

THE EFFECT OF LANGUAGE PROFICIENCY
AND L2 VOCABULARY LEARNING STRATEGIES
ON PATTERNS OF BILINGUAL LEXICAL PROCESSING

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1. Introduction

The present paper describes the study carried out in order to demonstrate that the proficiency of the L2 (nonnative) language and the L2 vocabulary learning strategies are important determinants for the pattern of bilingual lexical processing. In the paper, I offer a brief critical analysis of the recently developed models of bilingual lexical representation and processing and then propose the variable interconnection hypothesis, attempting to provide a framework within which the issue of bilingual lexical representation and processing can be addressed more adequately. I next describe the LDT experiment, which I carried out with Polish-English bilingual language users in order to verify the variable interconnection hypothesis. The results of the experiment suggest that the language learner's L2 proficiency and their preferred L2 vocabulary learning strategies exert a considerable influence on the patterns of lexical representation and processing.

2. Recent models of bilingual representation and processing

One recent interest in the psycholinguistic research on bilingualism has been the issue of how bilingual language users store and process their L2 lexis. A number of proposals have emerged and psycholinguists have set out to test their validity. These proposals came to be known as 'processing hypotheses' or 'models of bilingual lexical representation and processing' (Chen and Leung 1989). All of these models share their commitment to differentiating between the underlying level of abstract concepts, common for the bilingual's two languages, and a lexical level of language-specific representations of L1 and L2 lexis. What differentiates between these various models is the nature of links, or connections, assumed to hold between the conceptual and lexical representations in the bilingual mental lexicon.

Two kinds of links have been postulated to hold between lexical representations within the mental lexicon. These are associative links, also referred to as lexical links (Altarriba 1992, Kroll and Sholl 1992), and referential, or conceptual links. Researchers of bilingual language processing seem to agree that associative links are those connecting word representations at the lexical level of the bilingual lexicon, while conceptual links hold between word representations and their meaning specifications at the conceptual level of the language system. Although there appears to be no disagreement among psycholinguists about defining the links themselves, there does occur some disagreement over which of the links are claimed to be present in the bilingual mental lexicon. It is precisely this issue that distinguishes between the various recently developed models of bilingual lexical representation.

Beginning with the word association model, it assumes the existence of direct associative links between semantically related words within a language and between translation equivalents. Semantically related words across languages are not connected under this account. Referential links hold only between L1 words and concepts, so that L2 words are connected to concepts indirectly, via their L1 translation equivalents (Chen 1992, Chen and Leung 1989, Keatley 1992, Kroll and Sholl 1992).

In contrast, the word interconnection model proposes that all kinds of lexical items, i.e., translation equivalents and semantically related words within and across languages, are interconnected via associative links (Chen and Leung 1989). However, the model does not specify whether conceptual links hold between both L1 and L2 words and concepts or only between L1 words and concepts.

The concept mediation model in turn, precludes the existence of associative links at the lexical level, claiming instead that L1 and L2 words are only linked indirectly, via amodal concepts which they share, and with which they are connected by means of conceptual links (Chen 1992, Chen and Leung 1989, Keatley 1992).

Next, the intermediate model of bilingual lexical representation suggests that beginner L2 learners use L1-to-L2 associations to process L2 lexis, while proficient bilinguals employ the concept-to-L2 links in producing L2. This is so because less advanced bilinguals cannot access concepts directly from L2 words due to the lack of conceptual links between them. Less advanced learners are therefore assumed to have only associative links developed in their mental dictionaries. As bilinguals become more proficient in their second language, direct conceptual links from the second language store to the conceptual store are also established (Chen 1992, Chen and Leung 1989).

Finally, the hierarchical model, building on the intermediate model, assumes the existence of both associative and conceptual links, but postulates that they vary in strength. Strong associative links proceed from L2 to L1 translation equivalent items, while weak associative links – from L1 to L2 items. Likewise, conceptual links connecting L1 items with their conceptual specifications are strong, while those connecting L2 items with concepts are weak and develop only gradually as the L2 learner becomes more proficient (Altarriba 1992, Kroll and Sholl 1992, Kroll 1993).

In what follows, I shall first present my reasons for rejecting each of these models and then propose the variable interconnection hypothesis which accounts for the nature of links holding between bilingual lexical representations.

As far as the word association model is concerned, I find two assumptions adopted by the model quite unacceptable. The first concerns the model's prediction that semantically related words across languages do not enter into meaning relations with one another via associative links. The model thus maintains that, while the English word *dog* will be linked to the semantically related English word *cat*, it will not be linked to the Polish semantically related word *kot*.

This assumption must be rejected in light of numerous psycholinguistic experiments which have demonstrated interlingual semantic priming effects (see, for example, Chen and Ng 1989, Grainger and Dijkstra 1991, Kirsner *et al.* 1984, Schwanenflugel and Rey 1986). These experiments have repeatedly shown that semantic facilitation, as measured by subject's reaction time on a lexical decision task, is either identical or highly comparable for both between- and within-language primes. Thus, subject's lexical decision to the word *dog* would be equally facilitated by the presentation of the within language semantic prime *cat* as by the presentation of the between-language prime *kot*. These results could not be accommodated by the word association model, which precludes the existence of associative links between semantically related items across languages and which, therefore, prohibits the possibility of interlingual semantic facilitation.

The second assumption of the word association model that I shall argue against is the claim that conceptual links obtain only between L1 lexical representations and concepts. Thus the model disallows direct connections between L2 items and their underlying concepts, assuming that L2 words are linked to concepts only indirectly, via their corresponding L1 translations. The grave consequence such a claim has for the bilingual language processing model is the implication that any kind of bilingual language processing, be it production or comprehension of language, involves 'mental translation' on the part of the bilingual language user. Hence, in order to produce an L2 utterance, the bilingual person, being unable to access L2 words directly from concepts, would first need to access L1 translation equivalents of the to-be-produced L2 words. Only then would L2 words become available for production.

On the comprehension side, upon hearing an L2 word, the bilingual would first need to access its L1 translation equivalent before finding out what the word means. This is a very unlikely scenario and an unnecessarily complicated one. It also confers a very restricted view on the process of becoming bilingual, in that it treats all bilinguals as a homogenous group acquiring their L2 in an essentially identical way, i.e., by the medium of their L1.

The acquisition of L2 through L1 instruction is, indeed, likely to instill strong associative links between translation equivalent items in the bilingual's mental dictionary. While many L2 learners do become bilingual by receiving instruction in their L1, there exists a wide population of bilinguals who acquire their L2 by immersing themselves in the L2 culture. In many cases such bilinguals learn new L2 words without really knowing their direct L1 translation equivalents. How would the word association model account for such bilinguals' ability to speak and understand L2 words? Presumably it wouldn't, since it fails to take into account many essential factors involved in, and contributing to, the process of becoming bilingual.

Depending on whether a bilingual is taught L2 by the medium of his or her L1 or whether he or she absorbs L2 while living in an L2-speaking country, different patterns of lexical representation are likely to emerge. Individual learning preferences, such as learning L2 words in translation-pair lists or in semantic sets as synonyms, without translating them to L1, will also have a great impact on the emerging bilingual lexical network. As long as the word association model fails to take these factors into account, it has to be rejected as partial and invalid.

Turning now to the word interconnection model, it is a considerable improvement on the word association model, as it allows associative links between all kinds of lexical items within the bilingual network. Under this model, then, interlingual semantic priming effects can be easily accounted for. However, what seems to be a major flaw of the model is its failure to acknowledge different types of learning experience that bilinguals can go through. By postulating that associative links between various kinds of lexical representations are the same for all bilingual speakers, the word interconnection model fails to address individual learning differences between L2 learners. It thus predicts that associative links between L1 and L2 translation equivalents will be the same for L2 learners acquiring their L2 through L1 instruction as for L2 learners becoming immersed in L2 without any recourse to their L1. Even though no empirical research has been carried out to prove this point, it seems intuitively appealing to claim that the nature of associative links holding between lexical representations in the lexicons of such two types of bilingual will be essentially different.

It therefore seems that, like the word association model, the word interconnection one cannot provide a means of accounting for varying lexical representations resulting from different kinds of bilingual experience. Let's examine if the concept mediation model offers a better account of bilingual lexical representation.

As has already been mentioned, the concept mediation model assumes the existence of conceptual links between L1 and L2 lexical units and their underlying amodal concepts. What I would argue against is the assumption that no associative links exist between lemma nodes at the semantic-syntactic level of the lexical network. Thus, within the concept mediation model, the semantically related items *dog* and *cat*, as well as translation equivalent items *dog* and *pies* are not directly linked with one another. They are linked only indirectly via amodal concepts that they share. Such a view of the bilingual lexicon fails to capture what seems to be a well-documented characteristics of lexical representations, namely, the fact that they are clustered into semantic fields within which lemmas enter into various kinds of meaning relations with one another.

Proceeding now to the intermediate hypothesis of bilingual lexical representation, it attempts to account for varying patterns of lexis processing by beginner and advanced L2 learners. Its main assumption is that beginner L2 learners process L2 words through their L1 translations, since they lack direct conceptual links between L2 items and concepts. As their proficiency increases, L2 learners start to employ conceptual links in L2 processing, since these links become established as well. Thus, the major difference between less and more advanced bilinguals is, under this

view, the fact that the former have only associative links while the latter have conceptual links as well in their mental lexicons.

The assumption that all beginner L2 learners process L2 words through their L1 translation equivalents and that they cannot establish direct links with corresponding concepts is, in my opinion, highly controversial. For one thing, it fails to take into account, as do the models discussed above, an essential factor influencing bilingual experience, namely, the context of L2 acquisition. But even disregarding this fact and assuming that the model accounts only for learners acquiring their L2 through L1-mediated school instruction, which promotes L2-to-L1 links, one cannot state for sure that such L2 learners do not establish links between L2 items and their underlying concepts.

Being a second language learner myself, I think it is highly unlikely and counterintuitive to postulate that a beginner L2 learner can access the concept DOG only by translating the L2 item *dog* into its Polish equivalent *pies*. Even if beginner L2 learners do tend to 'mentally translate' L2 words into L1 when processing them, it does not mean that they cannot simultaneously access their conceptual specifications through direct links obtaining between L2 items and concepts. I would claim that they can, indeed, do it, especially if L2 words are highly imageable and concrete, in which case their conceptual specifications are identical to those for corresponding L1 items.

The final model to be discussed, the hierarchical one, is basically a modification of the intermediate hypothesis. Like the intermediate hypothesis, it assumes that beginner L2 learners will process their L2 via L1 mediation, while proficient bilinguals will have a direct access to concept nodes and so they will process L2 via conceptual mediation. This assumption has already been criticized in the paragraphs above, so I shall not repeat my critical remarks here.

What I would wish to focus on is yet another assumption made by proponents of the hierarchical model, namely, that associative and conceptual links vary in strength. Accordingly, the model postulates that associative, or lexical, links from L2 to L1 translation equivalents are stronger than lexical links from L1 to L2. In turn, conceptual links between L1 items and their underlying concepts are stronger than conceptual links between L2 items and concepts, since the former are the first to be acquired.

The difference in strength of associative links between L1 and L2 has been postulated by Kroll and Stewart (1990) in an attempt to account for the particular result that they obtained on translation task, namely, that the speed and accuracy of translation depends on the direction of translation. Performance of nonfluent and fluent bilinguals employed in their study was similar in that both groups translated faster and more accurately from the second language into the first (L2 to L1) than from the first language into the second (L1 to L2). This asymmetry in translation latencies led them to hypothesize that the two forms of translation reflected a difference in reliance on lexical vs conceptual mappings. More specifically, they postulated that translation from L1 to L2 required concept mediation and thus took longer, whereas translation from L2 to L1 could be accomplished directly by lexical mediation from L2 to L1.

The hypothesis that the translation route from L1 to L2 requires conceptual processing while the route from L2 to L1 is mediated by lexical connections appears to be controversial and unconvincing. First of all, the hypothesis makes a curious and quite unrealistic assumption that the bilingual can 'cut off', or block, certain connections while processing one language and others while processing another language. More specifically, it assumes that, for reasons difficult to comprehend, when translating an L1 item into L2, the bilingual cannot address the L2 item directly, despite the fact that both items are connected via a lexical link. Instead, s/he has to first access the concept underlying both items, and only from there activate the L2 translation. What it essentially amounts to postulating is that, when translating from L1 to L2, the bilingual has to temporarily 'cut off' or block a direct associative link connecting translation equivalents in his or her mental dictionary, so that the corresponding L2 item can be accessed indirectly, via mediation of the conceptual level. Why this should be so or what mechanism could be responsible for blocking direct access of L2 items via existing lexical links remains unexplained.

Likewise, the authors fail to justify why translation from L2 to L1 should proceed directly via lexical mediation, rather than indirectly, via conceptual mediation. Surely conceptual links do obtain between L2 units and concepts, since they are supposedly employed in mediating translation from L1 into L2. Since Kroll and Stewart fail to provide any sound theoretical justification for their claims, the account of the observed asymmetries they propose cannot be taken as a very convincing one.

In light of this fact, there appears to be no compelling reason for adopting this particular hypothesis, especially since one can think of a number of more plausible alternative explanations of the reported asymmetry. Greater speed of translation from L2 to L1 than from L1 to L2 may be an effect of instruction, resulting from the fact that L2 learners are more likely to perform language tasks requiring translation from their L2 to L1 than vice versa. Also, when learning new vocabulary items, learners tend to mentally encode them in terms of their corresponding L1 translations, so that the direction of processing when encountering new L2 lexis proceeds from L2 to L1, rather than from L1 to L2. On the other hand, the translation route from L1 to L2 is employed by L2 learners only in other types of task, such as L1-to-L2 translation exercises. It is, therefore, very likely that subjects' performance in Kroll and Stewart's study resulted from a particular type of L2 instruction that they received.

Another possible account of the effect observed by Kroll and Stewart deals with the concept of 'automatization' of language processing. This concept, well-established already in William James' (1930) psychological writings, underlies the information-processing frameworks of language acquisition, which describe the acquisition of language skills as a gradual change from controlled to automatic processing of language representations (Hulstijn 1989, McLaughlin, Rossman and McLeod 1983, McLaughlin 1990).

More specifically, under the information-processing approach, the acquisition of language skills is viewed as the establishment of complex procedures, integrating elementary pieces of information. In the beginning stages of skill acquisition, the se-

lection and coordination of these pieces of information, and their subsequent integration into procedures, requires a great deal of attention on the part of the learners. With growing practice, the execution of the steps in such a procedure becomes a matter of routine, until finally a ready-made procedure is formed in long-term memory. As the procedure gains a place in long-term memory, the execution of its parts does not require much attention any more, and its processing is automatic.

Essentially the same mechanism can be postulated for directionality effects reported by Kroll and Stewart in translation tasks. Since translation from L2 to L1 is likely to be much more often performed by L2 learners than translation from L1 to L2, to use the information-processing terminology, the 'procedure' for the former is much more automatic and thus executed faster than that for the latter.

On the whole, it seems that the hierarchical model proposed by Kroll and Sholl (1992) lacks sound theoretical justification. The reported asymmetry in translation, which led the authors to put forward the model, might be as well explained as the effect of instruction or as the function of skill automaticity involved in translation from L2 to L1 on the one hand, and from L1 to L2 on the other.

In short, it seems that the major weakness of the recently developed models of bilingual lexical representation and processing is their failure to take into account essential factors influencing bilingual experience, such as the context of L2 acquisition and different learning strategies employed by bilingual learners to acquire L2 lexis.

3. The variable interconnection hypothesis

Unlike the models reviewed above, the model that I am proposing in this paper does take all these factors into account and assigns them a major role in determining the nature of associative connections obtaining between lexical units in the bilingual's mental dictionary. Influence of these varying factors contributing to bilingual experience on the strength of bilingual lexical connections is captured by what I have labeled the 'variable interconnection hypothesis'.

The variable interconnection hypothesis postulates that two kinds of links exist between nodes of the bilingual lexical network. These are associative links and the conceptual links. The former connect together L1 and L2 lemmas at the semantic-syntactic level of the lexicon. The latter lead from L1 and L2 lemmas to their concept nodes at the conceptual level of the language system. Associative links are assumed to connect semantically related items both within and across languages, as well as translation equivalents. The variable interconnection hypothesis holds that associative links connecting various nodes will vary in strength according to the type of a bilingual person's experience in his or her L2.

To provide an example, an L2 learner whose second language learning experience occurs exclusively in a classroom setting, via L1-mediated instruction, is likely to develop strong associative links between L1 and L2 translation equivalents in his or her mental lexicon. At the same time, associative links between semantically related L2 items in such a bilingual's lexicon are likely to be much weaker than those connecting L1 and L2 translations.

In contrast, an L2 learner who gets immersed in the second language, either because of living in an L2-speaking country or because of obtaining intensive instruction conducted solely in L2, is likely to develop a differing pattern of lexical representations. The lexicon of such a bilingual person will contain very strong associative links connecting semantically related lexical units within and across languages. On the other hand, associative connections linking translation equivalents will be much weaker, or in some cases even non-existent; the situation experienced on occasion by many bilingual speakers who 'know' what the L2 word means, can use it perfectly well in context and cite a list of its synonyms, yet are unable to provide its exact L1 equivalent.

It follows from the foregoing that any suggested model of bilingual lexical representation and processing must specify in detail the type of bilingual speakers to whom it refers in terms of their L2 learning experience. Likewise, it appears an implausible, or, should I say, an inappropriate undertaking, to put forward a bilingual model of lexical representation and processing which aspires to account for the totality of the world's bilingual population. In light of these considerations, the lexical models proposed so far are simply inadequate, as they claim to account for language processing executed by bilinguals undefined as to their language learning background. It seems only natural then that experimental studies conducted in support of each of the proposed models have provided widely differing and contradictory results – each study has probably investigated a different group of bilingual subjects varying in terms of their L2 experience.

To avoid this methodological pitfall, I will first define the type of bilingual population to whom predictions of the variable interconnection hypothesis have been applied. The model as elaborated on in this paper refers to Polish learners of English at a high school and University levels. These learners differ in their L2 proficiency and preferred vocabulary acquisition strategies. High school Polish students who participated in my experiment can be viewed as beginning, or nonfluent bilinguals, whose L2 acquisition occurs mostly through L1-mediated instruction in an institutionalized setting. They have almost no contacts with native speakers of English and, apart from satellite television, radio or newspapers, school is their only source of English. The learning strategy they adopt most often is that of translating a newly acquired L2 item into Polish and remembering the Polish equivalent. They will sometimes learn a new English word in a larger context or record its semantic associates, such as a synonym or collocation. Their overriding vocabulary learning strategy, however, is that of remembering English-Polish translation pairs. The Polish high school learners of English constituted in my experiment a group of nonfluent Polish-English bilinguals, referred to in further analysis as Group A.

In turn, University students, can be defined as highly proficient and fluent bilinguals, who have become partially immersed in their L2 due to instruction carried out largely in English. They receive, on average, as many as around 20 hours of input in English a week, a substantial amount of it coming from native speakers. Some of them have been to English-speaking countries, having spent there a year or more. Some maintain social relations with native speakers outside their classroom.

These proficient bilinguals differ with respect to their bilingual experience and vocabulary learning strategies that they employ. While some of them rely largely on learning L2 lexis in L2 semantic sets, to the neglect, or even exclusion, of L1 translations, others do employ the strategy of remembering translation equivalent L1-L2 pairs. University students constituted the fluent bilingual group in my study, and they were further divided into two subgroups, depending on their preferred vocabulary learning strategy. Group B comprised those fluent bilingual language users whose favorite vocabulary learning strategy was that of remembering L2 words in L2 semantic sets (the 'L2 semantic set' subgroup); while Group C – those fluent students of English who learned L2 vocabulary in English-Polish translation pairs (the 'paired-associate' subgroup).

Having described the type of bilingual subjects whose patterns of lexical representation and processing have been examined in my study, I shall now turn to the description of these bilinguals' lexical network, as envisaged by the variable interconnection hypothesis.

4. Lexical network of nonfluent Polish-English bilinguals

Beginning with nonfluent Polish high school learners of English, it seems justified to assume that the L2 lexicon of such nonfluent bilinguals is only fragmentary and largely incomplete. Thus, the emerging bilingual lexicon will consist of a relatively well established morpho-phonological-orthographic level, including lexeme specifications of L2 items' orthographic, morphological and phonological properties, as well as of a partially developed semantic-syntactic level. At the semantic-syntactic level, most lemma entries have not yet been 'filled' with complete information about a word's semantic-syntactic properties, and not all associative links between lemma nodes have been formed.

Under the variable interconnection hypothesis, associative links obtaining between semantically related items within a language are much stronger than those connecting semantically related items across languages. The hypothesis hence predicts that the semantically related lexical items *kot* and *pies* will be more tightly linked than the semantically related items *kot* and *dog*, as the latter pair belongs to two different languages.

The rationale behind this claim lies in the fact that semantically related lexical items are much more likely to be encountered together within a language than across languages. In case of our beginning Polish-English bilingual, semantically determined associative links between his or her L1 lemmas have been formed long before the L2 is acquired. It is therefore only natural that these well-established links will be stronger than the newly created ones. Likewise, L2 items are much more likely to cooccur with semantically related L2 items (e.g., when being taught in semantic sets) than with semantically related items in the learner's mother tongue. With nonfluent Polish-English bilinguals, lemmas for English words will be largely incomplete, and only weak associative links will obtain between them. Similarly, links connecting semantically related L1 and L2 lemmas will be very tenuous.

A further assumption of the variable interconnection hypothesis for our group of Polish-English nonfluent bilinguals is that in their lexicons direct translation equivalents are bonded more strongly than just semantically related lexical items across languages, but less strongly than semantically related items within the learners' L1. Thus, the associative link between *kot* and *cat* (translation equivalents) will be stronger than that between *kot* and *dog* (across-language semantic relation) but weaker than the associative link between *kot* and *pies* (within-language L1 semantic relation).

This is so because, especially in the beginning stages of foreign language acquisition, high school L2 learners seem to employ translation strategy to encode and process L2 lexis. This strategy is also encouraged by L2 instruction, which, in most Polish high schools, is mediated through the learners' mother tongue. Therefore, while semantically motivated associative links between L1 and L2 lemmas may still be only partial or even non-existent in the lexicon of a nonfluent Polish-English bilingual, associative links between L1 and L2 translations will very likely exist. These links will, however, be weaker than those grouping L1 lemmas into semantic fields, as the latter were the first to be established.

Finally, the variable interconnection hypothesis assumes that direct conceptual links are created between L2 lemmas and their amodal concept nodes as soon as lemma entries are coded in the lexicon. Thus, unlike the intermediate hypothesis and hierarchical model, which proposed that newly acquired L2 items are linked to the conceptual level only indirectly, via associative links with their corresponding L1 items, the variable interconnection hypothesis does allow for accessing the conceptual level directly from L2 lemmas. The essential implication it carries for lexical processing is that nonfluent bilinguals can process L2 items without the lexical mediation of their L1 translations.

However, since a beginning L2 learner's knowledge about semantic and pragmatic characteristics of a newly acquired L2 item is limited, the conceptual link s/he will establish between this item and the conceptual level will be 'incomplete'. What I mean by 'incomplete' is that the meaning code stored in the entry's lemma representation will point to only a few core features of the corresponding concept node at the conceptual level.

As the learner's experience with the L2 item accumulates and his or her semantic knowledge about the word expands, the meaning code for the word will be restructured, so that it will point to other semantic features shared by its corresponding concept node as well. This process of restructuring the meaning address stored in the lemma continues until the learner has acquired a correct conceptual specification of the L2 item's meaning (or until the learner thinks he or she has acquired a correct meaning, the phenomenon known in Second Language Acquisition as 'fossilization', cf. Selinker 1972).

Having described the major predictions of the variable interconnection hypothesis for the group of beginner Polish learners of English, let us briefly review how it envisages the emerging bilingual lexicon. Fragment of such a lexicon is shown in Figure 1.

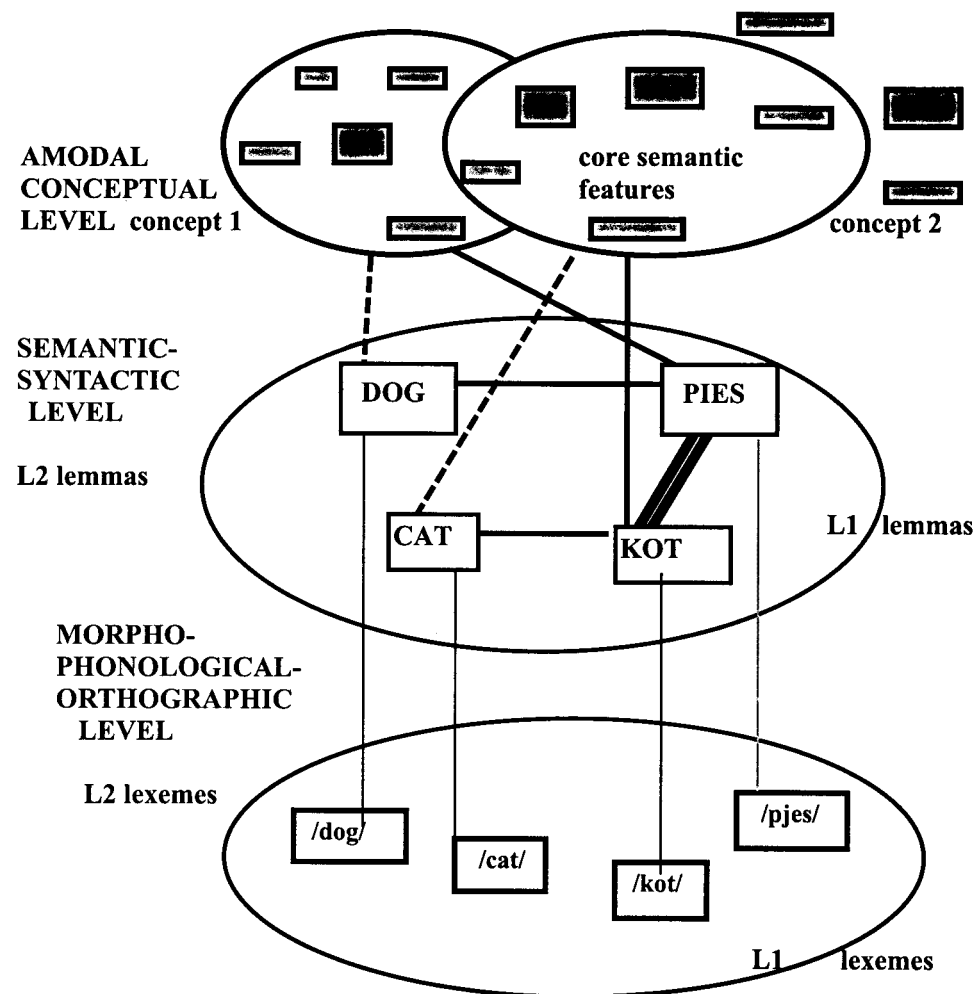


Figure 1. Fragment of the lexical network of a nonfluent Polish-English bilingual.

As can be seen in the Figure, the lexical network of a nonfluent Polish-English bilingual consists of lemmas and lexemes as well as of partially developed links between them. The morpho-phonological-orthographic store for L2 is assumed to be already developed. In the drawing, the lexemes for *cat* and *kot* are linked since they share initial and final phonemes /k/ and /t/, and thus occupy a neighboring space in the phonological network. Proceeding to the semantic-syntactic level, it consists of a network of L1 lemmas with strong associative links connecting semantically related items (as shown by a double line between *kot* and *pies*). The corresponding L2 lemma network is only partially developed in that its entries are incomplete and associative links between them not yet fully established. Lemmas for *dog* and *cat* are, therefore, not connected in the drawing. L2 lemmas are connected with their L1

translations via associative links, which are assumed to be weaker than these connecting semantically related L1 lemmas. Weaker associative links holding between translation equivalents (*dog-pies*, *cat-kot*) are indicated in the Figure by means of a single line. Finally, conceptual links extend from both L1 and L2 lemmas to their semantic feature specifications at the conceptual level. The incomplete nature of conceptual links for L2 lemmas (by which I mean that they are linked to only some of the semantic core features making up the concept nodes that correspond to them) is shown in the drawing by means of dotted lines. Since the figure depicts the emerging bilingual lexicon, inter-language links between semantically related lexical items have not been formed yet in this lexicon. Thus, there are no links extending from *dog* to *kot* and from *cat* to *pies*.

The state of affairs captured by this schematic representation of the lexicon is only momentary, as the lexical network is constantly being developed. New representations are being entered and the nature of links changes as a function of the learner's proficiency and the amount of language processing executed by the language system. As the learner's proficiency increases, the L2 network expands and becomes tightly linked with L1 network, becoming gradually structured along similar lines.

In what follows, I will describe predictions of the variable interconnection hypothesis for the lexicon of proficient Polish students of English. My description will be based on the schematic illustration presented in Figure 2 below. As can be seen in the Figure, the variable interconnection hypothesis predicts that for proficient Polish-English bilinguals, the strongest associative links hold between semantically related lexical items within the bilingual's L1. Thus, double line links *pies* to *kot*. In this respect, the lexicon of a fluent bilingual is similar to that of a nonfluent bilingual, where L1 links are also presumed to be the strongest of all at the semantic-syntactic level of the network.

The difference between the fluent and nonfluent bilingual's lexicon lies in the fact that, while the former contained very tenuous or no links between L2 semantically related items, the fluent bilingual's lexicon does contain strong links connecting L2 semantic associates. Since, however, L2 links are established later than those for L1, associative connections between *dog* and *cat* are presumed to be weaker than those between *pies* and *kot*, as shown by the thinner double line between *dog* and *cat* in the drawing. Next in strength come links between translation equivalents, which are shown by a single line (*dog-pies*, *cat-kot*). The weakest associative links are assumed to obtain between semantically related lemmas across languages, as shown by a dotted line linking *pies* with *cat* and *dog* with *kot*. These links were not present in the emerging bilingual lexicon.

Another difference between the nonfluent and fluent bilingual's lexicon concerns conceptual links extending from L2 lemmas to core semantic features. In the nonfluent bilingual network they were incomplete, while in the fluent bilingual's lexicon they are already well established, since the concept specifications for L2 lexical items have been acquired by the proficient bilingual speaker. The

lines connecting *dog* and *cat* with their corresponding concepts are therefore continuous, and not dotted, as was the case for the nonfluent bilingual's network.

The arrangement illustrated in Figure 2, according to which links between semantically related L2 lemmas are stronger than links between L1 and L2 translations, is true for those students of English who tend to acquire L2 lexis in semantic sets, frequently disregarding their Polish translations. Such bilingual subjects are indeed likely to establish strong links between L2 semantic associates and weaker ones between translation equivalent lexical units.

The strength of lexical links will, however, be different in the mental lexicons of those students who, rather than employing semantic elaboration techniques for remembering new L2 vocabulary, rely on the paired associate learning strategy. By focusing on L1-L2 translation equivalent pairs, instead of on the semantic associates of the target L2 lexis, the paired associate vocabulary learning strategy promotes the establishment of strong associative connections between L1-L2 translation pairs in the bilingual lexicon.

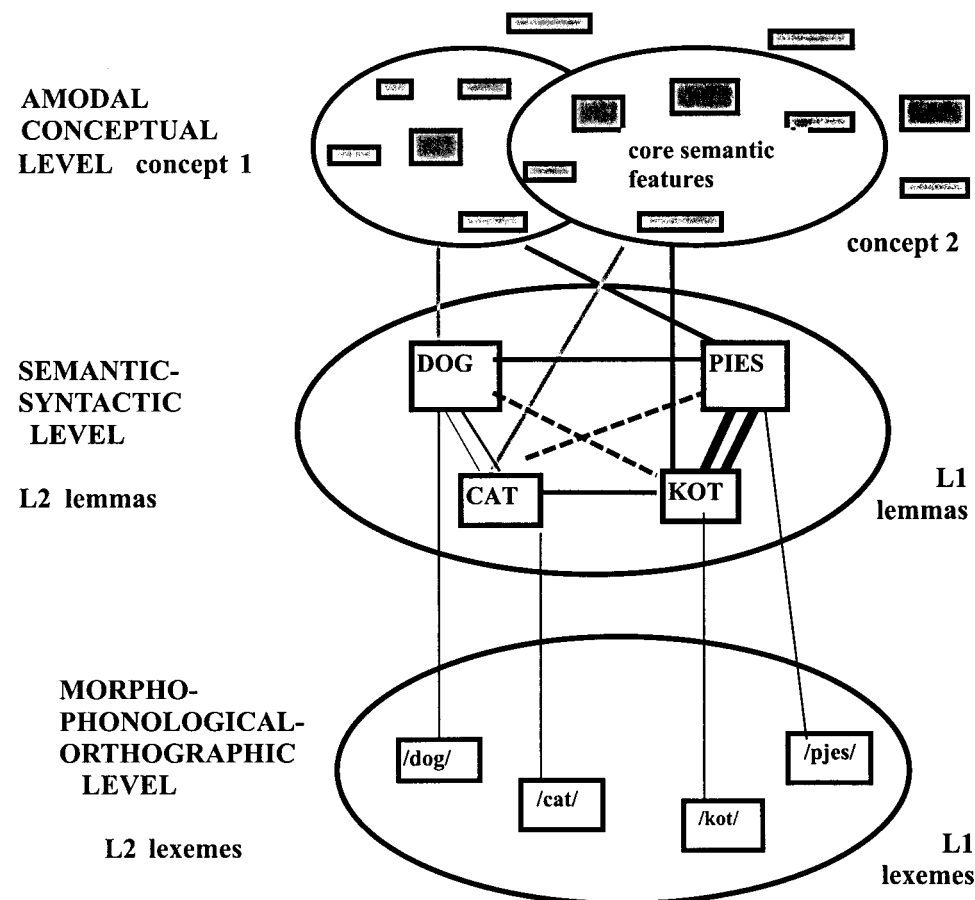


Figure 2. Fragment of the lexical network of a proficient Polish-English bilingual.

To account for such bilinguals' lexical representations, we would have to restructure the semantic-syntactic level along the lines presented in Figure 3 below.

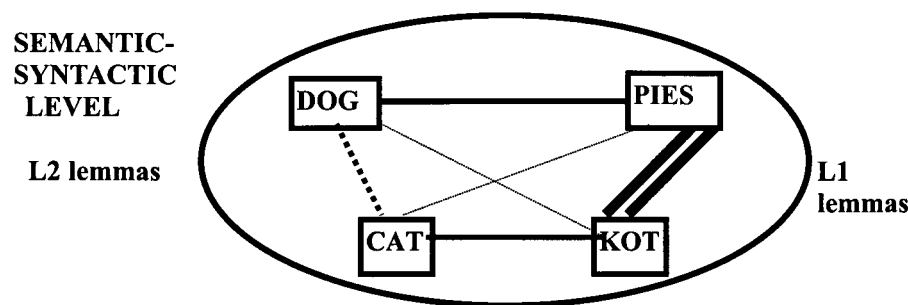


Figure 3. Associative connections at the semantic-syntactic level of a proficient Polish-English bilingual whose preferred L2 learning strategy is based on L1 translations.

Connections between L1 semantic associates remain the strongest, as they were the first to be established in the lexicon. This is shown in the drawing by means of a double line linking lexical items *kot* and *pies*. Next in strength come links between translation equivalents (*dog* and *pies*, *cat* and *kot*), which are stronger than links obtaining between semantically related L2 lemmas (*dog* and *cat*). They are therefore marked in the drawing by means of a single line, while links between L2 lemmas by means of a thick dotted line. The weakest connections hold between inter-language semantically related items (*cat* and *pies*, *dog* and *kot*), which are marked in the drawing as a thin dotted line.

Thus, under the variable interconnection hypothesis, the strength of associative links obtaining between translation equivalents and semantically related items will be determined by students' preferred lexis learning strategy. To find out if these predictions were correct, I conducted the Lexical Decision Task experiment.

5. The Lexical Decision Task experiment research hypothesis

One of the major assumptions of the psycholinguists employing the primed LDT in their investigations is that the amount of priming (defined as the shorter RT to the target stimulus following the prime) reflects the closeness and strength of connections holding between the prime and the target words in the bilingual memory (cf. Altarriba 1992, Chen and Ng 1989, DeGroot 1983, DeGroot and Nas 1991, Gerard and Scarborough 1989, Grainger and Beauvillain 1987, Jin 1989, Keatley 1992, Kirsner *et al.* 1980, Kirsner *et al.* 1984, Meyer and Ruddy 1974, Potter *et al.* 1984, Scarborough *et al.* 1984, Schwanenflugel and Rey 1986, Votaw 1992). Thus, the stronger the connection between any given two words in the bilingual lexical net-

work, the bigger the amount of priming (or the shorter the RT to the target) should be for these two words in the LDT. If, for instance, translation equivalents are postulated to be linked more strongly in the bilingual lexicon than across-language semantic associates, then a Polish-English bilingual subject should respond faster to the target stimulus *DOG* when primed with its translation equivalent *PIES* than when primed with its across-language semantic associate *KOT*.

Based on this reasoning, the following research hypotheses can be formulated for each of our groups of Polish-English bilingual subjects:

For nonfluent Polish-English bilinguals – high school learners of English (referred to as Group A), the shortest RT should be obtained for prime-target pairs containing L1 semantic associates (*pies-kot*); the longer RT – for prime-target translation pairs (*dog-pies*; *pies-dog*); still longer – for L2 semantic associate pairs (*cat-dog*) and across-language semantic associates (*cat-pies*, *dog-kot*); while the longest – for unrelated prime-target within- or across-language pairs (*shoe-live*; *teraz-radość* (*now-joy*); *dyrygent* (*conductor*)-*hot*; *my-kapusta* (*cabbage*)). Thus, the ordering of prime-target relations according to the RT they evoke could be schematically represented in the following way:

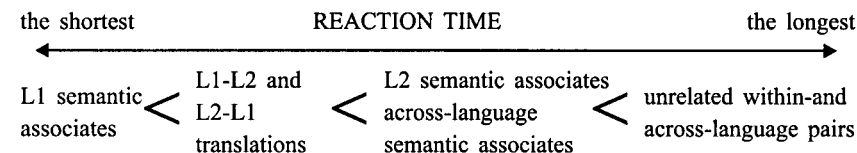


Figure 4. Predicted ordering of RTs to various prime-target pairs for Group A.

The variable interconnection hypothesis makes no specific predictions about the strength of L1-to-L2 versus L2-to-L1 translation connections, so the two types of prime-target relations are grouped together in this ordering. Connections between both Polish-English and English-Polish translation equivalents are assumed to be generally weaker than those holding between Polish semantic associates and generally stronger than the remaining kinds of links existing in the mental dictionaries of nonfluent Polish-English bilinguals. Even though the variable interconnection hypothesis does not distinguish between the two types of prime-target translation pairs in terms of the RTs the two would evoke, it seems intuitively appealing to postulate that English-Polish prime-target pairs will take shorter to identify in the LDT than Polish-English ones, as bilingual subjects' reaction should be faster to native language target words than to L2 target words.

Likewise, for the nonfluent bilinguals, the hypothesis does not differentiate between RTs obtained for L2 semantic associate pairs and those obtained for across-language semantic associate pairs. The two types of prime-target relations are postulated to yield longer RTs than those for either L1 semantic associate pairs or

translation equivalent pairs, but shorter than RTs for unrelated prime-target pairs. This grouping stems from the fact that, under the view adopted here, the developing lexicon of a Polish-English bilingual contains very weak links between L2 semantic associates and comparably weak links extending between across-language associates. The exact nature and strength of these links is difficult to determine, as, depending on individual experience, in some nonfluent bilinguals across-language links or L2 semantic associate links may be nonexistent, while in others – they may already exist but be very weak. Making an exact prediction about the difference in strength between the two types of links would be an impossible task, or, if done, it would lack a sound theoretical justification.

Turning now to research hypotheses for the group of fluent Polish-English bilinguals, they will differ according to the vocabulary learning strategy adopted by individual fluent bilinguals. Depending on the expressed preference for learning L2 lexis either in L2 semantic sets or in translation pairs, the fluent bilingual group has been divided into the 'L2 semantic' subgroup and the 'paired-associate' subgroup. Following are research hypotheses for the two subgroups:

For the 'L2 semantic' subgroup (referred to as Group B in further analysis), the shortest RT should be obtained for prime-target pairs containing L1 semantic associates (*pies-kot*); a slightly longer RT should be shown for L2 semantic associate pairs (*dog-cat*); next in terms of the RT length should be prime-target relation including L1-L2 and L2-L1 translation equivalents; then – still longer RT should obtain for across-language semantic associates (*cat-pies, kot-dog*); and the longest RT – for unrelated within- and across- language prime-target pairs.

Schematically, the ordering of prime-target relations for Group B according to the RT they evoke should thus look as follows:

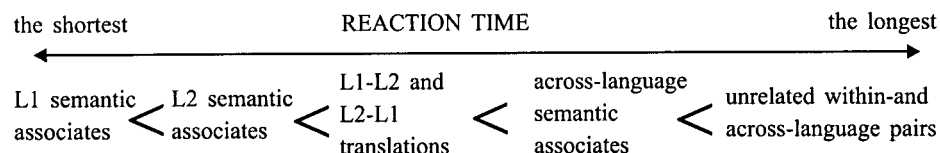


Figure 5. Predicted ordering of RTs to various prime-target pairs for Group B.

As was the case for Group A, also here both L1-to-L2 translations and L2-to-L1 translations are grouped together, as the variable interconnection hypothesis does not account for the varying strength of links between translation equivalents depending on the directionality of translation. It may well be the case that the strength of associative connections between translation equivalent lexical nodes will differ according to whether a bilingual person learns and revises L2 vocabulary more often in L2-L1 pairs or in L1-L2 pairs.

For the 'paired associate' subgroup (also referred to as Group C in further analysis), the shortest RT should be demonstrated for prime-target pairs containing L1 semantic associates (*pies-kot*); a longer RT should be shown for prime-target L1-L2

and L2-L1 translation equivalent pairs; next in terms of RT length should come prime-target pairs consisting of L2 semantic associates (*dog-cat*); then – still longer RTs should be shown for prime-target pairs including across-language semantic associates (*dog-kot; pies-cat*); finally, the longest RT should be demonstrated for unrelated within- and across-language prime-target pairs.

Schematically, the ordering for Group C should be as in the drawing below:

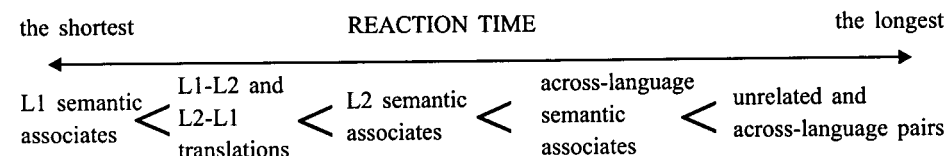


Figure 6. Predicted ordering of RTs to various prime-target pairs for Group C.

As seen in the research hypotheses formulated above, the independent variables in this study were the bilingual subjects' level of proficiency, their preferred L2 lexis learning strategy, and the type of prime-target relation in the LDT. In turn, the dependent variable was the amount of priming expressed as RT to the target stimulus. The underlying construct in the study, operationalized by means of the dependent variable, was the varying strength of links holding between entries in the bilingual lexical network.

As already stated, the subjects of the study were the Polish-English high school and University students. The nonfluent group (Group A) consisted of 26 subjects, the fluent 'L2 semantic' group (Group B) – included 17 subjects, while the fluent 'paired-associate' group (Group C) – only 6 subjects. All of the subjects had normal or corrected-to-normal vision, and they were right-handed.

6. Design of the study

The LDT consisted of 320 prime-target pairs, which included the following types of prime-target relations:

- 1) 80 word-nonword pairs (40 Polish-nonword and 40 English-nonword pairs)
- 2) 30 Polish-English translation equivalent prime-target pairs
- 3) 30 English-Polish translation equivalent prime-target pairs
- 4) 30 within-language Polish-Polish semantically related prime-target pairs
- 5) 30 within-language English-English semantically related prime-target pairs
- 6) 60 across-language semantically related prime-target pairs (30 Polish-English and 30 English-Polish pairs)
- 7) 60 pairs of unrelated prime-target pairs (15 Polish-Polish, 15 English-English, 15 Polish-English, and 15 English-Polish pairs).

Numbers next to each type of prime-target relations will be used in further data analysis instead of full names of these relations. Examples of words used in the study can be seen in the table below.

Table 1. Examples of stimulus words used in LDT experiment.

TYPE OF RELATION		EXAMPLES
word-nonword	Polish-nonword	nitka (needle)-ygtsrao, wzwyż (up)-ujctsei, prędko (swift)-lnwopyo
	English-nonword	judge-ierwwdo, they-mioswd, sky-ykleil
translations	Polish-English	prędko-swift, widzieć-see, cicho-quietly, rzucać-throw
	English-Polish	oyster-ostryga, sheep-owca, needle-igła, light- jasny
within-language semantic associates	Polish-Polish	sąd-sprawiedliwość (court-justice), gładki-szorstki (smooth-rough), nitka-igła (thread-needle), przelotne-spojrzenie (casual-glance), nigdy-zawsze (never-always), liściasty-las (deciduous-forest)
	English-English	white-black, bread-butter, religion-belief, bed-sleep, stone-throw, then-now, spy-traitor, probably-likely
across-language semantic associates	Polish-English	kiedy (when)-then, dyskotekowa (disco)-music, dyrygent (conductor)-conduct, cukier (sugar)-sweet, niebo (sky)-blue, kolor (color)-black, noc (night)-sleep
	English-Polish	where-tutaj (here), shell-ostryga (oyster), eye-spojrzenie (look), cat-pies (dog), green-las (forest), thread-igła (needle)

unrelated pairs	Polish-Polish	ośniewający-tutaj (brilliant-here), mały-spojrzenie (muscle-look), przelotne-owoc (casual-fruit), chwala-pies (glory-dog), woda-zadziwiający (water-astonishing), kiszona-jasny (sour-bright)
	English-English	thread-afraid, God-quietly, apple-swift, fear-sell, always-butter, never-conduct
	Polish-English	niebo (sky)-doctor, wzrok (eyesight)-sweet, zimny (cold)-see, gniewać (be angry)-widow, kiedy (when)-belief, wdowiec (widower)-music, wiara (faith)-over
	English-Polish	nurse-zawsze (always), slow-zdrowie (health), cat-igła (needle), they-właściwie (properly), cabbage-skok (jump), fruit-nam (us), fast-sprawiedliwość (justice)

All the English target words were taken from Postman and Keppel's (1970) norms of word association, while Polish target words were Kurcz's (1967) translations of the Kent-Rosanoff's (1910) list. Primes semantically related to target stimuli were primary associates to these targets taken from Postman and Keppel's (1970) norms and from Kurcz's (1967) norms. Their semantic relatedness to targets was additionally verified with 5 native speakers of English and 5 bilingual Polish University teachers of English. The unrelated prime-target pairs were constructed by re-pairing the targets with unrelated primes. Finally, following Chen and Ng (1989), the nonword targets were constructed by means of randomizing letters of the original Polish and English words. All the nonwords so constructed were meaningless and unpronounceable. Critical items were counterbalanced across two lists with differing orders of prime-target pairs. All the stimuli were displayed in lower-case letters on the computer screen. They were preceded by a trial set of 15 prime-target pairs to familiarize the subjects with the experimental procedure.

The subjects were tested individually in an experimental session which lasted approximately 25 minutes. The sessions took place in a quiet computer laboratory at different times of the day. Care was taken to ensure the same lighting for each subject. The subjects were seated in front of a computer screen. At the beginning of the experimental session they were given oral instructions by the experimenter who informed them that they would be shown pairs of English and Polish letter strings on a computer screen and that their task was to decide whether or not the second letter string of each pair was a word (either Polish or English). The subjects were in-

structed to press the "y" key on the computer keyboard if the second letter string was a real word or the "n" key if it was not. They were encouraged to respond as quickly and as accurately as possible. All the subjects responded with their dominant (right) hand.

On each trial, a prime item was displayed in a green field in lower-case letters for 300 ms in the center of the computer screen. The prime was followed immediately by a target item displayed in a red field in lower-case letters in the center of the screen. Beneath the red field with the target stimulus, a question: "Is X (the target stimulus) a word? (Y/N)" appeared to prevent the subjects from making a mistake of responding to a prime rather than to a target. The target word remained on the screen until the subject pressed either key, which triggered the display of the successive prime. Response latency (in milliseconds) and accuracy were recorded by the computer. The subjects' reaction time was measured from the onset of target display to the pressing of the response key.

7. Results and discussion

Mean reaction times (for correct responses) were calculated separately for each of the three groups (A,B,C) of bilingual subjects for the seven types of prime-target relations. These data were subjected to separate two-way analyses of variance (ANOVAs) with two sources of variation (the type of prime-target relation, and the order of presentation of stimuli). The order of presentation of stimuli was taken into account in the data analysis, since it turned out to significantly affect subjects' reaction time to stimulus words. Mean reaction times (in milliseconds) for all types of prime-target pairs for Groups A, B, and C are listed in Table 2.

Table 2. Mean RTs (in milliseconds) for all types of prime-target pairs for Groups A, B, and C.

Kind of Relation	GROUP A	GROUP B	GROUP C
1	91.0	67.2	86.4
2	83.0	59.4	86.2
3	78.6	58.6	73.5
4	78.1	63.8	71.0
5	83.4	58.2	73.5
6	83.2	60.3	75.0
7	89.2	60.6	80.1

As might be expected, mean RTs were longer for Group A, the nonfluent group, than for the two fluent groups for almost all types of prime-target relations. The only exception is RT to relation coded as 2 (i.e., Polish-English translation pairs), which, while substantially longer (83.0 ms) than that for Group B (59.4 ms), was still slightly shorter than RT to this relation obtained for Group C (86.2 ms). This effect may have resulted from Group C's preference for learning L2 lexis in English-Polish, rather than in Polish-English translation pairs. Indeed, Group C's reaction time

to English-Polish translation pairs (coded as 3 in the Table) was much shorter (73.5 ms) than that for Polish-English translation pairs (86.2 ms). Group C's mean RT to English-Polish translation pairs (73.5 ms) was also shorter than Group A's mean RT to this type of relation (78.6 ms). However, the nonfluent bilinguals also seem to prefer the L2-to-L1 (English-Polish) paired associate learning, rather than the L1-to-L2 (Polish-English) lexis acquisition. Their mean RT for English-Polish translations (coded as 3) was shorter (78.6 ms) than that for Polish-English translations (83.0 ms).

The overall longer RTs obtained for Group A indicate that these nonfluent bilingual speakers have relatively weak links between lexical nodes in their mental dictionaries. Hence, the amount of priming for each pair of prime-target relation was smaller (and, consequently, RTs longer) than the amount of priming evidenced for the more fluent bilinguals, whose lexicons contain strong associative links. It appears from the Table that the recognition of nonword letter strings (coded as 1) was the most difficult for all bilingual subjects, as latencies to this type of pairing were the longest in Groups A, B, and C.

Mean RTs for each group were subjected to a two-way Analysis of Variance. The statistics for Group A are shown in Table 3.

Table 3. Statistics for Group A.

Source of variation	Sum of Squares	Degrees of freedom	Mean square	F-ratio	Critical Value for Significance Level $\alpha=0.05$
Variants (I, II)	33261.806	1	33261.806	50.236	3.858
Kind of Relation (0,...,6)	15374.903	6	2562.484	3.870	2.0986
Interaction	8841.3704	6	1473.5617	2.226	2.0986
Residual	413819.92	625	662.11187		
Total	471282.94	638			

As shown in Table 3, the type of prime-target relation had a significant effect on subjects' RTs. In addition, it turned out that the ordering of stimuli (labeled Variants I and II, as there were two different lists of stimuli), also had a significant influence on the amount of priming. Since the values of F-Fisher-Snedecore's statistics were bigger than their corresponding critical values ($F=50.236 > 3.858$; $\alpha=0.05$; and $F=3.870 > 2.0986$; $\alpha=0.05$), the null hypothesis that there is no significant influence of the sources of variation (i.e., variants of stimulus ordering and types of prime-target relations) and of their interaction on subjects' RT was rejected. Next, homogeneous groups were calculated, with the use of Tukey's confidence levels at the level of significance $\alpha=0.05$. The resulting ordering of types of prime-target pairings according to the RTs they evoked was as follows:

$$4 < 3 < 2 < 6 < 5 < 7 < 1$$

Figure 7. Obtained ordering for Group A.

This means that the greatest priming was obtained for semantically related Polish-Polish prime-target pairs (with RT – 78.1 ms); the smaller priming (78.6 ms) for English-Polish translations; still smaller (83.0 ms) – for Polish-English translations; next in terms of RT length came across-language semantically related pairs (83.2 ms); then- English-English semantic associates (83.4 ms); still longer RT was manifested for unrelated prime-target pairs (89.2 ms); while the longest RT (91.0 ms) – for nonword letter strings.

These results are consistent with the research hypothesis formulated in this section, which predicted the following ordering for Group A:

$$4 < \begin{matrix} 2 \\ 3 \end{matrix} < \begin{matrix} 6 \\ 5 \end{matrix} < 7$$

Figure 8. Predicted ordering for Group A.

Even though no specific prediction was made as to the ordering of types 2 and 3, it was tentatively suggested that English-Polish translation pairs should be identified faster than Polish-English translations, because L1 targets are likely to be recognized faster than L2 targets. This tentative suggestion turned out to be true for our nonfluent bilinguals. Likewise, no specific prediction was made about the ordering of relations coded as 5 and 6, due to the lacking theoretical basis for making assumptions about the strength of across-language and L2 semantic associates in individual bilinguals' developing lexicons. For this particular group of nonfluent Polish-English bilingual speakers, across-language semantic links turned out to be stronger (and thus produced a greater priming effect) than English-English semantic associates.

Turning now to the statistical analysis of the data obtained for Group B, the influence of the sources of variation (i.e., variants of stimulus ordering and types of prime-target relations) and of their interaction on mean RTs was found to be significant, as presented in Table 4.

Table 4. Statistics for Group B.

Source of variation	Sum of Squares	Degrees of freedom	Mean square	F – ratio	Critical Value for Significance Level $\alpha=0.05$
Variants (I, II)	22197.045	1	22197.045	67.435	3.858
Kind of Relation (0,...,6)	7189.904	6	1198.317	3.641	2.0986
Interaction	7111.4156	6	1185.2359	3.601	2.0986
Residual	205726.38	625	329.16221		
Total	242274.2	638			

Since the values of F-Fisher-Snedecore's statistics were bigger than their corresponding critical values ($F=67.435 > 3.858$, $\alpha=0.05$; and $F=3.641 > 2.0986$, $\alpha=0.05$), the null hypothesis that there is no significant relationship between the sources of variation and the subjects' mean RT was rejected. The ordering of RTs from the shortest to the longest was the following:

$$5 < 3 < 2 < 6 < 7 < 4 < 1$$

Figure 9. Obtained ordering for Group B.

while the ordering predicted by the research hypothesis formulated earlier was:

$$4 < 5 < \begin{matrix} 2 \\ 3 \end{matrix} < 6 < 7$$

Figure 10. Predicted ordering for Group B.

The two orderings are almost identical, the only exception being the reaction type coded as 4 (standing for Polish-Polish semantic associate pairs), which moved from the beginning to almost the end position, after the relation coded as 7 and before the relation coded as 1. Thus, contrary to the research hypothesis, which predicted that latencies to Polish-Polish semantic associate pairs would be the shortest, they appeared to be longer than all types of prime-target relations, except type 1 (i.e., nonword strings), which produced the longest latencies. The ordering of the RTs for the remaining types of prime-target pairings was, however, as predicted by the variable interconnection hypothesis.

The shortest RT (58.2 ms) was obtained for English-English semantic associates, which confirms the prediction that fluent bilingual speakers, whose preferred L2 learning strategy is that of acquiring new lexis in L2 semantic sets, are likely to have very strong associative links between L2 lexical nodes in their bilingual lexicons. Contrary to the view adopted here, which predicts that the strongest links hold between L1 lexical nodes, for these bilingual subjects L2 semantic associate links turned out to be the strongest, as demonstrated by the greater semantic facilitation effect recorded for L2 semantic associate pairs. This effect may have been caused by bilingual subjects' expectations to find more English than Polish stimuli.

As predicted, the smaller facilitation effect (RT of 58.6 ms) was demonstrated for the relation type coded as 3 (i.e., English-Polish translation pairs); while still smaller (RT – 59.4 ms) – for the relation coded as 2 (i.e., Polish-English translations). Thus, as was the case for the nonfluent bilinguals from Group A, the fluent ones from Group B also took faster to respond to native language translations than to L2 translations. Apparently, the learning strategy (learning vocabulary in English-Polish rather than in Polish-English pairs) affects the speed of processing, depending on the directionality of translation.

Next in terms of the amount of priming came across-language semantic associates (relation type 6), which produced mean RT of 60.3 ms, and thus confirmed the

view that across-language semantic links are weaker than within-language semantic links and translation links.

Unrelated prime-target pairs (coded as 7) produced a still smaller facilitation effect (RT of 60.6 ms); while an even smaller amount of priming (RT – 63.8 ms) was obtained for Polish-Polish semantic associates. As already stated, this particular type of pairing was predicted to evoke the greatest facilitation, so this prediction of the variable interconnection hypothesis was not confirmed. Finally, as was the case for the nonfluent group, also here the longest latencies (RT – 67.2 ms) were recorded for nonword targets (relation type 1).

The statistical analysis for the 'paired-associate' fluent bilingual subjects (Group C) is presented in Table 5. Unfortunately, no significant relationship was found to obtain between types of prime-target relations and subjects' response latencies (MSe=3597.64, F=0.847, 2.0986; $\alpha=0.05$).

Table 5. Statistical analysis of the data for Group C.

Source of variation	Sum of Squares	Degrees of freedom	Mean square	F – ratio	Critical Value for Significance Level $\alpha=0.05$
Variants (I, II)	212537.65	1	212537.65	50.033	3.858
Kind of Relation (0,...,6)	21585.84	6	3597.64	0.847	2.0986
Interaction	23131.183	6	3855.1971	0.908	2.0986
Residual	2654977.8	625	4247.9644		
Total	2912084.9	638			

Even though no significant relationship was found to obtain between prime-target relation types and subjects' RTs, different types of stimulus pairings did produce different amounts of priming. I compared mean RTs obtained for each type of prime-target relation to see what the ordering was. The ordering of prime-target relation types, proceeding from the shortest to the longest RT was thus the following:

$$4 < 3 < 5 < 6 < 7 < 2 < 1$$

Figure 11. Obtained ordering for Group C.

while the ordering predicted by the research hypothesis based on the variable interconnection view is:

$$4 < \begin{matrix} 2 \\ 3 \end{matrix} < 5 < 6 < 7$$

Figure 12. Predicted ordering for Group C.

The two orderings are almost identical, the only difference between them being the position of the relation coded as 2 (i.e., Polish-English translation pairs), which, while postulated to occupy the second position in RT ordering, turned out to be almost the last in the experiment, just before mean RT for nonword letter strings (coded as 1).

The rationale behind the ordering I proposed in my research hypothesis for the 'paired-associate' group of fluent Polish-English bilinguals was that, since those students expressed their preference for acquiring L2 words by means of remembering their Polish translation equivalents, then links connecting translation nodes in those bilinguals' mental dictionaries should be relatively strong. In my hypothesis, I did not distinguish between priming effects for Polish-English versus English-Polish translation pairs, assuming that RTs to both types of pairs would be longer than those obtained for Polish semantic associate pairs (coded as 4), and shorter than the latencies for the remaining types of prime-target relations. It turned out, however, that the directionality of paired-associate learning (L1-to-L2 versus L2-to-L1) can significantly affect the speed of processing of the two types of pairings. Presumably, the more natural way of learning L2 vocabulary is that of recording first English words and then their Polish translations, rather than the other way round. This strategy must have been adopted by our fluent bilinguals, whose performance on the LDT demonstrated a significant priming effect for English-Polish (RT – 73.5 ms), but not for Polish-English (RT – 86.2 ms) translation pairs.

In accordance with the predictions of the variable interconnection hypothesis, the strongest links seem to obtain between Polish semantic associates, since this type of prime-target relation (coded as 4) produced the greatest facilitation effect (RT – 71.0 ms). Next in terms of the amount of priming came English-Polish translation pairs (coded as 3) (RT – 73.5 ms), which confirms predictions of the variable interconnection hypothesis that bilinguals' preferred vocabulary learning strategy determines the strength of links in their lexical networks. Since bilinguals in Group C expressed their preference for learning L2 lexis in translation pairs, translation links in their mental lexicons appeared to be very strong, weaker only than links extending between Polish lexical entries.

In accordance with my research hypothesis, next in the ordering of prime-target pairings was relation type coded as 5, i.e., English semantic associate pairs, which produced mean latency of 74.0 ms. Thus, links between semantically related English lexical entries turned out to be weaker than those holding between translation nodes in the mental lexicons of 'paired associate' fluent bilinguals. As might be recalled, the opposite was found to be true for 'L2 semantic sets' fluent bilinguals, whose performance demonstrated shorter latencies for English semantic associates than those for translation prime-target pairs. It thus appears that the strategy of L2 learning does exert a significant influence on the strength of lexical connections in the bilingual memory.

Also in accordance with my research hypothesis, mean RT (75.0 ms) obtained for type 6 of prime-target relation (i.e., across-language semantic associates) was bigger than mean RTs to the already analyzed types 4, 3, and 5, while smaller than

that obtained for type 7 (i.e., unrelated prime-target pairs), which elicited the mean RT of 80.1 ms. This confirms the view that across-language links between semantically related lexical entries are relatively weak in the bilingual mental lexicon.

Yet weaker priming (RT of 86.2 ms) was reported for type 2 of prime-target relation (i.e., Polish-English translation pairs), which may be explained as an effect of the directionality of processing of inter-language translations, most often employed by the bilinguals under investigation (learning L2 words in L2-L1, and not in L1-L2 pairs). However, it seems difficult to explain why this type of stimulus pairing produced smaller facilitation than did unrelated prime-target pairs. Finally, as was the case for the remaining groups, the smallest facilitation was reported for relation type 1, that is, nonword letter strings, which appeared the most difficult to recognize.

Summing up, the data analysis revealed a significant effect of prime-target relation type on subjects' RTs and yielded confirmation of most of the predictions. Most importantly, it has been demonstrated that the strategy of L2 learning significantly influences the strength of connections obtaining in bilingual lexical networks. Bilinguals from Group B, whose preferred L2 learning strategy was learning L2 in L2 semantic sets rather than in translation pairs, responded faster to English semantic associate pairs than to translation pairs. The opposite was found for bilinguals from Group C, who employed the paired associate vocabulary learning strategy. These bilinguals responded faster to translation stimuli than to L2 semantic associate stimuli, which demonstrates that translation links were stronger than those linking L2 semantically related lexical entries in their mental lexicons. Thus, the major tenet of the variable interconnection hypothesis has been shown to be valid for my sample of bilingual subjects.

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