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SEMANTIC PRIMING EFFECTS IN BILINGUAL WORD FRAGMENT COMPLETION

ANNA CIEŚLICKA
Adam Mickiewicz University, Poznań

ABSTRACT

The paper presents a word fragment completion experiment whose aim was to investigate intralanguage and interlanguage semantic priming effects and to verify the hierarchical model of bilingual lexical organization. It starts with a brief review of the most representative studies into the structure and functioning of the bilingual lexical store conducted during the past decades in an attempt to address the question of how two or more languages known by a bi(multi)lingual are stored and processed. It then addresses the issue of conceptually-driven versus data-driven processes and identifies the characteristics of the word fragment completion task, which has been employed by psycholinguists to measure conceptual- and lexical-level priming and to test various proposals concerning bilingual memory structure. The paper then reports on the word fragment completion task conducted with a group of eighty fluent Polish-English bilinguals, who were instructed to conceptually manipulate material in one language and then to complete fragmented stimuli either in the same or in a different language. Results are next analyzed for the effects of within and between language priming and implications concerning the structure of the L2 lexicon are discussed.

1. Brief review of studies into bilingual memory organization

The structure of the second language learners' mental lexicon and relations between languages in the cognitive network of the second language user have been the topic of much research throughout the past few decades. As Cook (2002) points out, the three logical possibilities concerning relations between two languages known by a bilingual can be viewed as forming a continuum, ranging from total separation, where the two languages are completely independent, through interconnection, where they are connected to a greater or lesser degree, to complete integration, where the two languages constitute a unified system. Historically, the distinction can be traced back to the first detailed description of bilingual memory organization proposed by Weinreich (1953), who differentiated between three kinds of bilingual memory systems, commonly referred to as *compound*, *coordinate*, and *subordina-*

tive. Whereas in compound bilinguals, a single unit of content is shared by two translation equivalents, in coordinate bilinguals there are separate meaning representations for both languages, and in the subordinative type, words in the second language (henceforth L2) can only access their underlying concepts via their mother tongue (henceforth L1) equivalents. The two latter types were subsequently fused into one, coordinate type, by Ervin and Osgood (1954), who tied the distinct bilingual memory types to the language acquisition history, claiming that coordinate bilingualism develops through experience with the two languages in separate contexts, whereas compound bilingualism through experience with both languages in the same context (as when the two languages are spoken interchangeably at home).

The distinction proposed by Weinreich and modified by Ervin and Osgood sparked a flurry of research aimed at determining if performance of bilinguals classified as compound or coordinate on different memory tests truly reflects differing types of language organization. Most of those early studies, however (see, for example, Jakobovits and Lambert 1961, Kolers 1963, 1965, 1966, Macnamara 1967, Penfield and Roberts 1959) brought contradictory results and were subsequently criticized for lack of strict criteria employed to categorize bilingual participants as either compound or coordinate (see Diller 1974, for a critical review of this early research). The consideration of the compound-coordinate distinction was generally dropped by the end of the 1960s, and the issue of the bilingual cognitive network became reformulated by Kolers (1963) as the controversy between the single-storage hypothesis on the one hand and the separate-storage view on the other. Koler's single-storage hypothesis was essentially a reformulation of Ervin and Osgood's (1954) compound model, in that it presupposed the storage of concepts in some kind of an abstract, non-linguistic form, common for bilingual's two languages. On the other hand, the separate-store hypothesis, based on Ervin and Osgood's coordinate model, assumed that meaning representations are formed specifically by means of the coding experience, i.e., in the language in which they were encountered. As Keatly (1992) rightly observes, by linking the question of single or separate models of the bilingual lexicon to the issue of the nature of representation and its construction in memory, Kolers' suggestion precluded the possibility of both forms of bilingualism to exist in one individual; thus making them mutually exclusive.

A whole array of experimental tools was subsequently employed to test whether the languages known by a bilingual share the same network or whether they form two separate lexicons. Some of these were word association, list learning, recall of language of presentation and studies examining effects of repetition across languages on list recall. However, as was the case with experiments attempting to verify the compound-coordinate distinction, also this research turned out to be largely contradictory. Whereas some studies provided results which were interpreted in support of common lexical storage (cf. Liepmann and Saegert 1974; Lopez et al. 1974; Lopez and Young 1974; Rose et al. 1975), others provided support for the separate storage view (Taylor 1971; Tulving and Colotla 1970) or brought contradictory evi-

dence that could not be reconciled with either position (cf. Cristoffanini et al. 1986; Kirsner 1986; Kolers and Gonzales 1980). Inadequacy of the strict single versus separate storage dichotomy was demonstrated by Durgunoglu and Roediger (1987), who suggested that the contradictory results obtained in psycholinguistic experiments were caused by the fact that various psycholinguistic studies measured different memory processes, namely, either conceptually-driven or data-driven processes. Whereas conceptually-driven processes focus on concepts represented by the stimuli, data-driven processes focus on their physical aspects, such as word's orthographic and phonological characteristics. Accordingly, conceptual tasks, which measure semantic and conceptual word representations (for example, free recall), yielded results consistent with the single-storage model, whereas data-driven tasks (for example, priming paradigms), involving identifying language-specific features, produced results compatible with the separate-storage model. Application of the distinction between conceptually- and data-driven processes to accounts of the bilingual lexical organization allowed explaining the otherwise confusing body of psycholinguistic literature and led to the emergence of a modified stance on the issue of bilingual cognitive network, under which the L1 and L2 lexicons are neither completely disconnected from each other nor totally unified.

According to the recent models of the L2 mental lexicon, the bilingual lexical storage is hierarchical, in that it consists of at least two layers of memory representation, one of which stores the meanings of words, whereas the other- their forms. Such a two-layered structure allows postulating segregation by language for one level and integration for the other. Accordingly, the currently accepted view of the bilingual lexical organization holds that, whereas the surface forms of L1 and L2 words constituting a translation pair are represented in separate, language-specific, lexical representations, word meanings are stored at the semantic level shared between the two languages (see, for example, Chen and Ng 1989; DeGroot and Nas 1991; Jin 1990; Kroll 1993; Kroll and Sholl 1992; Kroll and Stewart 1994; Kroll and Tokowicz 2001). Crucial evidence for such a structure of the bilingual memory comes from repetition priming studies which test the presence of a repetition priming effect, whereby presentation of a word in one language facilitates performance on a task involving its translation equivalent. It appears that the presence or absence of such an effect depends on whether the bilingual memory task measures data-driven or conceptually-driven processes. Accordingly, such tasks as free recall of words from a list presented earlier or a semantic-decision task (e.g., categorizing presented words as either concrete or abstract, animate or inanimate, etc.), which rely on conceptually-driven processes, overwhelmingly show the presence of a repetition priming effect across languages, thus suggesting that semantic level (meaning) representations are shared for both languages. On the other hand, data-driven tasks, such as word fragment completion or lexical decision, typically show absence of translation-priming effects, thus suggesting that lexical level (word form) representations are represented separately, in a language-specific way (see, for example,

Gerard and Scarborough 1989; Kirsner et al. 1980; Kirsner et al. 1984). The use of word-fragment completion as a tool for investigating bilingual lexical network is discussed in further detail in the next section.

2. Word-fragment completion: A tool for investigating lexical-level and semantic-level processes?

In the word fragment completion task, participants are presented with degraded stimuli, which are fragments of previously studied or nonstudied items (*e-e-h-nt*), and are asked to complete fragments with the first solution that comes to mind *(elephant)*. The probability that a particular word will be generated in a word fragment completion increases if a word has been presented in the study phase of the experiment. Performance in a word fragment completion is believed to be the function of an activation and integration process. Presenting a word in a study phase activates its memory representation, hence making this word more available for production than other, unactivated words (Graf and Mandler 1984). While the word fragment completion task has been typically viewed as a data-driven measure (see previous section), some theorists claim that by manipulating the experimental conditions one can make this task reflect semantic-level processing as well. Thus, for example, Challis and Brodbeck (1992) tested the influence of the learning conditions that promoted either physical (for example, asking subjects the question: *How many vowels does the word contain?)* or semantic processing (e.g., *Does the word denote an animal?)* on participants' subsequent performance on the word fragment completion task and found that priming in the test was greater in the semantic than physical condition.

The view that a word fragment completion test can be taken to reflect conceptually-driven processes was also expressed by Hamann and Squire (1996), Neill et al. (1990), and Weldon (1991, 1993), who suggested that perceptual and conceptual processing can both affect priming in word fragment completion, depending on the particular encoding conditions. Based on the results of his study, which demonstrated a substantial conceptually driven element in the word fragment completion task, Gardiner (1988) has likewise claimed that generating an item in a word fragment completion test entails both a surface, data-driven and a semantic, conceptually-driven component.

In their review of implicit memory tests, Horton et al. (2001) suggest that, since the word fragment completion task requires problem solving, it is likely to induce switching to a conscious retrieval strategy and making participants think back to the study list to help identify the possible candidates for completing degraded stimuli. They conclude by stating that the word fragment completion task cannot be viewed as reflecting purely automatic and perceptually-based retrieval. An essentially similar suggestion was forwarded by Roediger and Challis (1992) who propose that conceptual processes can affect word fragment completion performance, especially if a fragmented word is modified by a meaningful context.

In summary, most researchers agree that the word fragment completion task can be treated as reflecting both data-driven and conceptually-driven memory processes and as a reliable measure of lexical and semantic-level activation accompanying the processing of linguistic stimuli. Because of these characteristics, the word fragment completion task has been employed in the psycholinguistic research to investigate the organization of the mental lexicon in bilingual (Smith 1991) and trilingual (Schonpflug 2000) speakers and to probe the activation of literal and figurative senses of idioms during the comprehension of figurative language (Giora and Fein 1999). In the study described in this paper, the word fragment completion task has been employed to test the presence of interlingual semantic priming effects and hence to verify the hierarchical model of the L2 lexicon. A detailed description of the study and its rationale is provided in the remainder of this paper.

3. The study

As has been mentioned earlier, word-fragment completion can be taken to reflect both lexical- and semantic-level processes in bilingual language processing. Semantic-level representations are likely to be activated if the study phase of the experiment promotes conceptual manipulation of the stimulus material. Following this logic, if the experimental conditions encourage semantic processing of the presented stimuli and if the hierarchical model of the bilingual lexicon is a true reflection of the way language information is stored in the bilingual mind, then presenting a word in one language during the study phase should facilitate later performance on its translation equivalent or semantic associate during the test phase. To provide an example, if a Polish-English bilingual encounters the English word TEACHER during the study phase, then he or she should be more likely to successfully complete the Polish fragmented word N__U__Z__C__E__ (NAUCZYCIEL), which is its translation equivalent, or the word S__K__ Ł__ (SZKOŁA, Eng. SCHOOL), which is its semantic associate, during the test phase than a bilingual person who encountered an unrelated English word FLOWER. This is so because translation equivalents and words semantically related across languages have, under the hierarchical view, common meaning representations at the semantic level of the language system. Since these semantic representations are presumably activated in the study phase, prior activation of a common semantic representation facilitates (primes) subsequent performance on a fragment completion by making lexical-level (word form) representations more active and hence faster available as possible candidates for completing degrading stimuli. The mechanism of activation demonstrated in word fragment completion is schematically presented in Figure 1.

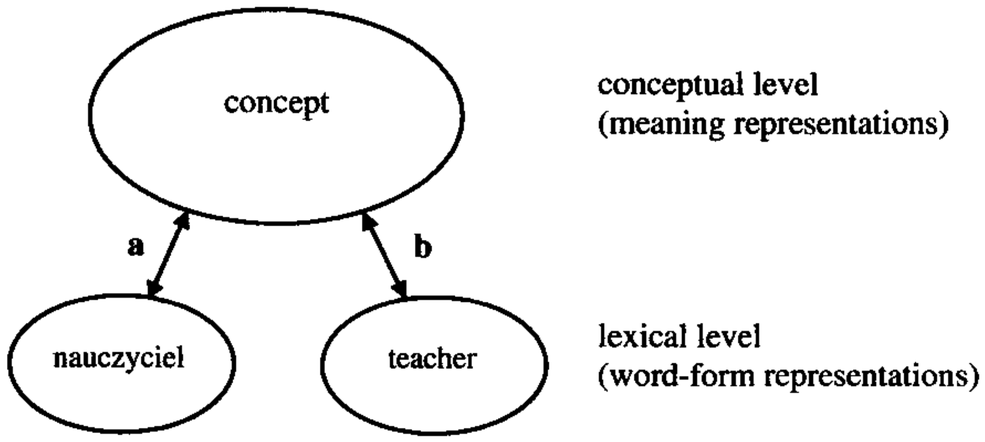

Figure 1. The mechanism of activation within the hierarchical model of bilingual lexical representation. The word-form representations at the lexical level are separate for each language, but meaning representations are common at the conceptual level. Activating the Polish word NAUCZYCIEL at the study phase of the experiment, causes the activation of the common concept underlying both NAUCZYCIEL and its English translation equivalent. The activation proceeds schematically via the route labeled "a" (from lexical-level representations to the conceptual level representations). The activated conceptual node further activates its corresponding word-form node for TEACHER (route "b")

To examine the hypothesis that conceptual manipulation of the material in one language facilitates bilingual language users' performance on degraded stimuli in another language, thus testifying to the common semantic-level representation for words in both languages, a word fragment completion test was conducted with a group of Polish fluent speakers of English. The task was modeled after Smith's (1991) experiment, in which French-English bilinguals were asked to read sentences and infer an item implied by each sentence. For example, from the sentence *Fish attacked swimmer* participants inferred the word SHARK. Following the conceptual integration stage, participants saw a list of degraded words in both languages, some of which were identical to the words presented in the study (e.g., F___S___ for FISH), while others corresponded to the inferred items (e.g., S__A__K for SHARK). The presence of priming effects across languages was taken as indicative of common underlying conceptual representations.

3.1 Method

3.1.1. Participants

Eighty fluent Polish-English bilinguals agreed to participate in the experiment. They were students of English as a second language, all studying in Year 5 at the School of English, Adam Mickiewicz University, Poznań, Poland. All of them could be described as proficient in English, as they had successfully passed the Practical English Examination administered at the end of Year 4 and located at the Proficiency level, as described by the University of Cambridge Local Examinations Syndicate. Among the 80 participants, 57 were female and 23 male. Forty participants constituted the experimental group and the other forty the control group. The assignment of participants to the experimental and control groups was random, so as to ensure that each group contained individuals who had obtained very good, good, and satisfactory grades in their English language courses.

3.1.2. Materials

Experimental materials consisted of 16 sentences in English and their translation equivalents in Polish. Some of the sentences were borrowed from Smith's (1991) original study and some were designed by the experimenter. The sentences were of the form "Noun + Verb Phrase + Noun Phrase" (for example, *Woman took the patient's pulse*), and the first noun was a general item, whose exact referent had to be inferred by participants. Thus, for the sentence quoted above, the inferred item was DOCTOR. In addition to the 32 sentences, a list of inferred items and repeated items was prepared which were later presented in a degraded format on a word fragment completion task. To provide an example, the inferred item for the sentence *Animal guarded the house* was DOG, whereas the repeated item was ANIMAL. A complete list of the English and Polish sentences, along with their inferred and repeated items, is provided in Appendix 1.

To study the effects of repetition priming (when the same item was repeated in the study and test phases) and semantic priming (when the item inferred in the study phase appeared again in the test phase), both within (intralanguage priming) and across (interlanguage priming) languages, each study sentence had to occur in four different conditions. Accordingly, the first condition included presentation of a sentence in one language and a subsequent repetition of one of its words in the same language on a test. Thus, the sentence *Building kept books* was followed by the presentation of the word B__O__ (BOOK). This condition will be referred to as 'same language repetition' throughout the rest of the paper. The second condition, labeled 'same language inferred', refers to the situation when the sentence was followed by the item that had to be inferred. Thus, the sentence *Building kept books* was fol-

lowed by the presentation of L__B__A__Y (LIBRARY). The third, 'different language repetition' condition refers to the cases when the sentence was presented in one language during the study phase and followed by a translation equivalent of one of the words it included during the word completion phase. To illustrate with our example, the English sentence *Building kept books* was followed by the degraded stimulus K__I__ __KA (KSIĄŻKA), which is the Polish translation of the English word BOOK. Finally, the fourth, 'different language inferred' condition included cases when a sentence in one language (*Building kept books*) was followed by a translation of the item that had to be inferred (B__ __L__O__ __K__, standing for BIBLIOTEKA, which is equivalent to the English LIBRARY).

So that each participant saw each sentence and each degraded stimulus paired with it only once, eight separate lists had to be prepared, each including only one variant of the same sentence (a sentence in Polish followed by Polish repetition, a sentence in Polish followed by Polish inferred item, a sentence in Polish followed by English repetition, a sentence in Polish followed by English inferred item, a sentence in English followed by English repetition, a sentence in English followed by English inferred item, a sentence in English followed by Polish repetition, or a sentence in English followed by Polish inferred item). Each list thus included 16 sentences, eight of which were Polish and eight English. Out of the eight Polish sentences, four were followed by same language (Polish) items in the test phase and four by the different language (English) items. Out of the four same and four different language items, two were repeated and two were inferred. Likewise, out of the eight English sentences, four were followed by same language (English) and four by the different language (Polish) items in the test phase. Out of the four same and four different language items, two were repeated and two were inferred. The 16 sentences were printed on a single sheet, one in each line. The degraded stimulus items were also printed on a single sheet, one in each line. They were grouped under the headings "Polish words" and "English words" to indicate to participants which language each fragmented word represented. An example of a complete list (List 1) of sentences and a list of stimulus words for completion provided in the test phase is shown in Appendix 2. Each variant of the list and its corresponding sheet for fragment completion was distributed to five participants.

In addition to the list of sentences for the experimental group, a list of unrelated sentences for the control group was prepared. The list consisted of 16 sentences, eight of which were Polish and eight English, unrelated in any way to the degraded stimuli presented in the test phase of the experiment. Forty participants who saw the control list were then given the same lists of fragmented words to complete as the experimental group in such a way that five people were assigned to List 1, five to List 2, five to List 3, etc., just as was the case with the experimental group. The difference between the performance of the experimental and control groups on the word fragment completion test was taken as indicative of the amount of priming caused by the sentences on the experimental lists.

3.1.3. Design

The design was a four-way analysis of variance (ANOVA) with one between-subject factor – group (experimental or control) and three within-subject factors- language of sentence presentation (Polish or English), language of word completion (same or different than the language of sentences) and stimulus type (repeated or inferred). The design can thus be summarized as 2 (group) x 2 (language of sentence) x 2 (language of stimulus) x 2 (stimulus type) mixed ANOVA.

3.1.4. Procedure

Participants were tested during the lecture in which they participated as part of their schedule. They were first shown a few exemplary sentences written on the blackboard and instructed to infer a particular item that each sentence implied. Thus, they were shown the sentence *Boat traveled underwater* and asked to make the inference of SUBMARINE. After a few sentences were correctly analyzed, the experimenter explained to participants that they would next receive a list of 16 sentences and would have to make a relevant inference for each of them in turn. The experimental sheets were next distributed to each person, with the instruction to cover the sheet and expose only one sentence at a time. At the signal provided by the experimenter, participants were to uncover the first sentence, look at it and infer the relevant item it implied. Participants were allowed 10 seconds for each sentence, after which the experimenter gave the signal to proceed to the next line. Participants were not allowed to look back at the sentences they had read but to focus only on the sentence they were currently reading. In this way, the sentences were read in a little over 2 minutes.

After the participants had finished reading the sentences, they were given sheets with fragmented words in English and Polish and instructed to look at each word in turn, under the experimenter's supervision, and to complete each fragment with the first word that came to mind. Participants in the experimental group received test sheets corresponding to the study list (e.g., a person who read list number 8 received a sheet with the identical number), whereas participants in the control group received lists numbered from 1 to 8 in a random fashion in such a way that each list was given to five people. This was done to ensure that an equal number of participants from the experimental and control groups completed the same fragmented list. The word fragment completion test was not expected. As was the case with the study phase, also here participants were instructed to cover the sheets and expose only one line at a time. They were given 30 seconds to complete each fragmented word, after which the experimenter instructed them to proceed to the next line. In this way, the word fragment completion took a little over 8 minutes.

3.2. Results and discussion

As mentioned earlier, the data were submitted to a four-way ANOVA, with one between-subject factor – group (experimental or control) and three within-subject factors- language of sentence presentation (English or Polish), language of stimulus presentation (same or different than the language of the sentence), and stimulus type (repeated or inferred). Summary of means and standard deviation values for each of the conditions is presented in Table 1.

Table 1. Means and standard deviations for two groups and various types of sentences and stimuli

Stimulus type	Polish sentence		English sentence	
	Same	Different	Same	Different
Repeated	57%	20%	46%	44%
Inferred	69%	46%	45%	72%

Analysis of the data summarized in Table 1 reveals that participants from the experimental group completed more fragmented stimulus words than did participants from the control group, for both types of sentences (Polish and English), and for all types of stimuli (same and different from the language of the sentence and either repeated or inferred). This indicates that the items repeated or inferred from the study phase of the experiment did indeed serve as efficient primes in the subsequent word fragment completion test. To be able to more directly compare the effectiveness of priming with same-or different-language repeated or inferred primes in both Polish- and English-language sentence conditions, percentage priming was calculated for each condition in the experimental group by comparing the obtained results against the baseline values obtained for the corresponding conditions in the control group. Percentage priming for repeated and inferred stimuli in same and different language conditions is presented in Table 2.

Table 2. Percentage priming obtained for both types of stimulus as a function of word-completion language (same or different than the language of study sentence)

Groups	Stimulus type	Polish sentence				English sentence			
		Same		Different		Same		Different	
		M	SD	M	SD	M	SD	M	SD
Experimental	Repeated	1.10	.59	1.35	.66	1.63	.63	.68	.66
	Inferred	1.40	.70	1.73	.51	1.63	.67	1.30	.80
Control	Repeated	.48	.68	1.10	.75	.88	.72	.38	.63
	Inferred	.43	.59	.75	.78	.88	.88	.35	.58

Overall, it seems that more priming was elicited for Polish (both repeated and inferred) stimuli following presentation of the Polish sentence in the study phase than for English (both repeated and inferred) stimuli following the English sentence. Hence, in the same language condition participants correctly completed more Polish fragments (57% repeated and 69% inferred) than English fragments (46% repeated and 45% inferred). These data appear quite logical, given the fact that participants were dominant in Polish despite their fluency in English. The data for the different language condition seem to support this tendency. Here, participants completed more fragmented words in Polish, which followed English sentences in the different language condition (44% repeated and 72% inferred) than English fragments following Polish sentences (20% repeated and 46% inferred). Overall then, it seems that completing Polish fragmented words was an easier task than completing English fragmented words.

Another interesting pattern that emerges from the data is the difference between priming percentages obtained for repeated items on the one hand and for inferred ones on the other. It might seem that a repeated stimulus (i.e., a test item identical to the earlier presented item) should lead to more facilitation than an inferred stimulus (i.e., a test item identical to the word which had to be inferred during the study phase). Quite contrary to this logic, inferred fragmented words were completed more successfully than repeated ones, and this result held across all conditions- for both same and different language stimuli following both Polish and English sentences. Such a result testifies to an essentially semantic nature of the word fragment completion task and to the fact that various elaborative processes engaging a conceptual level of language processing are consciously undertaken by participants when performing the task. This could help explain why semantically inferred items appear more effective as primes than merely repeated ones, as the latter basically operate at the data-driven, lexical level of language processing.

The most important question from the point of view of our research hypothesis concerns differential priming in the same and different language conditions. As mentioned earlier, demonstrating comparable priming effects for items in both same and different language conditions would testify to the shared conceptual representations for both languages known by a bilingual and to the validity of the hierarchical account of bilingual lexical representation. To statistically verify priming effects obtained in all conditions, a mixed ANOVA was next conducted, whose most important results are reported in Table 3.

The results of the analysis indicate a significant main effect of Group ($F(1, 78) = 87.76$, $p < 0.0001$), which confirms our earlier analysis of the means obtained for the experimental and control groups and presented in Table 1. Participants in the experimental group completed significantly more fragmented words than did participants in the control group. This testifies to the efficiency of primes repeated or inferred in the study phase by participants in the experimental group. The difference in performance between both groups is shown in Figure 2.

Table 3. Analysis of Variance results for main effects and interaction effects of Language of Sentence, Language of Stimulus, Stimulus Type, and Group on correct responses. Note: η^2 = effect size

Source	*df*	*SS*	*MS*	*F*	*Sig.*	η^2
		Between subjects				
Intercept	1	652.06	652.060	784.96	0.000	.91
GROUP (G)	1	72.90	72.900	87.76	0.000	.53
Error	78	64.79	.831			
		Within subjects				
Language of Sentence (LSEN)	1	1.41	1.41	2.83	0.097	.04
Error	78	38.82	.50			
Language of Stimulus (LSTIM)	1	.90	.90	2.56	0.114	.03
Error	78	27.44	.35			
Stimulus Type (STYP)	1	3.03	3.03	7.62	0.007	.09
Error	78	30.97	.40			
LSEN x G	1	.03	.03	.05	0.823	.00
LSTIM x G	1	1.41	1.41	3.99	0.049	.05
LSEN x LSTIM	1	40.00	40.00	66.25	0.000	.46
Error	78	47.10	.60			
LSEN x STYP	1	.03	.03	.08	0.775	.00
Error	78	23.67	.30			
LSTIM x STYP	1	1.06	1.06	3.50	0.065	.04
Error	78	23.60	.30			
LSEN x LSTIM x STYP	1	.76	.76	1.72	0.194	.02
Error	78	34.37	.44			
LSTIM x STYP x G	1	1.60	1.60	5.30	0.024	.06
LSEN x STYP x G	1	.06	.06	.19	0.668	.00
LSEN x LSTIM x STYP x G	1	.63	.63	1.42	0.237	.02

Whereas participants in the control group responded correctly to the mean number M= 27.0 of fragmented stimulus words, the corresponding figure obtained by the experimental group was M= 53.75.

Another significant main effect was found for Stimulus Type ($F(1, 78) = 7.62$, $p < 0.01$). As mentioned earlier, repeated stimuli led to less priming than inferred stimuli in both same and different language conditions. More specifically, for same language repeated stimuli following Polish and English sentences the percentage of priming was 57% and 46% respectively, whereas for inferred stimuli it was 69% and 45%. In the different language condition, in turn, the percentage priming for repeated stimuli was 20% following presentation of Polish sentences and 44% following presentation of English sentences. The corresponding figures for inferred stimuli were 46% and 72% (for the summary of priming percentages see Table 1 earlier in the section). The advantage of inferred over repeated primes in terms of the number

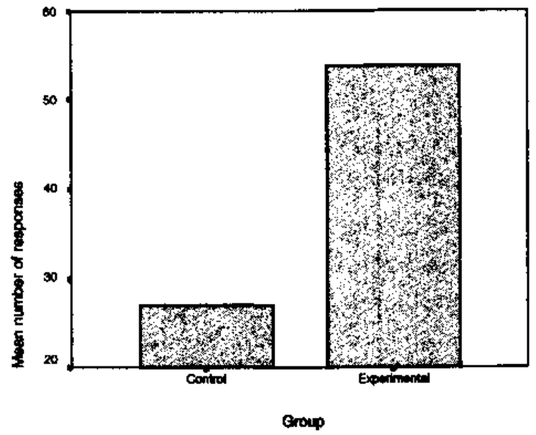

Figure 2. Mean number of correct responses obtained by participants in the control and experimental groups

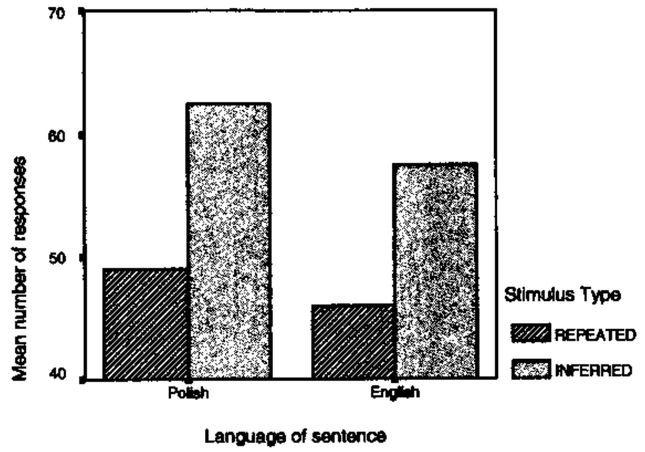

Figure 3. Mean number of correct responses following presentation of Polish and English sentences as a function of Stimulus Type (the data concern the experimental group only)

of correct responses that they elicited in the experimental group is graphically illustrated in the bar chart in Figure 3.

As seen in the bar chart, significantly more correct responses were obtained for fragmented stimuli following presentation of Polish sentences when the primes were inferred (M= 62.5) than when they were repeated (M= 49.0). Likewise, for word fragments following presentation of English sentences, substantially more correct answers were obtained for stimuli which were inferred (M= 57.5) than for stimuli which were repeated (M= 46.0).

Apart from the robust effects of Group and Stimulus Type, no other main effects turned out to be statistically significant. Thus, Language of Sentence presented during the study phase of the experiment did not affect participants' performance on the

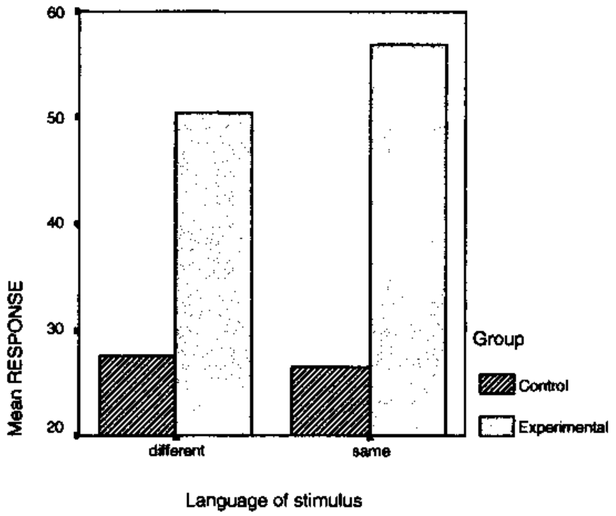

Figure 4. Mean number of correct responses obtained by Control and Experimental Groups as a function of Language of Stimulus

word fragment completion task (F (1, 78) = 2.83, p > 0.05). Similarly, Language of Stimulus failed to affect participants' performance in a statistically significant way (F (1, 78) = 2.56, p > 0.05). The fact that participants' performance did not differ as a function of whether the stimulus they saw was in the same language as the language of the sentence they had studied previously or whether it was in a different language provides support for the hypothesis that semantic representations of L1 and L2 lexical items are shared in the bilingual mental lexicon. The results obtained by both groups as a function of Language of Stimulus are depicted graphically in the bar chart in Figure 4.

A close look at the bar chart reveals that, irrespective of whether the language of stimulus was the same as or different than the language studied in the conceptual phase of the experiment, both control and experimental groups completed a comparable number of fragments. More specifically, participants from the control group completed correctly the mean number M= 26.5 of same language fragmented stimuli and the mean number M= 27.5 of different language stimuli. Likewise, participants from the experimental group answered comparably to stimuli in both same and different language conditions. The relevant figures are M= 57 for same and M= 50.5 for different language stimulus words. Overall then, performance was not affected by whether the languages at study and test were the same or different, which testifies to the simultaneous availability of semantic representations of L1 and L2 translations in the course of language processing by bilinguals.

Turning now to the interaction effects obtained in the ANOVA, the only two-way interaction which turned out to be statistically significant was that between Language of Sentence and Language of Stimulus (F (1, 78) = 66.25, p < 0.0001). As

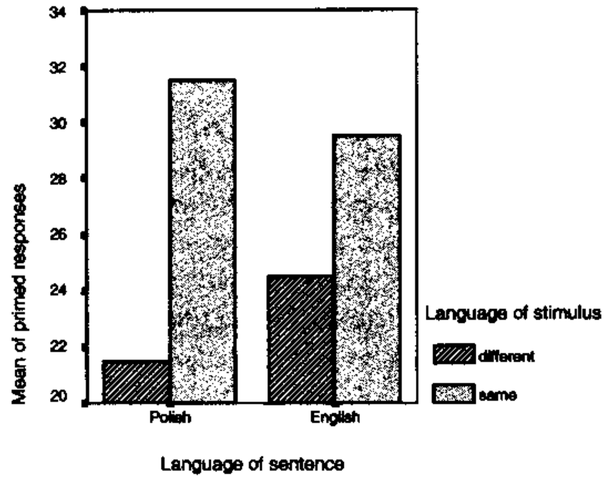

Figure 5. Mean number of primed responses (i.e. the number resulting from deducing the baseline values from the overall number for the Experimental Group) obtained by the Experimental Group as a function of Language of Sentence and Language of Stimulus

reported earlier in the section (compare Table 2), considerably more priming was obtained for different language stimuli following presentation of English sentences (44% for repeated and 72% for inferred items) than for different language stimuli following presentation of Polish sentences (20% for repeated and 46% for inferred items). These results show the general predominance of Polish over English completed answers, which is quite logical, given the fact that participants were native speakers of Polish and that Polish was their dominant language. The interaction between Language of Sentence and Language of Stimulus is graphically illustrated in Figure 5.

Overall, the mean number of primed responses was bigger for Polish fragmented stimuli than for English ones. Thus, same language stimuli following Polish sentences were completed more often (M= 31.5) than same language stimuli following English sentences (M= 29.5), and different language stimuli following English sentences were completed more often (M= 24.5) than different language stimuli following Polish sentences (M= 21.5).

Another ANOVA result important for our hypothesis concerning interlanguage priming effects is lack of a significant interaction between Language of Sentence and Stimulus Type (F (1, 78) = .08, p > 0.05) on the one hand and between Language of Stimulus and Stimulus Type (F (1, 78) = 3.50, p > 0.05) on the other (see Table 3). It thus appears that participants' performance on the word fragment completion task including both repeated and inferred stimuli was unaffected by whether those stimuli were earlier studied in English or in Polish sentences and whether they were later to be completed in the same or in the different language than the language of the study phase. These results provide additional support for the suggestion that

shared semantic representations were accessed in the course of studying items in one language, making their translation equivalents available for later processing in the test phase of the experiment.

As far as three-way interactions revealed in the ANOVA are concerned, only the Language of Stimulus by Stimulus Type by Group interaction appeared significant ($F(1, 78) = 5.30$, $p < 0.05$), which confirms the earlier reported results concerning differences between the number of correct responses produced by participants from the control and experimental groups, as well as between repeated and inferred stimulus items. Summary of the means obtained for repeated and inferred items in the same and different language conditions by participants from both groups is provided in the bar charts in Figure 6.

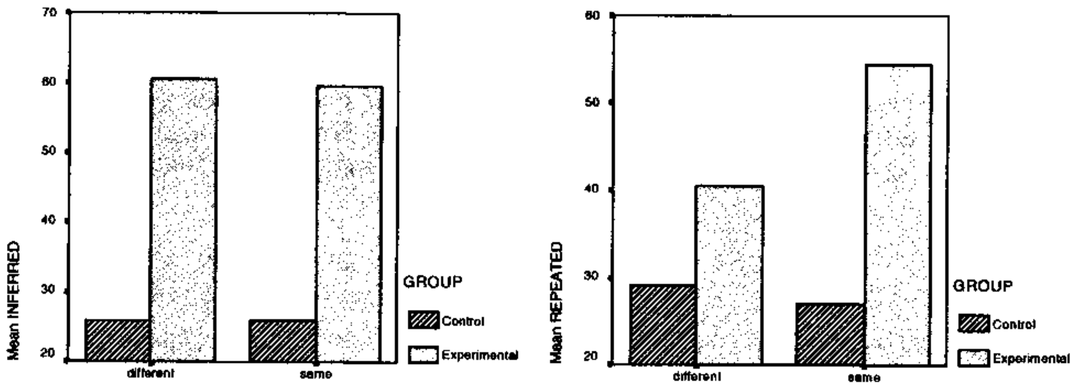

Figure 6. Mean numbers of correctly completed inferred (left part of the panel) and repeated (right part of the panel) stimuli as a function of Language of Stimulus and Group

The bar charts show that, whereas inferred stimuli elicited a comparable number of correct responses in the same and different language conditions within Experimental and Control Groups (left panel), the numbers of correct responses elicited for repeated items (right panel) varied more substantially for the same and different language conditions within both groups. More specifically, whereas the mean numbers of correctly completed inferred stimuli were identical for the same and different language conditions in the Control Group (M= 26.00), and highly comparable in the Experimental Group (M=59.5 for the same and M= 60.5 for the different language condition), the mean numbers of correct answers for repeated stimuli varied from M=27.00 in the same to M= 29.00 in the different language condition in the Control Group and from M= 54.5 in the same to M=40.5 in the different language condition in the Experimental Group.

4. Conclusions

The study described in this paper has provided evidence suggesting that two languages of a bilingual have a common semantic representation and that accessing an item in one language can activate its translation equivalent or semantic associate in another language. Thus, Polish-English bilinguals participating in the study were susceptible to both within- and between-language semantic priming, completing significantly more fragmented words when these words were repeated or inferred in the same or different language in the study phase than when they were preceded by unrelated study items. More direct support for the hierarchical model of bilingual memory representation comes from the statistical analysis of the results, which revealed that participants' performance was not affected by whether languages at study and test were the same or different. This result is consistent with the results reported by Smith (1991) in her word fragment completion experiment conducted with French-English bilinguals.

An important difference between the study reported by Smith and the one described here concerns the stimulus materials employed for the experimental group. In Smith's study different experimental groups were exposed to study sentences in one language only (either English or French), whereas Polish-English bilinguals participating in the experiment described in this paper were exposed to both English and Polish sentences in the study phase. Exposing participants to sentences in both languages during the study and conceptualization stage might have encouraged them to engage in the 'bilingual mode' of processing to a larger extent than if they had been exposed to monolingual lists only (see Grosjean 2001 for a discussion of the bilingual's language modes). Subsequently, both languages might have become activated to a considerably larger extent than if the lists had been monolingual, in which case functioning at the monolingual end of the language mode continuum could have been more likely. Verifying if this indeed would be the case requires further research.

Similarly to the results obtained by Smith, which showed greater accuracy in completing word fragments in the participants' native language than second language, also here Polish-English bilingual subjects completed more words in Polish than in English, and this advantage held true in both the same and different language conditions. This finding reflects the fact that bilinguals were generally more proficient in Polish than in English. Another interesting observation that has emerged from the analysis of the data concerns priority of correctly completed inferred over repeated responses. This priority turned out to be statistically significant for all items, irrespective of the language of sentence presentation and of whether the fragmented stimuli were in the same or different language than the language of presented sentences. The finding of the priority of priming effects for inferred over repeated items suggests that participants were in fact engaging in deep semantic processing of the study items and resorting to the products of this processing as retrieval

clues for completing fragmented stimuli. It hence appears that when performing the word fragment completion task language users employ not only lexical-level information based on surface characteristics of studied items, but also semantic information. Had the Polish-English bilinguals relied primarily on the surface characteristics of the studied items the priming percentage obtained for repeated stimuli should have exceeded that obtained for inferred items.

In summary, the present experiment is important not only for its implications concerning the structure of the bilingual language user's lexical network and interaction of two languages in the course of language processing, but also for what it reveals about the processes involved in the word fragment completion task. The present data indicate that the hierarchical model of bilingual lexical memory, postulating a language-specific lexical level with information about word forms and a shared semantic level with conceptual specifications, may be an accurate description of the way in which two languages are stored in the second language user's mental lexicon. The data also imply that common meaning representations are accessed in the course of processing language stimuli and that this semantic information is recruited in completing fragmented stimuli in the word fragment completion test.

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APPENDIX 1

A complete list of the sentences employed in the experiment along with their inferred and repeated items used in the word fragment completion test (sentences from 17 to 32 and their corresponding targets are Polish translation equivalents of sentences 1-16 and their English targets)

Sentences used in the study phase	Repeated target	Inferred target
Fluid pleased newborn.	newborn	milk
Building kept books.	book	library
Fish attacked swimmer.	swimmer	shark
Vehicle flew passengers.	passenger	airplane
Person guarded flock.	flock	shepherd
Mammal chewed tree bark.	tree	beaver
Box held body.	body	coffin
Headgear safeguarded motorcyclist.	motorcyclist	helmet
Animal guarded the house.	animal	dog
Offender stole jewelry.	offender	thief
Organ circulated blood.	organ	heart
Worker delivered mail.	worker	postman
Man worked for the newspaper.	man	reporter
Furniture was used for sleeping.	furniture	bed
Woman took the patient's pulse.	woman	doctor
Vessel was filled with beer.	vessel	glass
Ciecz zadowoliła noworodka.	noworodek	mleko
Budynek mieścił książki.	książka	biblioteka
Ryba zaatakowała pływaka.	pływak	rekin
Pojazd przetransportował pasażerów w powietrzu.	pasażer	samolot
Człowiek pilnował stada.	stado	pasterz
Ssak gryzł korę drzewa.	drzewo	borsuk
Skrzynka przechowywała ciało.	ciało	trumna
Nakrycie głowy chroniło motocyklistę.	motocyklista	kask
Zwierzę strzegło domu.	zwierzę	pies
Przestępca ukradł biżuterię.	przestępca	złodziej
Organ pompował krew.	organ	serce
Pracownik dostarczył pocztę.	pracownik	listonosz
Mężczyzna pracował dla gazety.	mężczyzna	reporter
Mebel służył do spania.	mebel	łóżko
Kobieta zmierzyła pacjentowi tętno.	kobieta	lekarka
Naczynie napełnione było piwem.	naczynie	kufel

APPENDIX 2

(A) An example of a complete list (List 1) of sentences provided in the test phase (the right-hand column lists corresponding stimulus words subsequently employed for completion)

List of sentences used in the conceptual integration (study) phase	Target words used for the completion task
Fluid pleased newborn.	NEWBORN
Building kept books.	LIBRARY
Fish attacked swimmer.	PŁYWAK (SWIMMER)
Vehicle flew passengers.	SAMOLOT (AIRPLANE)
Człowiek pilnował stada. (Man guarded flock.)	STADO (FLOCK)
Ssak gryzł korę drzewa. (Mammal chewed tree bark.)	BÓBR (BEAVER)
Skrzynka przechowywała ciało. (Box held body.)	BODY
Nakrycie głowy chroniło motocyklistę. (Headgear safeguarded motorcyclist.)	HELMET
Animal guarded the house.	ANIMAL
Offender stole jewelry.	THIEF
Organ circulated blood.	ORGAN
Worker delivered mail.	LISTONOSZ (POSTMAN)
Mężczyzna pracował dla gazety. (Man worked for the newspaper.)	MĘZCZYZNA (MAN)
Mebel służył do spania. (Furniture was used for sleeping.)	ŁÓŻKO (BED)
Kobieta zmierzyła pacjentowi tętno. (Woman took patient's pulse.)	WOMAN
Naczynie napełnione było piwem. (Vessel was filled with beer.)	GLASS

(B) An example of an actual list with degraded words distributed in the test phase

ENGLISH WORDS:

N__W__ __RN
L__ __R__RY
B__D__
A__ __M__L
T__I__F
W__M__N
G__A__S
H__L__ __T

POLISH WORDS:

P__Y__ __K
S__ ___ __L__T
S__A__O
B__ __R
__R __A__
L__S__ __N__ __Z
M__ __ __Z__Z__A
Ł__Ż__ __