual education of majority language children: The Immersion experiments in review. Applied Psycholinguistics, 1983, 4, 1-46.

Glass, A.L., & Holyoak, K.J. Alternative conceptions of semantic memory. Cognition, 1975, 3, 313-339.

Glass, A.L., Holyoak, K.J., & O'Dell, C. Production frequency and the verification of quantified statements. Journal of Verbal Learning and Verbal Behavior, 1974, 13, 237-254.

Gough, P.B., Alford, J.A., & Holly-Wilcox, P. Words and contexts. In O.J.L. Tzeng and H. Singer (Eds.), Perceptions of print: Reading research in experimental psychology. Hillsdale, N.J.: Erlbaum, 1981.

Heider, E.R. "Focal" color areas and the development of color names. Developmental Psychology, 1971, 4, 447-455.

Heider, E.R. Universals in color naming and memory. Journal of Experimental Psychology, 1972, 93, 10-20.

Holyoak, K.J., & Glass, A.L. The role of contradictions and counterexamples in the rejection of false sentences. Journal of Verbal Learning and Verbal Behavior, 1975, 14, 215-239.

Jacobson, J.Z. Effects of association upon masking and reading latency. Canadian Journal of Psychology, 1973, 27, 58-69.

Jakobovits, L., & Lambert, W.E. Semantic satiation among bilinguals. Journal of Experimental Psychology, 1961, 62, 576-582.

James, W. The principles of psychology. New York: Holt, 1890.

Kellaghan, T., & Macnamara, J. Reading in a second language. In M.D. Jenkinson (Ed.), Reading instruction: An international forum. Newark, Del.: International Reading Association, 1967.

Kirsner, K., & Smith, M. Modality effects in word identification. Memory & Cognition, 1974, 2, 637-640.

Kolers, P.A. Interlingual word associations. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 291-300.

Kolers, P.A. Bilingualism and information processing. Scientific American, 1968, 218, 78-86.

Kolers, P.A. Reading and talking bilingually. American Journal of Psychology, 1966, 79, 357-376.

Lambert, W.E. Measurement of the linguistic dominance of bilinguals. Journal of Abnormal and Social Psychology, 1955, 50, 197-200.

Lambert, W.E., Havelka, J., & Crosby, C. The influence of language acquisition contexts on bilingualism. Journal of Abnormal and Social Psychology, 1958, 56, 239-244.

Lambert, W.E., Havelka, J., & Gardner, R.C. Linguistic manifestations of bilingualism. American Journal of

Psychology, 1959, 72, 77-82.

Lambert, W.E., Ignatow, M., & Krauthammer, M. Bilingual organization in free recall. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 207-214.

Lambert, W.E., & Moore, N. Word-association responses: Comparisons of American and French monolinguals with Canadian monolinguals and bilinguals. Journal of Personality and Social Psychology, 1966, 3, 313-320.

Lambert, W.E., & Rawlings, C. Bilingual processing of mixed-language associative networks. Journal of Verbal Learning and Verbal Behavior, 1969, 8, 604-609.

Lambert, W.E., & Tucker, G.R. The bilingual education of children: The St. Lambert experiment. Rowley, Mass.: Newbury House, 1972.

Liedke, W.W., & Nelson, L.D. Concept formation and bilingualism. Alberta Journal of Educational Research, 1968, 14, 225-232.

Loftus, E.F. Activation of semantic memory. American Journal of Psychology, 1973, 86, 331-337.

Loftus, E.F. Spreading activation within semantic categories: Comments on Rosch's "Cognitive representations of semantic categories". Journal of Experimental Psychology: General, 1975, 104, 234-240.

Loftus, G.R., & Loftus, E.F. The influence of one memory retrieval on a subsequent memory retrieval. Memory & Cognition, 1974, 2, 467-471.

Lorch, R.F. Effects of relation overlap on retrieval and comparison processes during sentence verification. Journal of Verbal Learning and Verbal Behavior, 1981, 20, 593-610.

Lorch, R.F. Priming and search processes in semantic memory: A test of three models of spreading activation. Journal of Verbal Learning and Verbal Behavior, 1982, 21, 468-492.

Macnamara, John. Bilingualism in primary education. Edinburgh: Edinburgh University Press, 1966.

Macnamara, J. The effects of instruction in a weaker language. Journal of Social Issues, 1967, 23, 121-135.

Macnamara, J. Bilingualism and thought. In J. Alatis (Ed.), Monograph Series on Languages and Linguistics. Washington, D.C.: Georgetown University Press, 1970.

Massaro, D.W., Jones, R.D., Lipscomb, C., & Scholz, R. Role of prior knowledge on naming and lexical decisions with good and poor stimulus information. Journal of Experimental Psychology: Human Learning and Memory, 1978, 4, 498-512.

McCormack, P.D. Bilingual linguistic memory: The independence-interdependence issue revisited. In P.A. Hornby (Ed.), Bilingualism: Psychological, social, and educational implications. New York: Academic Press, 1977.

Mervin, C.B., Catlin, J., & Rosch, E. Development of the structure of color categories. Developmental Psychology, 1975, 11, 54-60.

Meyer, D.E. On the representation and retrieval of stored semantic information. Cognitive Psychology, 1970, 1, 242-300.

Meyer, D.E., & Schvaneveldt, R.W. Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. Journal of Experimental Psychology, 1971, 90, 227-234.

Murphy, G.L. Cue validity and levels of categorization. Psychological Bulletin, 1982, 91, 174-177.

Myers, J.L., & Lorch, Jr., R.F. Interference and facilitation effects of primes upon verification processes. Memory & Cognition, 1980, 8, 405-414.

Neely, J.H. Semantic priming and retrieval from lexical memory: Evidence for facilitatory and inhibitory processes. Memory & Cognition, 1976, 4, 648-654.

Neely, J. Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited-capacity attention. Journal of Experimental Psychology: General, 1977, 1, 226-254.

Nott, C.R., & Lambert, W.E. Free recall of bilinguals. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 1065-1071.

Paivio, A., & Desrochers, A. A dual-coding approach to bilingual memory. Canadian Journal of Psychology, 1980, 34, 388-399.

Paivio, A., & Lambert, W.E. Dual coding and bilingual memory. Journal of Verbal Learning and Verbal Behavior, 1981, 20, 532-539.

Peal, E., & Lambert, W.E. The relation of bilingualism to intelligence. Psychological Monographs, 1962, 76, 1-23.

Paradis, M. The stratification of bilingualism. In M. Paradis (Ed.), Aspects of bilingualism. Columbia, S.C.: Hornbeam Press, 1978.

Posner, M.I. Chronometric explorations of the mind. Hillsdale, N.J.: Erlbaum, 1978.

Posner, M.I., Boies, S.J., Eichelman, S.H., & Taylor, R.L. Retention of visual and name codes of single letters. Journal of Experimental Psychology Monograph, 1969, 79 (1, Pt. 2).

Posner, M.I., & Synder, C.R.R. Attention and cognitive control. In R.C. Solso (Ed.), Information processing and cognition: The Loyola Symposium. Hillsdale, N.J.: Erlbaum, 1975.

Rao, T.S. Development and use of directions text for measuring degree of bilingualism. Journal of Psychological Researches, 1964, 8, 114-119.

Ratcliff, R., & McKoon, G. Does activation really spread? Psychological Review, 1981, 88, 454-462.

Rips, L.J., Shoben, E.J., & Smith, E.E. Semantic distance and the verification of semantic relations. Journal of Verbal Learning and Verbal Behavior, 1973, 12, 1-20.

Rosch, E. On the internal structure of perceptual and semantic categories. In T.E. Moore (Ed.), Cognitive development and the acquisition of language. New York: Academic Press, 1973.

Rosch, E. Linguistic relativity. In A. Silverstein (Ed.), Human communications: Theoretical explorations. Hillsdale, N.J.: Erlbaum, 1974.

Rosch, E. Cognitive representations of semantic categories. Journal of Experimental Psychology: General, 1975, 104, 192-233.

Rosch, E., & Mervis, C.B. Family resemblances: Studies in the internal structure of categories. Cognitive Psychology, 1975, 7, 573-605.

Rosch, E., Mervis, C.B., Gray, W.D., Johnson, D.M., & Boyes-Braem, P. Basic objects in natural categories. Cognitive Psychology, 1976, 8, 382-439.

Ryan, C. Reassessing the automaticity-control distinction: Item recognition as a paradigm case. Psychological Review, 1983, 90, 171-178.

Scarborough, D.L., Cortese, C., & Scarborough, H.S. Frequency and repetition effects in lexical memory. Journal of Experimental Psychology: Human Perception and Performance, 1977, 3, 1-17.

Schaeffer, B., & Wallace, R. The comparison of word meanings. Journal of Experimental Psychology, 1970, 86, 144-152.

Schuberth, R.E., & Eimas, P.D. Effects of context on the classification of words and nonwords. Journal of Experimental Psychology: Human Perception and Performance, 1977, 3, 27-36.

Schvaneveldt, R.W., & McDonald, J.E. Semantic context and the encoding of words: Evidence for two modes of stimulus analysis. Journal of Experimental Psychology: Human Perception and Performance, 1981, 7, 673-687.

Schvaneveldt, R.W., & Meyer, D.E. Retrieval and comparison processes in semantic memory. In S. Kornblum (Ed.), Attention and performance IV. New York: Academic Press, 1973.

Segalowitz, N. Psychological perspectives on bilingual education. In B. Spolsky & R.L. Cooper (Eds.), Frontiers of bilingual education. Rowley, Mass.: Newbury House, 1977.

Segalowitz, N., & Lambert, W.E. Semantic generalization in bilinguals. Journal of Verbal Learning and Verbal Behavior, 1969, 8, 559-566.

Shaffer, D. Is bilingualism compound or coordinate? Lingua, 1976, 40, 69-77.

Smith, E.E., Shoben, E.J., & Rips, L.J. Comparison processes in semantic memory. Psychological Review, 1974, 81, 214-241.

Stanovich, K.E., & West, R.F. The effect of sentence context on ongoing word recognition: Tests of a two-process theory. Journal of Experimental Psychology: Human Perception and Performance, 1981, 7, 658-672.

Stanovich, K.E., & West, R.F. On priming by sentence context. Journal of Experimental Psychology: General, 1983, 112, 1-36.

Stanovich, K.E., West, R., & Feeman, D. A longitudinal study of sentence context effects in second-grade children: Tests of an interactive-compensatory model. Journal of Experimental Child Psychology, 1981, 32, 185-199.

Swain, M. Writing skills of grade 3 French immersion pupils. *Working Papers on Bilingualism*, 1975, *7*, 1-38.

Swain, M. French immersion: Early, late or partial? *Canadian Modern Language Review*, 1978, *34*, 577-585.

Taylor, M. Speculations on bilingualism and the cognitive network. *Working Papers in Bilingualism*, 1974, *2*, 68-124.

Tweedy, J.R., Lapinski, R.H., & Schvaneveldt, R.W. Semantic context effects on word recognition: Influence of varying the proportion of items presented in an appropriate context. *Memory & Cognition*, 1977, *5*, 84-89.

Vygotsky, L.S. *Thought and language*. Cambridge, Mass.: M.I.T. Press, 1962.

Warren, R.E. Stimulus encoding and memory. *Journal of Experimental Psychology*, 1972 *94*, 90-100.

Warren, R.E. Time and spread of activation in memory. *Journal of Experimental Psychology: Human Learning and Memory*, 1977, *3*, 458-466.

Weinreich, V. *Languages in contact*. The Hague: Mouton, 1953.

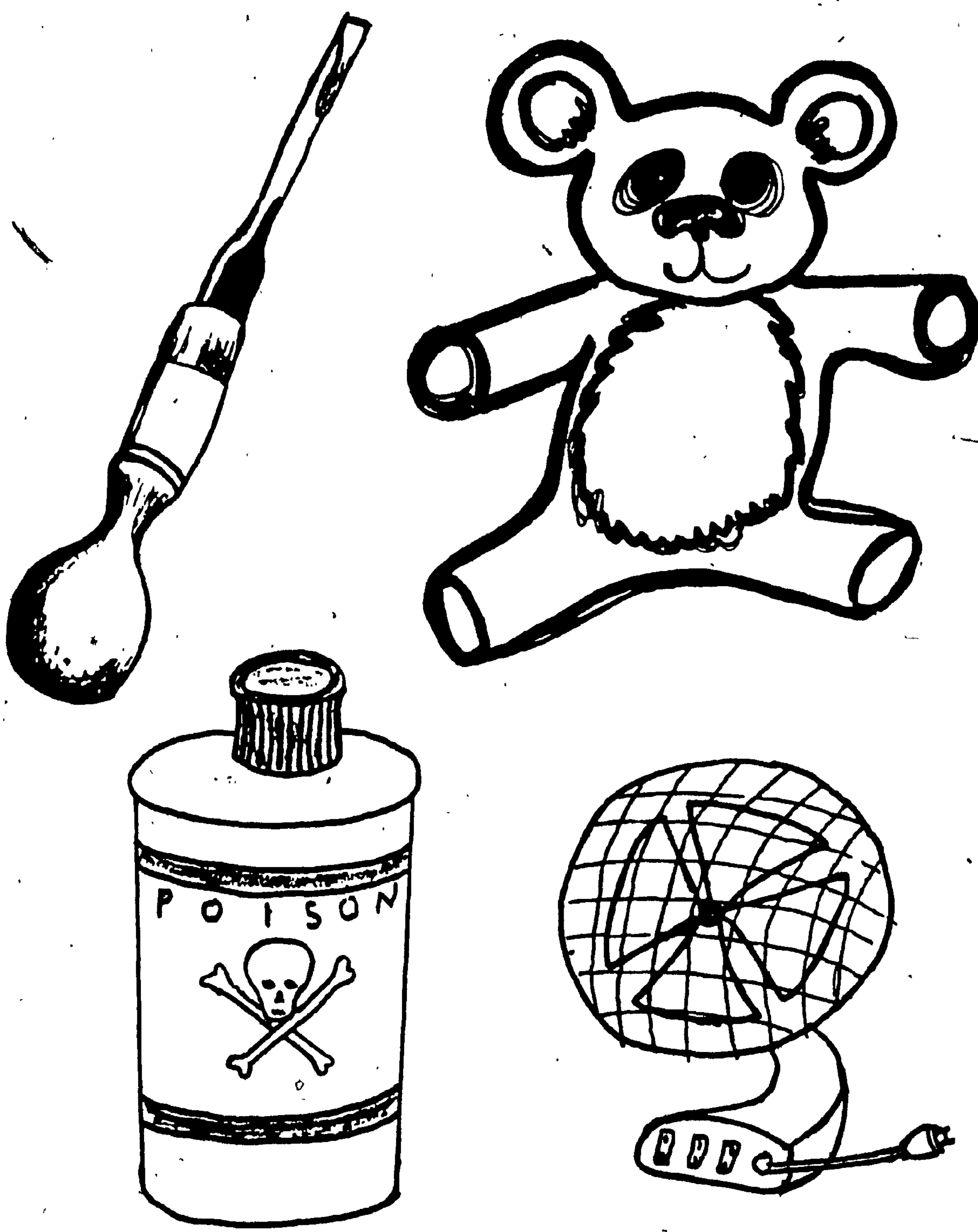
West, R.F., & Stanovich, K.E. Automatic contextual facilitation in readers of three ages. *Child Development*, 1978, *49*, 717-727.

West, R.F., & Stanovich, K.E. Source of inhibition in experiments on the effect of sentence context on word recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 1982, *8*, 385-399.

Wickelgren, W.A. Network strength theory of storage and retrieval dynamics. *Psychological Review*, 1976, *83*, 466-478.

APPENDIX A

Sample of drawings used in Experiments.



APPENDIX B

Mean reaction time (in msec.) for physically identical, same category and different category data at high and low levels of prototypicality and 200, 500 and 1650 SOA for neutral, English and French primed trials - Experiment 2.

Physically Identical

	High			Low		
SOA:	200	500	1650	200	500	1650
Neutral	752	762	800	796	817	866
English	728	717	741	848	910	944
French	739	735	745	876	943	945

Same Category

	High			Low		
SOA:	200	500	1650	200	500	1650
Neutral	1046	1138	1141	1512	1608	1642
English	939	916	971	1370	1352	1355
French	954	897	949	1438	1336	1511

Different Category

	High			Low		
SOA:	200	500	1650	200	500	1650
Neutral	1253	1201	1325	1462	1475	1556
English	1121	1163	1274	1380	1416	1651
French	1195	1213	1268	1499	1478	1631

APPENDIX C

Analysis of variance summary table for physically identical data in Experiment 2.

Source	df	Mean Square	F	Sig. Level
I (SOA)	2	68500.8	2.47	n.s.
IXS (Subject)	34	27750.5		
T (Prototypicality)	1	1501990.1	37.23	<.001
TXS	17	40347.8		
P (Prime)	2	27425.1	6.11	<.006
PXS	34	4484.9		
IXT	2	26412.1	2.25	n.s.
IXTXS	34	11751.6		
IXP	4	3324.2	.72	n.s.
IXPXS	68	4605.5		
TXP	2	134112.0	21.86	<.001
TXPXS	34	6135.8		
IXTXP	4	3525.9	.75	n.s.
IXTXPXS	68	4710.5		
S	17	277983.0		

APPENDIX D

Analysis of variance summary table for same category data in Experiment 2.

Source	df	Mean Square	F	Sig. Level
I (SOA)	2	99232.1	.90	n.s.
IXS (Subject)	34	110507.0		
T (Prototypicality)	1	1741210.0	76.73	<.001
TXS	17	226920.0		
P (Prime)	2	1221150.0	45.20	<.001
PXS	34	27013.8		
IXT	2	8030.7	.13	n.s.
IXTXS	34	63753.0		
IXP	4	80885.0	2.74	<.04
IXPXS	68	29542.4		
TXP	2	45936.5	2.86	n.s
TXPXS	34	16050.6		
IXTXP	4	18969.0	.68	n.s.
IXTXPXS	68	27750.6		
S	17	966946.		

APPENDIX E

Analysis of variance summary table for different category data in Experiment 2.

Source	df	Mean Square	F	Sig. Level
I (SOA)	2	605431.0	1.56	n.s.
IXS (Subject)	34	387869.0		
T (Prototypicality)	1	6428760.0	24.84	<.001
TXS	17	258798.0		
P (Prime)	2	75092.7	2.30	n.s.
PXS	34	32693.9		
IXT	2	36292.1	.42	n.s.
IXTXS	34	86645.9		
IXP	4	43960.2	1.43	n.s.
IXPXS	68	30813.2		
TXP	2	40035.2	1.09	n.s.
TXPXS	34	36616.6		
IXTXP	4	20149.1	.59	n.s.
IXTXPXS	68	34353.1		
S	17	197832.0		

APPENDIX F

Mean reaction time (in msec.) for physically identical, same category and different category data at high and low prototypicality and 200, 500 and 1650 SOA for neutral, English and French primed trials - Experiment 3.

Physically Identical

	High			Low		
SOA:	200	500	1650	200	500	1650
Neutral	799	815	849	814	855	913
English	775	742	785	855	919	955
French	779	739	827	862	916	995

Same Category

	High			Low		
SOA:	200	500	1650	200	500	1650
Neutral	1104	1193	1153	1537	1551	1779
English	900	909	962	1360	1283	1406
French	974	889	1006	1562	1488	1609

Different Category

	High			Low		
SOA:	200	500	1650	200	500	1650
Neutral	1223	1253	1304	1380	1551	1525
English	1173	1183	1178	1391	1441	1442
French	1171	1175	1230	1464	1551	1480

APPENDIX G

Analysis of variance summary table for physically identical data in Experiment 3.

Source	df	Mean Square	F	Sig. Level
I (SOA)	2	161427.0	3.22	n.s.
IXS (Subject)	34	50058.9		
T (Prototypicality)	1	936379.0	48.79	<.001
TXS	17	19191.8		
P (Prime)	2	776.3	.18	n.s.
PXS	34	4262.6		
IXT	2	46819.8	4.36	<.03
IXTXS	34	17731.6		
IXP	4	1308.7	.34	n.s.
IXPXS	68	3887.2		
TXP	2	98832.5	11.66	<.001
TXPXS	34	8476.7		
IXTXP	4	7925.9	2.08	n.s.
IXTXPXS	68	3809.3		
S	17	345219.0		

APPENDIX H

Analysis of variance summary table for same category data in Experiment 3.

Source	df	Mean Square	F	Sig. Level
I (SOA)	2	302269.0	1.89	n.s.
IXS (Subject)	34	159594.0		
T (Prototypicality)	1	2011220.0	42.45	<.001
TXS	17	473761.0		
P (Prime)	2	1683230.0	35.93	<.001
PXS	34	46849.6		
IXT	2	89228.7	1.13	n.s.
IXTXS	34	79102.8		
IXP	4	47755.1	1.01	n.s.
IXPXS	68	47359.0		
TXP	2	209360.0	4.30	<.03
TXPXS	34	48737.3		
IXTXP	4	51613.4	.81	n.s.
IXTXPXS	68	63572.0		
S	17	1898340.0		

APPENDIX I

Analysis of variance summary table for different category data in Experiment 3.

Source	df	Mean Square	F	Sig. Level
I (SOA)	2	124524.0	.73	n.s.
IXS (Subject)	34	169436.0		
T (Prototypicality)	1	5459750.0	89.12	<.001
TXS	17	61265.7		
P (Prime)	2	139171.0	4.81	<.02
PXS	34	28925.2		
IXT	2	56481.9	1.56	n.s.
IXTXS	34	36231.8		
IXP	4	21675.9	1.16	n.s.
IXPXS	68	18661.3		
TXP	2	47796.5	1.99	n.s.
TXPXS	34	24073.8		
IXTXP	4	15602.3	.84	n.s.
IXTXPXS	68	18513.7		
S	17	1055510.1		

APPENDIX J

Mean reaction time (in msec.) for same category data at 200 and 1650 SOA as a function of prototypicality, presentation and language and for different category data at 200 and 1650 SOA as a function of prototypicality and language - Experiment 4.

Same Category

	High				Low			
	BL.	LO	L1	L2	BL.	LO	L1	L2
At 200 SOA:								
English	848	721	752	775	1101	966	963	1043
French	910	778	840	858	1216	1189	1154	1211
At 1650 SOA:								
English	967	804	873	956	1167	972	1059	1117
French	1022	859	1038	1015	1277	1142	1255	1257

Different Category

	High	Low
At 200 SOA:		
English	1007	1121
French	1058	1205
At 1650 SOA:		
English	1168	1233
French	1158	1276

APPENDIX K

Analysis of variance summary table for same category data in Experiment 4.

Source	df	Mean Square	F	Sig. Level
I (SOA)	1	1186370.0	2.46	n.s.
IXS (Subject)	34	482131.0		
T (Prototypicality)	1	9331240.0	343.55	<.001
IXT	1	237210.0	6.19	<.02
TXS	34	38314.0		
L (Language)	1	2112780.0	38.91	<.001
IXL	1	713.3	.13	n.s.
LXS	34	54305.0		
P (Presentation)	3	478032.0	29.24	<.001
IXP	3	67737.3	4.14	<.01
PXS	102	16347.6		
TXL	1	268799.0	7.47	<.01
IXTXL	1	8796.9	.24	n.s.
TXLXS	34	36002.7		
TXP	3	11666.7	.54	n.s.
IXTXP	3	7519.1	.35	n.s.
TXPXS	102	21791.9		
LXP	3	34652.8	2.88	n.s.
IXLXP	3	9088.7	.75	n.s.
LXPXS	102	12045.5		
TXLXP	3	13023.1	.80	n.s.
IXTXLXP	3	2941.2	.18	n.s.
TXLXPXS	102	16240.5		

APPENDIX L

Analysis of variance summary table for different category data in Experiment 4.

Source	df	Mean Square	F	Sig. Level
I (SOA)	1	441228.0	1.77	n.s.
S (Subject)	34	249446.0		
T (Prototypicality)	1	441671.0	38.85	<.001
IXT	1	13475.3	1.18	n.s.
TXS	34	11367.3		
L (Language)	1	63966.8	5.10	<.04
IXL	1	23639.1	1.88	n.s.
LXS	34	12542.3		
PXL	1	16533.7	2.09	n.s.
IXPXL	1	875.2	.11	n.s.
PXLXS	34	7891.8		