CHAPTER
14

Stroop Interference in Bilinguals:
The Role of Similarity
Between the Two Languages

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ABSTRACT

A bilingual Stroop task was used to examine how bilinguals access and store
words in two languages. The goal of this research was to examine if language
similarity and language proficiency have influences on the representation of
bilingual information. We tested bilinguals of similar languages (i.e., English–
German and German–English) and bilinguals of dissimilar languages (i.e., Eng-
lish–Greek and Chinese–English). Some participants were fluent in both lan-
guages; others were only at an intermediate level of proficiency in the second
language. The results indicate that beginners access words in the foreign lan-
guage via the corresponding word in the mother tongue. The highly proficient
bilinguals of two dissimilar languages seem to store the two corresponding
words in two different dictionaries, which are connected only at the semantic
level. The highly proficient bilinguals of two similar languages, on the other
hand, experience considerable between-language interference, indicating that
they do not separate the two dictionaries to the same extent as the bilinguals
of two dissimilar languages. Implications for learning a second language are
discussed.

A bilingual version of the Stroop (1935) color word task is often employed
to examine lexical representations in bilinguals (Dyer, 1971; Preston & Lam-
bert, 1969). In Stroop’s original experiment, participants saw a color word,
such as red, in an incongruent ink color, such as blue. The participant’s task
was to ignore the word and to name the ink color (i.e., say “blue”). Generally,
participants have considerable difficulty with this task, compared to a task in which they just have to name the ink color of color patches. The difference in response times between naming the ink colors of incongruent color words and naming the ink colors of color patches is known as Stroop interference. The bilingual version of this task involves color words of both languages, and the bilingual participants are asked to respond on some trials in their dominant language (L1) and on other trials in their nondominant language (L2). This bilingual task yields two within-language (i.e., L1 words and L1 responses; L2 words and L2 responses) and two between-language (i.e., L1 words and L2 responses; L2 words and L1 responses) interference scores, and the relations among these four scores allow conclusions about how bilinguals store and access words in two languages.

The general finding is that within-language interference is greater than between-language interference (MacLeod, 1991). This effect has been shown with English–Hungarian and English–French bilinguals (Preston & Lambert, 1969), English–Spanish bilinguals (Dyer, 1971), Chinese–English and Japanese–English bilinguals (Fang, Tzeng, & Alva, 1981), and Arabic–Hebrew bilinguals (Tzelgov, Henik, & Leiser, 1990, Experiment 1). The difference is attributed to the fact that bilinguals store words of different languages in different mental dictionaries. When only one language is involved, as in the within-language conditions, the stimulus is highly compatible with the response and can exert more interference than in the between-language conditions, in which the interference has to spread from one dictionary to another.

The between-language interference is usually about 75% of the within-language interference (MacLeod, 1991). However, the exact relation between the two types of interference varies considerably between studies. The ratio of between- to within-language interference is sometimes as low as 61% in Chinese–English bilinguals (Fang et al., 1981) and 68% in English–Hungarian bilinguals (Preston & Lambert, 1969, Experiment 1) but sometimes as high as 95% in English–French bilinguals (Preston & Lambert, 1969, Experiment 1). This variation has been attributed to the orthographic similarity between the two languages. The more similar the two languages' orthography, the more compatible the interfering stimulus with the response and the greater the between-language interference. Fang et al. (1981) showed that the ratio of between- to within-language interference increases as the two languages become more orthographically similar (see also Dyer, 1971).

The fact that within-language interference is always greater than between-language interference has been challenged by a number of studies in which contradicting results were obtained. In Preston and Lambert's (1969) English–German bilinguals, the ratio of between- to within-language interference was 100% (see Experiment 2, Group 1). Likewise, Tzelgov et al. (1990) found greater between- than within-language interference for Hebrew–Arabic bilinguals responding in Arabic (116%). Gerhand, Deregowski, and McAllister (1995) got a similar result with Gaelic–English bilinguals responding in Gaelic (184%). Ehri and Ryan (1980) used a picture-word interference task and also observed larger between- than within-language interference in English–Spanish bilinguals. Other results put some doubt on the role of orthographic similarity for the pattern of the two types of interference. The ratio of between- to within-language interference in English–Spanish bilinguals responding in Spanish was sometimes 66% (Dyer, 1971) and sometimes 112% (Fang et al., 1981). Lee, Wee, Tzeng, and Hung (1992) examined Chinese–English, Malay–English, and Indian–English children and found no effects of orthographic similarity on the ratio of between- to within-language interference.

In response to some of the earlier inconsistent findings, Mägiête (1984) suggested that the participants' level of proficiency in L2 is important because the method of accessing and storing words in the two languages may change as individuals become more fluent in L2. She compared the within- and between-language interference of five groups of German–Swedish bilinguals who varied in the amount of time they had lived in Sweden. Low-proficiency bilinguals, who had 1 year of residence, experienced more interference with L1 (German) color words than with L2 (Swedish) color words. In other words, there was greater within-language interference when the participants named the ink color in L1 but greater between-language interference when they responded in L2. High-proficiency bilinguals, who had 3 or more years of residence, experienced more or less equivalent amounts of interference. Participants clearly dominant in Swedish, who were born in Sweden or had arrived in Sweden shortly after birth, showed a slight reversal; that is, they experienced somewhat greater interference from L1 (Swedish) than from L2 (German) color words in both response languages. Mägiête concluded that not language similarity but language proficiency was the determinant of the patterns of within- and between-language interference. The more fluent someone is in a given language, the greater potential color words from that language have to produce interference.

Chen and Ho (1986) took up Mägiête's (1984) idea of conducting developmental studies and compared several groups of Chinese–English bilinguals with different levels of proficiency in English. They found that L1 (Chinese) color words produced more interference than L2 (English) color words in both response languages when participants were not very fluent in L2. However, beyond a certain level of proficiency in L2 (i.e., grade 8 and above), there was greater within- than between-language interference in both response languages. This pattern could be observed with three different groups of bilinguals varying in the degree of proficiency in L2 (i.e., grade 8, grade 10, and college). However, the differences in proficiency among these groups did not affect the various interference scores. In other words, once participants have reached a certain level of proficiency in L2, proficiency no longer matters. The sole determinant of the interference is whether the
stimulus color word and the response are in the same language or not. Comparing their results to those of Mägiste, Chen and Ho suggested that language similarity and language proficiency jointly affect the patterns of within- and between-language interference. When L1 and L2 are very similar, language proficiency matters. If L1 and L2 are fairly dissimilar, the compatibility between stimulus and response is the driving force, at least beyond a certain point of language proficiency in L2.

Chen and Ho (1986) argued that the differences between their Chinese–English bilinguals and Mägiste’s (1984) German–Swedish bilinguals can be attributed to the difference in language similarity between the two languages because the two studies resembled each other in all other important aspects. However, language similarity is not the only dimension by which the two studies can be distinguished. There were two other important differences. First, Mägiste tested students of similar age, whereas in Chen and Ho’s study, language proficiency was related to age. That is, the older students were more proficient in English. Second, Mägiste’s participants lived in the country where L2 (Swedish) was spoken, but Chen and Ho’s participants lived in Hong Kong where L1 (Chinese) was spoken. This difference goes together with the fact that Mägiste’s high-proficiency participants learned to write in L2, whereas the participants in Chen and Ho’s study learned to write in L1. To summarize, alternative explanations can be suggested for the differences between Mägiste’s results and those of Chen and Ho.

The purpose of the present research was to examine the role of language similarity and language proficiency for the patterns of within- and between-language interference under relatively controlled conditions. As the review of the literature suggests, many studies yielded contradictory results. However, a direct comparison between different studies is often difficult because they involve different types of bilinguals, and often it is unclear how proficient participants really were in L2. Our goal was to resolve some of the contradictions by examining bilinguals who were alike in all respects except the two languages they spoke.

Why is it important to study the Stroop interference scores of bilinguals? The patterns of within- and between-language interference allow us to draw conclusions about how bilinguals access and store lexical information. Potter, So, Von Eckardt, and Feldman (1984) discussed two models about the association between equivalent words in a bilingual’s two languages. According to the word association model, the foreign word is associated with and can only be accessed via the corresponding word in the mother tongue. There is no direct connection between the foreign word and the semantic concept itself. Understanding the meaning of a foreign word is a two-step process, first translating it into the mother tongue and then accessing the concept. The concept mediation model, on the other hand, suggests that there are no direct links between the corresponding words in the two languages but that the two words can be accessed independently and are connected only on the semantic level, via an amodal conceptual system (see also Dufour & Kroll, 1995; Kroll, Michael, & Sankaranarayanan, chap. 16, this volume). The two models are shown in Fig. 14.1.

Results showing that L1 color words produce more interference than L2 color words in both response languages are consistent with the word association model. Obviously, reading and understanding L2 color words involves more processing steps, and this difference is why L2 words produce less interference than L1 color words. These results have typically been obtained with bilinguals at a low or intermediate level of proficiency (Chen & Ho, 1986; Mägiste, 1984; Tzeglov et al., 1990). Results showing that within-language interference is greater than between-language interference in both response languages support the concept mediation model. In the between-language condition, interference has to spread via the amodal system from one dictionary to the other, whereas in the within-language condition, the interfering stimulus can exert its effect directly. These results have been observed in bilinguals who had a relatively high level of proficiency in L2 (Chen & Ho, 1986; Fang et al., 1981; Lee et al. 1992; Preston & Lambert, 1969; Tzeglov et al., 1990).

Chen and Ho (1986) suggested a mixed model of language representation in order to account for the data from Chinese–English bilinguals (see also Chen, 1992). Beginners in L2 are assumed to store words according to the word association model whereby a word in L2 first has to be translated into L1 before its meaning can be accessed. As their proficiency in L2 increases, the associative links between the parallel words in the two languages are gradually replaced by concept mediation links so that the two words can be accessed independently and are connected only via the semantic level. There is now abundant evidence for a developmental sequence from word association to concept mediation (see Chen & Leung, 1989; de Groot & Hocks, 1995; Kroll & Curley, 1988; but see de Groot & Poot, 1997, and Potter et al., 1984, for contradicting evidence).

Although Chen and Ho’s (1986) mixed model of language representation accounts for a large number of findings involving a bilingual version of the Stroop task, it cannot explain the results for highly proficient bilinguals of very similar languages (Mägiste, 1984; Preston & Lambert, 1969). Remember that here, equal amounts of interference in all four within- and between-language conditions are typically observed. So far, nobody has put forward ideas on how these bilinguals represent lexical information. We suggest a multiple access model, according to which the parallel words in the two languages can be accessed independently, are both connected to the semantic concept, but have nevertheless maintained strong associative links between each other (see de Groot, 1992, for a similar approach). As a result, meaning can be accessed directly from both words, but the activation of one word automatically carries along the activation of the parallel word in
the other language (see Fig. 14.1). Evidence for this view comes from studies that suggest the existence of a direct associative link between the parallel words in the two languages for high proficiency bilinguals speaking two similar languages (de Groot & Nas, 1991).

We conducted two studies in which we examined the within- and between-language interference exhibited by bilinguals speaking either two similar languages or two dissimilar languages. As mentioned previously, some earlier studies are difficult to compare because they involve different bilinguals in different settings. In order to assess the effects of language similarity, it was necessary to use participants who were alike in all respects except the two languages they spoke. In Study 1, we used participants who all had the same mother tongue (i.e., English), had all learned to write in this language, and were bilingual in English and one other language, the second language being either similar or dissimilar to English. We chose English–German and English–Greek bilinguals. Roughly half the participants were very fluent in L2, whereas the other half were at an intermediate level of fluency in L2. In Study 2, we used participants who all had the same second language (i.e., English), had all learned to write in their first language, and were bilingual in one other language and English with the first language being either similar or dissimilar to English. German–English and Chinese–English bilinguals with a high level of proficiency in L2 (English) participated in the second study.

We predicted that the dominant form of memory organization in low-proficiency participants would be word association. We expected that L1 color words would produce greater interference than would L2 color words in both response languages. This prediction should apply to all types of low-proficiency bilinguals regardless of the similarity of L1 and L2. In agreement with Chen and Ho's (1986) mixed model of language representation, we predicted that high-proficiency bilinguals would display a qualitatively different way of storing lexical information. However, we also expected language similarity to play an important role. High-proficiency bilinguals of two dissimilar languages were expected to use concept mediation, which would show itself in greater within- than between-language interference in both response languages. High-proficiency bilinguals of two similar languages were expected to have multiple access to the words of both languages. Thus, we expected to find equal amounts of interference in all four within- and between-language conditions.

**STUDY 1**

**Method**

**Participants.** Participants in this research were 19 English–German and 17 English–Greek bilinguals in the age range 25–48 years. The participants were contacted by the experimenter and volunteered to be part of the
experiment. All participants except one were born in the United States, and all were English dominant. Most had parents or grandparents who spoke L2 (German or Greek, respectively). Participants were assigned to the high- and low-proficiency groups according to their own judgment. High-proficiency participants considered themselves to be at least fairly fluent in L2. They indicated that they regularly read texts in L2 and frequently used L2 in conversations with family members or at gatherings of the corresponding cultural community in their home town. Low-proficiency participants considered themselves to be at an intermediate level in L2. Most took advanced-level language classes in L2. They indicated that they read simple texts in L2 but not on a regular basis and that they used L2 rather infrequently in informal conversations. In total, there were 10 low-proficiency and 9 high-proficiency English–German bilinguals and 5 low-proficiency and 12 high-proficiency English–Greek bilinguals. All participants claimed to have normal color vision.

**Design.** The experiment is composed of 24 conditions: 2 types of bilinguals (English–German, English–Greek) × 2 levels of language proficiency (high, low) × 3 kinds of stimulus material (color patches, color words in English, color words in the second language) × 2 response languages (English, second language). The first two factors varied between participants; the other two were within-participants factors. Response time to name the ink color of the stimuli was the dependent variable.

**Materials.** Stroop color interference cards were constructed with 56 items per card, 7 in each of 8 rows. There were two English cards, with color words written in English (i.e., blue, red, green, yellow), and four L2 cards, two with German color words (blau, rot, grün, gelb) and two with Greek color words (χρωμα, κόκκινο, πράσινο, κίτρινο). Each color word was printed in a color that did not match its name. On each card, 14 stimuli were printed in each of the four ink colors. The corresponding L2 cards in German and Greek were strictly identical; that is, the disposition of color words and ink colors was the same except that the color words were in German in one case and in Greek in the other case. Two control cards were created with oval color patches in blue, red, green and yellow. Each participant saw six of these cards—two control cards, two English cards, and two L2 cards—and, therefore, saw 336 items in total.

**Procedure.** The participants were tested individually in sessions that lasted about 20 minutes. English–Greek bilinguals performed the following six tasks: (a) named colors of color patches in English, (b) named colors of color patches in Greek, (c) named colors of English color words in English, (d) named colors of English color words in Greek, (e) named colors of Greek color words in English, and (f) named colors of Greek color words in Greek. English–German bilinguals performed the same tasks, but they saw German color words and responded in German in the corresponding conditions. The order of the card presentation was approximately counterbalanced across participants, though all participants started with the two control cards before going on to the color-word cards. The instructions for all conditions were to name the color in which the word was written as quickly as possible, while ignoring the word itself.

**Results.**

The mean response times for the four experimental groups are presented in Table 14.1. However, it does not make sense to compare the participants’ response times on the different color-word cards because they do not reveal the amount of interference created by the color words. Two participants with the same response times to a certain color-word card may have experienced a very different amount of interference by the color words. Based on a suggestion by Dunbar and MacLeod (1984), we calculated for each participant four interference scores, the differences in response time between each of the four color-word cards and the control card that was responded to in the same language. The mean interference scores are shown in Fig. 14.2. The two top panels of Fig. 14.2 show the data for low-proficiency bilinguals, and the two bottom panels show high-proficiency bilinguals.

<table>
<thead>
<tr>
<th>Low Proficiency</th>
<th>High Proficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>English-German (N = 10)</strong></td>
<td><strong>English-Greek (N = 5)</strong></td>
</tr>
<tr>
<td>Response language: L1 (English)</td>
<td></td>
</tr>
<tr>
<td>Color patches</td>
<td>32.0</td>
</tr>
<tr>
<td>Color words in L1</td>
<td>52.3</td>
</tr>
<tr>
<td>Color words in L2</td>
<td>44.0</td>
</tr>
<tr>
<td>Response language: L2 (German or Greek)</td>
<td></td>
</tr>
<tr>
<td>Color patches</td>
<td>46.3</td>
</tr>
<tr>
<td>Color words in L1</td>
<td>57.4</td>
</tr>
<tr>
<td>Color words in L2</td>
<td>55.1</td>
</tr>
</tbody>
</table>
We had predicted that for low-proficiency participants, L1 color words would always produce more interference than L2 color words and the patterns of within- and between-language interference would not depend on language similarity. To test these predictions, we conducted a 3-factor analysis of variance that included only the data from low-proficiency participants (see top panels of Fig. 14.2). Stimulus language and response language were treated as repeated measures, and type of bilingual served as the between-participants factor. The dependent measures were the participants’ interference scores. The results showed a strong main effect of stimulus language, $F(1, 13) = 36.17, p < .0001$, indicating that L1 (English) color words produced considerably more interference than color words in L2 (German or Greek). This result was observed in every cell of the design. Post hoc comparisons showed that L1 color words produced more interference than L2 color words for low-proficiency English–German bilinguals responding in English, $F(1, 9) = 10.09, p = .05$, and responding in German, $F(1, 9) = 4.03, p = .08$, as well as for English–Greek bilinguals responding in English, $F(1, 4) = 37.52, p = .004$, and responding in Greek, $F(1, 4) = 3.81, p = .12$.

The main effect of stimulus language is qualified by a stimulus language by response language interaction, $F(1, 13) = 4.76, p < .05$, suggesting that English color words are particularly disturbing when participants are asked to name the ink color of the stimuli in English compared to when they name the ink color in L2. Also, the stimulus language main effect is stronger for English–Greek bilinguals than for English–German bilinguals, $F(1, 13) = 11.05, p < .01$. Finally, and most important, the three-way interaction of stimulus language, response language, and type of bilingual was not significant, $F(1, 13) < 1$. This result shows that the patterns of within- and between-language interference are not affected by the similarity of the two languages. Low-proficiency English–German and English–Greek participants seem to store lexical information in the same manner. The fact that L1 color words produce considerably more interference than L2 color words in every single condition suggests that low-proficiency bilinguals cannot activate a word in the foreign language without activating at the same time the corresponding word in their mother tongue.

Our predictions for the high-proficiency participants depended on language similarity. For English–German participants, we had expected to find equal amounts of interference in all four conditions. For English–Greek bilinguals, we predicted the within-language interference to be stronger than the between-language interference. Taken together, we expected the pattern of within- and between-language interference to depend strongly on language similarity. We conducted another 3-factor analysis of variance, including only high-proficiency participants (see bottom panels of Fig. 14.2). The results yielded again a stimulus language main effect, $F(1, 19) = 8.97, p < .01$. As before, L1 (English) color words produced more interference than L2 color words (German or Greek). This effect was mostly driven, however, by cells in which participants responded in English; post hoc comparison for English–German bilinguals, $F(1, 11) = 4.17, p = .08$; for English–Greek bilinguals, $F(1, 11) = 29.07, p = .0002$. When participants responded in L2 the effect disappeared (English–German bilinguals, $F(1, 8) < 1$) or was reversed (English–Greek bilinguals, $F(1, 11) = 8.03, p = .02$).

As for low-proficiency bilinguals, the stimulus language reliably interacted with response language for high-proficiency bilinguals, $F(1, 19) = 21.32, p < .001$, providing yet another example of the large amount of interference that English color words produce when participants respond in English. More relevant is the significant interaction among stimulus language, response language, and type of bilingual, $F(1, 19) = 13.05, p < .01$. Whereas the high-proficiency English–Greek bilinguals showed much stronger within- than between-language interference scores, the two types of interference
language. It is interesting to explore whether the same results would be found if the two types of bilinguals share L2 but have a different dominant language.

**STUDY 2**

To establish the generalizability of our results, we conducted a second study in which we used German–English and Chinese–English bilinguals. These two participant groups all had the same second language (i.e., English), learned to write in their first language, and were bilingual in one other language and English with the first language being either similar or dissimilar to English. We decided to test only participants who were highly proficient in L2 because the contradicting results in the literature concern only high-proficiency bilinguals. Mägiste (1984), Chen and Ho (1986), and our first study all showed the same pattern for low-proficiency bilinguals, namely that L1 color words produce more interference than L2 color words regardless of response language. The theoretically interesting question really concerns only highly proficient bilinguals. Is it true that in these individuals, the connections between the corresponding words in the two languages depend on the similarity between the two languages? Study 2 addressed this question with German–English and Chinese–English bilinguals.

**Method**

**Participants.** Twelve German–English and 12 Chinese–English bilinguals volunteered to participate in the study (age 23–35 years). All participants shared a number of characteristics: They were born and raised in their home country (i.e., Germany or China), attended school there, learned to write in L1 (i.e., German or Chinese), learned English during adolescence or at adulthood, and had lived in the United States for at least 3 years but not more than 8 years at the time of the experiment. All were fluent in English, were involved in teaching or research at the University of Colorado, and indicated that they read frequently in English. However, all said that their mother tongue was clearly the dominant language. The Chinese–English participants were all from mainland China and spoke Mandarin. All participants claimed to have normal color vision.

**Design.** The design was the same as in Study 1, but the language proficiency factor disappeared because we only used high-proficiency participants. Study 2 was composed of 12 conditions: 2 types of bilinguals (German–English, Chinese–English) × 3 kinds of stimulus material (color patches, color words in L1, color words in English) × 2 response languages (L1, English). The first factor varied between participants; the other two were within-
participants factors. Response time to name the ink color of the stimuli was the dependent variable.

**Materials and Procedure.** The two Greek color word cards were replaced by two Chinese color word cards. Besides this difference the material and the procedure were identical to that of Study 1. Participants saw three types of cards: control cards, L1 cards (German or Chinese), and English cards. They saw two cards of each type, and their task was to name the color of stimuli once in L1 and once in English. The order in which the cards were presented was counterbalanced across participants.

**Results and Discussion**

The mean response times for the two experimental groups are presented in Table 14.2, and the mean interference scores are presented in Fig. 14.3. The results closely replicate those of Study 1. A 3-factor analysis of variance with stimulus language and response language as repeated measures, type of bilingual as a between-participants factor, and interference scores as the dependent measure revealed a reliable interaction of all three factors, F(1, 22) = 26.83, p < .0001. Whereas the interference scores of German–English bilinguals do not seem to depend on stimulus language or response language, the interference scores of Chinese–English bilinguals are affected to a large extend by whether stimulus language and response language are the same. Post hoc comparisons showed that the interaction of stimulus language and response language was not significant in German–English bilinguals, F(1, 11) = 1.39, p > .10, but was very large and significant in Chinese–English bilinguals, F(1, 11) = 32.22, p < .0001. In contrast to Study 1, the 3-factor analysis of variance did not reveal a main effect for stimulus language, such that L1 color words did not produce consistently more interference than L2 color words. In fact, the only cell of the design in which the difference between L1 and L2 color words was significantly greater than zero was that including Chinese–English bilinguals responding in Chinese, F(1, 11) = 16.74, p < .002. In sum, these data show that high-proficiency German–English and Chinese–English bilinguals differed in the way they stored bilingual lexical information. The factor responsible for this difference seems to be the similarity between the two languages (for another example of the influence of orthographic similarity between L1 and L2 on linguistic processes, see Buck-Gengler, Romero, Healy, & Bourne, chap. 12, this volume).

To what extent did participants experience interference when they saw L1 color words and named the ink color in L2? A 1-factor analysis of variance with type of bilingual as the independent variable reveals that the interference scores for German–English bilinguals were reliably larger than the interference scores for Chinese–English bilinguals in this condition, F(1, 22) = 13.47, p < .001 (interference for German–English bilinguals M = 18.1 s; for Chinese–English bilinguals M = 6.0 s). Again, it appears that high-proficiency bilinguals of similar languages do not efficiently inhibit L1 words when producing L2 words, compared to high-proficiency bilinguals of dissimilar languages.

**GENERAL DISCUSSION**

We hypothesized that the structure of bilingual lexical representations depends on the level of proficiency in L2 and on the similarity between L1 and L2. We suggested that when individuals are not yet very proficient in L2,
there are direct associative links between corresponding words in the two
languages. With increasing proficiency in L2, the associative links are gradu-
ally replaced by concept mediation links on the semantic level. However,
part of our hypothesis was that this pattern should not apply to very similar
languages because the associative links between parallel words in similar
languages are never replaced and the two languages are never stored
independently.

The results of the two studies confirmed our predictions. First, both
low-proficiency English–German and low-proficiency English–Greek bilinguals
in Study 1 displayed greater within- than between-language interference when they responded in L1, whereas there was an inverse relation when they responded in L2. In other words, the L1 (English) color word always produced greater interference than the L2 color word (German or Greek). Similar results have been obtained by other researchers who used low-proficiency bilinguals in their studies (Chen & Ho, 1986; Mägište, 1984). Taken together, these results suggest that the L1 word is accessed directly but that the corresponding L2 word can be accessed only via this L1 word. This translation strategy is best described by the word association model. The method of accessing the L2 word by first activating the corresponding L1 word seems to be a general characteristic of bilinguals at a low level of proficiency in L2. The similarity of L1 and L2 does not seem to play a role.

Second, high-proficiency English–Greek (Study 1) and Chinese–English (Study 2) participants showed in both response languages greater within-
than between-language interference. This supports the idea of concept med-
iation links: When two languages are involved (i.e., between-language condi-
tion), activation has to spread from one area of the lexicon to the other, via the semantic level, in order to create interference. In contrast, when the task involves only one language (i.e., within-language condition), there is no need for the activation to spread via the semantic level to create interference, and therefore, interference is greater in the latter case than in the former. Similar results have been obtained with high-proficiency Arabic–He-
brew (Teitelgov et al., 1990) and Chinese–English bilinguals (Chen & Ho, 1986).

Third, the high-proficiency English–German (Study 1) and German–Eng-
lish (Study 2) bilinguals do not seem to fit either the word association model
or the concept mediation model. It is not true that L1 color words always
produce greater interference than L2 color words, which indicates that they
have direct access to words in L2. However, it is also not true that they
display greater within- than between-language interference, which indicates
that they have maintained strong associative links between the correspond-
ing words in the two languages. A similar result has been obtained by
Preston and Lambert (1969, Experiment 2) with English–German bilinguals.
As soon as one word is activated, the corresponding word in the other
language is activated also. It does not seem to matter whether the presented
word is blue or blau because upon the presentation of either, both words are activated automatically.

To summarize, this research provides evidence for a developmental se-
quence in language representation according to which students of a foreign
language shift their method of accessing and storing bilingual information
as they move from being a beginner to being a highly proficient bilingual
(Chen & Ho, 1986; Kroll & Stewart, 1994). However, the present studies also
make clear that this shift is not the same for all types of bilinguals. When
L1 and L2 are fairly similar, they change from a translation strategy, accessing
the L2 word via the corresponding L1 word, to a multiple access strategy,
in which strong associative links are maintained between the corresponding
words in the two languages. We can assume that when highly proficient
bilinguals of two similar languages communicate in L2, L1 is also activated
to some extent. When L1 and L2 are fairly dissimilar, improvement in L2 is
accompanied by a change from a translation strategy to a concept mediation
strategy, in which the parallel words in the two languages have only weak
direct associative links. The two languages are kept relatively separate from
each other, and we can assume that highly proficient bilinguals of two
dissimilar languages succeed quite efficiently in switching off one language
while they communicate in the other one.

Indeed, multiple access and concept mediation are best understood as
the extremes of a continuum. Even high-proficiency bilinguals of two similar
languages are able to use concept mediation (Dufour & Kroll, 1995), and it
would be unreasonable to assume that no associative link whatsoever exists
between the corresponding words in the two languages in a highly proficient
Chinese–English bilingual. Nevertheless, the stronger the direct associative
link between L1 and L2, the more an individual uses the multiple access
strategy. The weaker the direct associative link between L1 and L2, the more
an individual uses the concept mediation strategy.

It might be worthwhile to examine the differences between the multiple
access model suggested here and Kroll and Stewart’s (1994) revised hierar-
chical model (see also Kroll et al., chap. 16, this volume). Both models
assume strong associative links between the concept and each of the two
lexicons in highly proficient bilinguals. Although the revised hierarchical
model assumes that the connections between concepts and words are
weaker for L2 than for L1 for bilinguals at an intermediate level of fluency,
the model clearly specifies that the two languages have similar conceptual
access at high levels of fluency in L2. Furthermore, both models suggest
direct links between the parallel words in the two languages, but the revised
hierarchical model considers these links to be asymmetrical. That is, the L2
word is very likely to activate the parallel L1 word, but the activation of the
L1 word is not automatically followed by an activation of the parallel L2
word. There is abundant experimental evidence for this asymmetry from
studies involving translation tasks and cross-language semantic priming (Kroll & Stewart, 1994; Tzelgov & Eben-Ezra, 1992). However, previous studies involving a bilingual version of the Stroop task have not produced asymmetric effects (Määrist, 1984; Preston & Lambert, 1969). The same is true for the experiments presented here because the between-language interference scores did not depend on the response language. It appears, then, that asymmetric effects are task specific. All in all, the results of the present experiment do not show evidence of an asymmetric connection between L1 and L2 words in high-proficiency bilinguals of similar languages.

What are the implications of this research for the training of foreign languages? The answer to this question depends on whether or not one believes that particular training methods affect the strategy of lexical storage that students adopt. Let us assume first that the strategy depends entirely on the similarity between L1 and L2 and cannot be influenced by the manner in which L2 is taught. Evidence for this position comes from Fang et al. (1981), who showed that the extent to which seven types of bilinguals used concept mediation was linearly dependent on the orthographic dissimilarity between the two languages. Chen (1990) and de Groot (1995) also claimed that the teaching method has very little impact on the way bilinguals represent lexical information. If this position is correct, the implications of our research are that the optimal foreign language training techniques should depend on the similarity between the students' mother tongue and the to-be-learned language. The goal is to lead students as quickly as possible to a strategy of lexical storage that resembles that of a highly proficient bilingual with the same two languages. For example, if English natives want to learn a similar language, such as German or Swedish, the goal is to use teaching methods that foster a multiple access strategy. If English natives want to learn a dissimilar language, the language teacher may be advised to use methods that promote a concept mediation strategy. Note that this position argues against foreign language classes in which students with different backgrounds all learn the same foreign language. Buck-Gengler et al. (chap. 12, this volume) came to a similar conclusion based on their research on utilization processes in reading.

A somewhat different position is that similarity between the two languages is the main determinant of the adopted strategy of lexical storage but nevertheless the particular training methods employed during language training have an impact, too. Given that the two models of storage can be distinguished mainly by the strength of the associative links that are maintained between the corresponding words in the two languages, it is not unreasonable to assume that external factors, such as teaching method, may have an influence on the extent to which both languages are always activated in parallel. Evidence for this point of view comes from Chen and Leung (1989), Ervin and Osgood (1954), and Gekoski (1980).

14. STROOP INTERFERENCE IN BILINGUALS

If we had the choice, would we be better off with a multiple access strategy or with a concept mediation strategy? The data from our studies show that English–Greek and Chinese–English bilinguals experience less interference than English–German and German–English bilinguals when the task is to name the ink color in L2 while ignoring the incongruent color word in L1. This is true when participants share the same dominant language (Study 1) or the same second language (Study 2). These results make the concept mediation strategy appear somewhat more desirable because this strategy allows the bilingual speaker to inhibit interfering stimuli from the dominant language while communicating in L2. If this reasoning is correct, the goal of language training should be to guide students toward adopting a concept mediation strategy.

The research presented in this chapter does not examine what kinds of foreign language training techniques may foster either a multiple access strategy or a concept mediation strategy. One could nevertheless speculate that translation exercises and learning foreign language words via the traditional vocabulary list will help maintain a direct associative link between two words in corresponding languages. On the other hand, monolingual definitions of words and conversation exercises in L2 may strengthen the link between the L2 word and the concept and, at the same time, weaken the link between the L1 and the L2 word, therefore promoting concept mediation. It will be the task of future research to determine if and how various training techniques affect the way bilinguals store lexical information in the two languages. In this study, we have shown that not all bilinguals represent lexical information in the same way. The way of structuring the knowledge largely depends upon the similarity between the two languages. Optimal foreign language training may depend on the similarity of the foreign language to the students' native language.

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