Effect of Bilingualism
on
Familiarity and Recollection in Recognition Memory: Application of a Process Dissociation Paradigm

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Abstract

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In this thesis the effect of advanced second language skills on recognition memory of first language words was investigated. Thirty English monolinguals and 30 bilinguals (1st language English, 2nd French) were compared on a list recognition task involving English words that were previously either read or presented as anagrams. A process dissociation framework (Jacoby, 1991) was used to separate the contributions of automatic (familiarity) and intentional (conscious recollection) processing. To enable statistical analyses, the original framework was extended to an items analysis in which the probability of recognition based on familiarity and recollection for individual words was estimated. The results did not provide, however, definitive support for any of the alternative expectations concerning possible effects of bilingualism on recognition of first language words. There was a trend for bilinguals to rely more on intentional and less on automatic processing,

compared to monolinguals. The effect of the enhanced depth of processing on the increased contribution of controlled processing to recognition memory was significantly stronger in the monolingual than in the bilingual group. This suggests that bilingualism may be associated with reduced efficiency of controlled processes involved in the elaboration of first language stimuli.

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Fluent bilinguals have been documented to be slower in first language information processing in comparison to monolinguals (Magiste, 1986). There is, however, only limited evidence on what type of cognitive mechanism might be responsible for this effect (Segalowitz, 1991), partly because of the lack of techniques to assess the role of specific processes. In this study a recently elaborated framework (Jacoby, 1991) will be applied to compare monolinguals and bilinguals with respect to the contribution of automatic and intentional processing to recognition memory in the first language.

Early research on the cognitive differences between bilingual and monolingual subjects. Despite progressing cultural and economic integration, the research on the phenomenon of the bilingualism has not yet provided definite answers to some essential questions. Since the beginning of the 20th century researchers have tried to determine the consequences of mastering two or more languages on cognitive abilities (Segalowitz, 1977; Keatley, 1992). Early studies in this area, however, treated bilingualism as an unidimensional phenomenon in attempts to assess its effect on higher cognitive functioning. Typically, new immigrants were compared to native monolingual speakers on verbal and nonverbal tests, and detrimental effects of bilingualism on intelligence were frequently reported (Appel & Muysken, 1987; Hoffman, 1991). The validity of these findings was later questioned on methodological grounds. For example, Hakuta (1986) pointed out that immigrants participating in these studies tended to have lower socio-economic status and, moreover, were often tested in their nondominant language, factors that could easily account for their inferior performance.

In contrast, in the 1960's and 1970's several authors reported that bilingual subjects were superior on tasks involving creative thinking and intelligence tests (Appel & Muysken, 1987). For example, in an influential study Peal and Lambert (1962) reported better performance of bilingual subjects on verbal as well as nonverbal intelligence tests. Although in that study several variables known to be related to intelligence (age, sex, socio-economic status) were controlled for, the authors admitted that the results might have been partly confounded due to selection bias. In order to be included in the bilingual sample a child was required to have rich vocabulary in both languages. Accordingly, those balanced bilinguals who had relatively limited vocabulary were omitted. Therefore, based on the previous studies showing positive correlation between language aptitude and intelligence, Peal and Lambert (1962) suggested that this selection procedure might be responsible for the observed superiority of bilinguals.

Hakuta (1986) argues that the conflicting results reported in the literature may partly reflect the misconception that there is just one global effect of bilingualism on cognitive skills. Accordingly, recent studies have focused on identifying specific differences in language performance between monolinguals and bilinguals rather than attempting to establish which of the two populations performs uniformly better (Favreau & Segalowitz, 1983). These studies use tasks involving elementary information processing that allow for an easier direct measurement of relevant performance (Magiste, 1979).

Effects of bilingualism on performance on memory tests. One line of current research focuses on the identification of experimental factors that systematically affect the performance of bilingual subjects on memory tests. In contrast to earlier studies that focused on intelligence testing, this research mainly uses tasks involving elementary levels of information processing. Magiste (1979) argues that such tasks provide more direct measures of the relative performance of bilinguals versus monolinguals. Ransdell and Fischler (1987), building on previous studies, isolated four dimensions on which facilitory, detrimental or no effect of knowing a second language on first language memory would be expected. They compared episodic versus semantic memory tasks, data-driven versus concept-driven processing, abstract versus concrete materials and, finally, outcome measures of accuracy versus speed of responding.

Previous studies had shown clear disadvantages of bilingualism on speeded semantic memory tasks (Magiste, 1979, 1980). Given these findings Ransdell and Fischler (1987) included two semantic tasks (lexical decision and object naming) and two episodic tasks (recognition and recall of list of words) to investigate whether the bilinguals' inferior performance is limited to semantic tasks or was characteristic of performance in all tasks.

Since semantic tasks typically draw on concept-driven processes and episodic tasks typically draw on data-driven processes (Snodgrass, 1984; Durgunoglu & Roediger, 1987), Ransdell and Fischler (1987) designed their experiments to separate the effects of these two factors. This was achieved by including one concept-driven and one data-driven test in both the semantic and episodic sets of tasks. Free recall and object naming represented concept-driven tasks while recognition and lexical decision task exemplified data-driven processing mediated by perceptual features of the word.

An additional manipulation included a comparison of performance with concrete and abstract words on each of the four tasks.

Ransdell and Fischler (1987) noted also that in previous studies reaction time was typically used as the dependent measure for semantic tasks whereas response accuracy was evaluated in episodic tasks. To avoid the potential criticism that differences in results between semantic and episodic tasks reflect differences in the choice of performance measures, both accuracy and latency were recorded in all four tasks.

Finally, the authors ensured that subjects were tested exclusively in English which was their native and presently dominant language. This restriction of the stimulus material to one language reduced the risk of activating the second linguistic code which could, in principle, slow response latency in bilinguals. The fact that the only difference between the two groups was that the bilingual subjects had mastered a second language made the results of the two experimental groups more comparable than in other studies (e.g., Magiste, 1980).

In none of the comparisons among the experimental conditions did Ransdell and Fischler (1987) find significant differences on measures of accuracy between bilinguals and monolinguals. The only observed differences were on response latencies in the recognition and lexical decision tasks. In the case of recognition tasks, differences between monolinguals and bilinguals were significant only for abstract words. In general, bilinguals were slower on one of the two semantic tasks (lexical decision but not object naming) and on one of the two episodic memory tasks (recognition but not recall). This pattern of results suggested that the episodic/semantic dimension does not provide a consistent basis on which to determine where bilinguals are at a disadvantage.

Ransdell and Fischler (1987) did observe that on concept-driven tasks (recall, object naming) bilinguals' and monolinguals' latencies were not significantly different whereas on data-driven tasks (recognition and lexical decision) bilinguals were significantly slower. Following Magiste (1979), Ransdell and Fischler (1987) claimed that the observed disadvantage of bilinguals on data-driven tasks may be due to their lower familiarity with the first language reflecting their more limited exposure to it, in comparison with monolinguals.

Ransdell and Fischler further supported their conclusion that the bilinguals' disadvantage was specific to data-driven tasks by observing that in the recognition task differences between the two groups of subjects were limited to abstract word condition. Abstract words are more difficult to represent in a supralinguistic imagery code than concrete words and are rather more likely to be stored in a language specific surface form (Paivio & Desrochers, 1980), hence recognition of abstract words is more data-driven compared to concrete words (Ransdell & Fischler, 1987).

In summary, as far as response latency measures are concerned, Ransdell and Fischler's (1987) results seem to be consistent with their conjecture that the bilinguals' disadvantage on data-driven tasks might reflect their lower familiarity with the first language. However, they fail to explain, and indeed fail to discuss, why in spite of this reduced familiarity there is no difference between bilingual and monolingual subjects on any measure of accuracy. Since Ransdell and Fischler's (1987) conjecture has been proposed *a posteriori*, it requires confirmation with independent data. Such a further investigation should explicitly address the idea that first language familiarity plays a role in determining performance differences between bilinguals and monolinguals.

Familiarity and Recollection as two bases for word recognition. There is a general consensus in the literature as to the nature of the psychological mechanisms underlying the phenomenon of stimulus familiarity and its role in recognition. Mandler (1980) posited that repeated exposure to a target event focuses the viewer's organizational processes on "perceptual, featural and intrastructural" characteristics of the event rather than on its relation to the context. Consequently, memory for these perceptual characteristics and the resulting increased perceptual integration of the elements of the target event are experienced as a "feeling of familiarity". A similar view is presented by Johnston, Dark and Jacoby (1985) who emphasized even more strongly subjects' reliance on the feeling of familiarity in perception. They argued that the relative ease with which an item is perceived as a result of previous encounters with the item, serves as a basis for its familiarity. These authors proposed that the familiarity attributable to this perceptual fluency could be operationally defined and measured in terms of the subject's performance on an identification task under conditions of impoverished presentation. High correlation would be expected between the measure of perceptual fluency and the probability of calling an item "old" if subjects relied only on familiarity in their judgment of previous occurrences. Therefore, familiarity is typically conceived as a context-free memory for perceptual features of a previously presented item.

Jacoby (1991) presented a similar notion of familiarity, although he broadened the idea by allowing that an item's relationship with other items also influences its familiarity. More importantly, he emphasizes that familiarity exemplifies automatic use of memory, that is, recognition based on familiarity is fast, relatively effortless, independent of intention and processing capacity.

In agreement with the two-factor model of recognition (Juola, Fischler, Wood, & Atkinson, 1971; Mandler, 1980), Jacoby states that conscious recollection is an alternative basis for judging previous occurrence of a target event. Recollection involves a conscious search of long-term storage (Mandler, 1980). In contrast to recognition based on familiarity, this search is intentional, relatively slow, subject to capacity limitations and, therefore, is viewed as reflecting controlled processing.

Jacoby (1991) argues that research on automatic and controlled processing in different domains (e.g. perception, attention, memory) is frequently flawed by the assumption that the tasks are process-pure. That is, researchers frequently employ tasks they believe to provide a measure of automatic processing (e.g. dichotic listening) without considering the possibility that performance on these tasks may also be partly influenced by intentional processing. In contrast, Jacoby (1991) postulates that every task involves a mixture of automatic and controlled processes, and the challenge is to assess the relative contribution of these processes to overall performance.

Process dissociation framework. Accordingly, Jacoby (1991) states that each recognition task involves a blend of processes reflecting familiarity (automatic processing) and recollection (controlled processing) that, following Mandler (1980), are assumed to be independent of each other. In order to estimate the separate contribution of familiarity and recollection to performance on a recognition task, Jacoby proposed a new methodological paradigm: the process dissociation framework. He has developed this paradigm in the context of list recognition tests similar to that used by Ransdell and Fischler (1987).

Jacoby's (1991) framework is based on two premises. The first, derived from elementary mathematics, states that in order to find two unknowns a set of two non-redundant equations is needed. That is, in order to separate the contribution of familiarity and recollection it is necessary to formulate two equations in which familiarity and recollection will summate in a different way. Each equation has to reflect relationships involved in a specific task and results of these tasks will provide numerical data necessary to solve the two equations. The second premise is that familiarity, being independent of intention, can either enhance or hamper a subject's performance, depending on the demands of a specific task. Hence, Jacoby designed two different recognition tasks, *inclusion* and *exclusion* tasks that can be expected to provide non-redundant information about the separate contributions of familiarity and recollection. In the inclusion task, automatic uses of memory (based on familiarity) increase the proportion of correct responses, over and above effects due to the contribution of conscious recollection. In contrast, in the exclusion task, reliance on familiarity leads to errors in recognition, if unopposed by controlled memory use (recollection).

Inclusion condition. More specifically, the inclusion task proposed by Jacoby (1991) includes three phases. In the first phase subjects *read* a list of words, without being aware that their memory for these words will be tested. In the second phase subjects *hear* a list of different words and are informed that these words will be later used in a memory test. In the last phase subject perform a *recognition* task involving the words presented in the two previous phases, as well as new words. Subjects are instructed to call "old" those words that were encountered in either of the previous phases and to call "new" those words not presented earlier in the experiment.

Jacoby assumes that in this task a word read in Phase 1 will be called "old" if it is either consciously recollected or recognized on the basis of familiarity. Put more formally, and assuming the independence of familiarity (F) and recollection (R), the probability of calling a Phase 1 word "old" in the inclusion task (OI) is :

$$OI = R + F - (R * F) \quad (1)$$

where R and F denote, respectively, the probability of recognizing a Phase 1 word on the basis of recollection and familiarity.

In other words, the probability of calling a Phase 1 word "old" in the inclusion task is the sum of the probability of calling it "old" because it was consciously recollected plus the probability it was called "old" because it was familiar minus the joint probability that it was both consciously recollected *and* it was familiar.

Exclusion condition. Experimental conditions in the exclusion task are identical to those just described with the exception of the Test Phase. In the exclusion condition subjects are told to call a word "old" only if it has been *heard* in the Phase 2 of the experiment. Other words, including words read in Phase 1, should be called "new". Given these instructions, Jacoby assumes that all Phase 1 words that are consciously recollected will be correctly identified as "new" since their source (visual) will be part of the information recollected. On the other hand, calling a word read in Phase 1 "old" is interpreted as an indication that the word was not recollected but that it was familiar (having been encountered in Phase 1) and that therefore the response reflects an automatic use of memory (familiarity). Accordingly, the probability of calling a Phase 1 word "old" in the exclusion condition (OE) is calculated as:

$$OE = F * (1 - R) \qquad (2)$$

In other words, the probability of calling a phase 1 word "old" in the exclusion task is the joint probability that it was recognized as familiar and not consciously recollected.

Estimating the contribution of Familiarity and Recollection. Solving equations (1) and (2), one obtains the following formulas to estimate the separate contributions of familiarity and recollection to recognition of experimental stimuli (Jacoby, 1991):

$$R = OI - OE \qquad (3)$$

$$F = OE / (1 - R) \qquad (4)$$

In other words, recollection is calculated as a difference between probability of calling a word "old" in the inclusion task and the probability of calling a word "old" in exclusion task. Familiarity is calculated as a ratio of probability of calling a word "old" in exclusion task to the probability the word was not consciously recollected.

The process dissociation paradigm provides a general framework that can be used in a variety of recognition tasks (Jacoby, Toth & Yonelinas, 1993). Jacoby (1991) provides an example of the application of his paradigm and the results are consistent with the two-factor model of recognition in so far both familiarity and recollection were found to have made substantial contributions. The estimates of familiarity were also validated by showing their close agreement to estimates derived from an independent experiment using the same stimuli but different experimental conditions (Jacoby,1991). In that experiment the possibility of conscious recollection was eliminated since during the recognition memory test subjects were engaged in a distraction task. Therefore, Jacoby (1991) assumed that the observed proportion of "old" responses could be interpreted as a direct estimate of the probability of recognition based on familiarity. When this direct estimate of probability of recognition based on familiarity was compared to that derived from the process dissociation framework (formula (4)) the results were practically identical.

Another process dissociation framework. Segalowitz (1991) used a different approach, originally proposed by Favreau and Segalowitz (1983), to estimate the contribution of automatic and controlled processing in bilinguals' first language. He was the first to propose that the previously documented slower performance in the first language of highly skilled bilinguals in comparison to less skilled bilinguals could be explained in terms of a differential effect of bilingualism on automatic and controlled processing. To investigate whether automatic and/or controlled processing in the first language is affected by advanced knowledge of the second language, Segalowitz (1991) adopted Neely's paradigm (1977) which allowed him to obtain indices of automaticity and controlled processing and to compare fluent balanced with fluent unbalanced bilinguals with respect to these indices. The paradigm used - a primed-lexical decision task - resembles the process dissociation framework in that it involves the condition where automatic and intentional processes function in opposition as well as the condition where they cooperate.

In the lexical decision task used by Segalowitz (1991), a target string of letters was preceded by a prime word which described a category of semantically related words or by a neutral prime (meaningless string of letters e.g. ooooo). Experimental manipulations involved the interval between the onset of the prime and the target (short or long), the semantic relation between the prime and the target (related or unrelated), and the subject's expectancy as to what category of words to expect after seeing the prime (related to prime or a specified unrelated category). On a small number of surprise trials subjects' expectancy was violated, so that instead of the expected semantically related target an unrelated target was presented or vice versa.

The pattern of results observed in the short stimulus onset asynchrony (SOA) condition was considered to reveal the operation of automatic processing as there was not enough time for a subject to execute an expectancy based strategy. In this condition subjects responded faster when the prime was semantically related to the target word than when the prime was neutral, regardless of the earlier established expectancies. The magnitude of this facilitation effect for related words in the short SOA condition was interpreted as an index of the strength of automatic processing. There were no inhibition effects (slower latencies in comparison with neutral trials) for targets unrelated to the primes. The magnitude of facilitation and inhibition at the long SOA, on the other hand, was interpreted as an index of controlled processing since expectancy and not semantic relatedness affected the speed of response in that condition (Segalowitz, 1991).

Comparing fluent balanced bilinguals (who read with the same speed in both languages) with fluent unbalanced bilinguals (who read faster in their first language than in their second language) with respect to these measures of automaticity and controlled processing, Segalowitz (1991) found that fluent balanced bilinguals displayed more automaticity but less efficient controlled processing in their first language than fluent unbalanced bilinguals. This indicates that in spite of their slower first language reading rate, fluent balanced bilinguals have at least as efficient automatic processing as fluent unbalanced bilinguals. Accordingly, bilinguals and monolinguals may be expected not to differ in the strength of automatic first language processing but with respect to intentional processing.

Hypotheses and objectives of the present study. We have seen that different studies on the effects of bilingualism on performance in first language cognitive tasks have yielded different findings. In some studies no difference between bilingual and monolingual subjects was found but more often bilinguals were reported to perform slower on many encoding and decoding tasks (Magiste, 1979; Ransdell & Fischler, 1987). There is a certain degree of controversy among researchers as to what type of psychological mechanism is responsible for such inferior performance of bilingual subjects in their first language. For example, Magiste (1980) attributed increased latencies of bilingual subjects to reduced automatic processing in the first language. Automatization of processing is considered to result from frequent and consistent practice (Schneider & Fisk, 1982). Fluent bilinguals, who may be expected to operate a great deal of the time in both their languages, will likely have less consistent and less frequent practice in a given language and, hence, less automaticity in their first language than monolinguals. The tendency to interpret shorter response latency as evidence of increased automaticity and longer latency as an indication of reduced automaticity has a long tradition in the research on bilingualism (Lambert, 1955).

Segalowitz (1991) argues, however, that using latency as a measure of automaticity ignores the possibility that increased response time might be due to a reduction in the efficiency of controlled rather than automatic processing in bilingual subjects tested in their first language and provides evidence to support this hypothesis. Accordingly, he suggests that automatization of word recognition in the first language developed in childhood is not so easily affected negatively by subsequent second language acquisition. The idea of partitioning the effects of bilingualism into two different types of cognitive processes offers an opportunity to better understand the complex phenomenon of functioning in two languages.

In this study an attempt was made to contribute to the discussion on whether first language automatic and/or controlled processing are affected by advanced second language skills in the context of a recognition memory task. The recently proposed process dissociation paradigm (Jacoby, 1991) was used to estimate independent contributions of automatic and controlled processes to the recognition of first language words and these estimates provide a basis for a comparison between monolingual and bilingual subjects. While the present study should be considered exploratory, a specific pattern of results may be expected based on the study of Ransdell and Fischler (1987) who compared similar groups of subjects in a similar type of task. As described earlier Ransdell and Fischler (1987) reported that bilinguals were slower than monolinguals on list recognition of the first language words. This finding would be conventionally interpreted as an indication of reduced automaticity in bilingual subjects (Lambert, 1955; Magiste, 1980).

It should be noted that the conventional interpretation of the reaction time was used exclusively to formulate preliminary hypothesis but has no implication for the interpretation of the results of this study. Estimation of the contribution of the familiarity and recollection is based on Jacoby's (1991) process dissociation framework which relies entirely on proportion of "old" responses, not speed of response. This approach eliminates the needs to choose *a priori* between the conventional interpretation of slow reaction time as an indicator of reduced automaticity and Segalowitz's (1991) argument that slow reaction time reflects reduced efficiency of controlled processing.

Using an inclusion task, Ransdell and Fischler (1987) found that recognition accuracy of bilinguals and monolinguals was equal. Yet, according to Jacoby familiarity and recollection have additive effects on the probability of correct responses in the inclusion task (formula (1), p.10). Therefore, if monolinguals' and bilinguals' performance is equally accurate in inclusion task and if, as assumed, the role of familiarity is reduced in the bilingual group then according to formula (1) this reduced role played by familiarity has to be compensated for by increased recollection in bilingual group. Consequently, it is expected under this interpretation that the contribution of familiarity in bilinguals' recognition of list words will be lower than in monolinguals and the contribution of recollection will be higher.

If confirmed by experimental results, the joint hypothesis that knowing a second language reduces familiarity, thus automaticity, and it increases the contribution of intentional processing could partly explain why the results of different studies are inconsistent in reporting either advantage or disadvantage of bilingualism on cognitive ability. In view of the above hypothesis, a differential effect of bilingualism on first language performance may be attributed to the degree to which performance on a particular task relies on automatic or conscious cognitive processes. On the other hand, if no evidence of reduced first language familiarity in bilinguals is observed, then Ransdell and Fischler's (1987) findings of differences only on latencies may suggest another interpretation. It is possible that while contributions of familiarity and recollection in bilinguals are the same as in monolinguals, the conscious search process assumed to underlie recollection (Gardiner, 1988) is slower in bilinguals, reflecting perhaps some differences in memory organization. Such a pattern of results would be more consistent with the findings of Segalowitz (1991) who reported that, in a lexical decision task, increasing second language skills were associated with increased latency but did not adversely affect automaticity.

Method

Subjects

Thirty English monolinguals and thirty English-French bilinguals participated in the study. The native language of all sixty subjects was English, as determined by a self-reported language acquisition questionnaire. Both monolingual and bilingual subjects rated different dimensions of their language performance (speaking,listening, reading, writing,) on a five-point scale (1=no ability; 2=very little; 3=moderate; 4=very good; 5=complete). Only those subjects who self-evaluated their knowledge of the first language as complete in all four aspects, and in case of bilinguals, of their second language as complete at least in two and as very good in two of the remaining aspects, were invited to participate in the study.

All subjects were screened using procedures adopted from Favreau and Segalowitz (1983). Subjects were required to read as quickly as possible a standardized English text and then to answer ten multiple-choice questions. As a result, each subject's optimal reading rate and comprehension score was measured. To be enroled in the study subjects had to meet the following conditions. Both for monolinguals and bilinguals the reading comprehension score had to be at least 70%. In addition, subjects were selected so that the difference between mean English-language reading rates for monolinguals and bilinguals did not exceed 10% of the monolingual group reading rate .

Bilingual subjects were additionally screened on a comparable French text and were required to have a comprehension score of at least 70%, and their reading rate in French was also measured.

Subjects in the monolingual and bilingual groups were randomly assigned to the two experimental conditions, inclusion and exclusion, so that fifty percent of each group participated in each condition.

Materials

A set of 120 five-letter English nouns of varying frequency and degree of concreteness selected from the list of 925 nouns published by Paivio, Yuille and Madigan (1968) were used as experimental stimuli. Fifteen words were presented visually as *anagrams* to be solved and fifteen words were presented visually in their normal form to be *read* by the subject in the first phase of the experiment. These words were intermixed in random order with the restriction that no more than three words from the same group (anagram, read) would follow one another. Anagrams had second and fourth letters unchanged and underlined, with the other letters randomly rearranged (Jacoby, 1991). Sixty additional words were *heard* in the second phase.

The test list used in Phase 3 of the experiment included all the words presented previously in Phase 1 and 2 plus thirty *new* words, all intermixed in random order and presented visually.

The words in the four stimulus groups (anagrams, read, heard, new) were matched with respect to frequency and degree of concreteness, using the following procedure. First, the pool of 120 words was divided into four unequal categories ranging from low to very high frequency based on Thorndike-Lorge ratings (Paivio et al, 1968) as follows: low =(0 - 18) occurrences per million; medium = (19 - 36); high = (37 - 49 & A=50); very high = (A=100) and above. Subsequently, each of the frequency categories was further divided into low- and high-concreteness words, using 4.0 as a cut-off on the 1-7 scale of concreteness (Paivio et al, 1968). Words in each of the eight resulting frequency x concreteness categories were then randomly assigned to four stimulus sets. As the result of the above matched random allocation the four sets were characterized by similar means and standard deviations of both frequency and concreteness (see Appendix A for lists of words selected to each set and Appendix B for summary statistics).

Ten additional five-letter English nouns were selected to serve as buffers to counteract possible primacy and recency effects in Phase 1 of the experiment (Jacoby,1991). Five of these words were presented to the subject in their normal form and five were presented as anagrams. Three buffer words and three buffer anagrams were included at the beginning of the list while the remaining two words and two anagrams ended the list. Buffers were excluded from the subsequent test and were not scored.

Procedure

Following Jacoby (1991), the experiment consisted of three successive phases. Each subject was tested individually in a single session. The procedure was the same for all subjects with the exception of the instructions in Phase 3 (test) which was different for the inclusion and exclusion conditions.

In Phase 1, subjects were asked to read words aloud and to solve anagrams presented in the centre of the computer screen, one at the time. In this phase, subjects were not informed that a test of memory recognition would follow (see Appendix C for Phase 1 detailed instructions).

In the Phase 2 all subjects heard words recorded on a tape at a 2-second rate. They were asked to repeat each word aloud and were advised that memory for these words would be tested later (see Appendix D for Phase 2 detailed instructions).

The final phase of the experiment consisted of a recognition test. The test list included 30 words from Phase 1 (15 read words and 15 anagrams), 60 words heard in Phase 2 and 30 entirely new words. Words appeared on a computer screen one at the time and subjects were required to decide whether the word was "old" or "new". In the inclusion condition they were instructed to call the word "old" if it has been earlier presented as anagram, read or heard, and to call it "new" if it has not been encountered in either of the two previous phases of the experiment. In the exclusion condition, subjects were required to call a word "old" only if it had been heard in Phase 2, otherwise the word was to be called "new" (see Appendix E and F for Phase 3 detailed instructions).

Results

The results presented below are organized as follows. First, I report results of screening and preliminary analyses necessary to establish whether the data gathered in this experiment, on which Jacoby's (1991) estimates of the contributions of automatic and controlled processing are subsequently based, meet certain basic requirements. For this, the comparability of the four groups of subjects in terms of their ability to solve anagrams in English, the consistency of data with the well established effect of the depth of elaboration on recognition (Jacoby & Craik, 1979), and the accuracy of read words recognition in the inclusion condition for monolingual and bilingual groups were assessed. Next, the results relevant to the main focus of this study are reported. For this, bilingual and monolingual subjects were compared with respect to overall estimates of the contributions of familiarity and recollection as well as corresponding estimates for individual experimental stimuli. Finally, the effects of word frequency and concreteness on familiarity and recollection were investigated.

Screening data. Monolingual subjects mean reading rate was 240 wpm (s.d. = 57) and bilinguals mean reading rate was 247 wpm (s.d. = 76). The difference between the two groups was less than 3% and it was not statistically significant ($t(58) = -.433$, $p > .5$). In the bilingual group the mean reading rate in the second language was 181 wpm which is 27% less than their mean reading rate in the first language.

Preliminary analyses. *General comparability of subject groups.* To demonstrate the comparability of subjects assigned to the four experimental conditions in terms of task-relevant cognitive skills, the mean proportion of solved anagrams was determined for each group. In Phase 1 of the experiment, monolingual subjects solved on average 88% and 87% of the anagrams in the inclusion and exclusion conditions respectively. Bilingual subjects solved on average 91% of the anagrams in both conditions. Using one-way ANOVA the differences in mean proportions of solved anagrams between all four groups were found not to be significant ($F(3,56)=0.45, p > 0.5$).

Depth of Processing effect. Two preliminary analyses were performed on the proportion of "old" responses presented in Tables 1a and 1b (these proportions are later used to estimate the contribution of familiarity and recollection using Jacoby's formulas). The purpose of the first analysis was to verify whether data from this experiment conform with well established effects of depth of processing on memory performance (Jacoby & Craik, 1979). This verification was deemed useful for increasing our general confidence in the procedures used here, in so far as the data on the proportion of "old" responses do not show unexpected characteristics that could adversely affect subsequent estimates of familiarity and recollection. It was expected, therefore, that in both language groups anagrams would be better recognized than read words, i.e. the probability of calling an

Table 1a.

Mean proportion (standard error) of calling an item OLD in Monolingual group

	STIMULI			
	ANAGRAM	READ	HEARD	NEW
CONDITION :				
INCLUSION	.83(.05)	.52(.04)	.73(.03)	.19(.03)
EXCLUSION	.17(.03)	.29(.05)	.61(.03)	.12(.02)

Table 1b.

Mean proportion (standard error) of calling an item OLD in Bilingual group

	STIMULI			
	ANAGRAM	READ	HEARD	NEW
CONDITION :				
INCLUSION	.70(.04)	.56(.03)	.74(.03)	.18(.03)
EXCLUSION	.16(.04)	.25(.03)	.57(.04)	.18(.03)

anagram "old" should be higher in the inclusion condition (correct responses) and lower in the exclusion condition (incorrect responses) compared to read words in each of these conditions. The reason for this expectation was that solving an anagram involves substantially more elaborated semantic processing than reading a word presented in its normal form.

To assess this, a two-way mixed ANOVA with language group (monolingual vs bilingual) as a between-subject factor and type of stimulus (read vs anagram) as a within-subject factor was carried out separately on proportions of "old" responses in the inclusion and the exclusion conditions. The reason for the separate analyses was that the results observed in the two conditions cannot be directly compared since the response "old" is correct in the inclusion but incorrect in the exclusion condition and a direct comparison of inclusion versus exclusion is not relevant here. In the inclusion condition (see ANOVA summary table in Appendix G) there was a significant effect of stimulus type ($F(1,28)=47.7, p<0.001$) and group by stimulus interaction ($F(1,28)=6.2, p<0.02$). Simple comparisons using paired t-tests confirmed that the mean proportion of items correctly called "old" in the inclusion condition was significantly greater for *anagrams* than for *read* words both for monolingual ($t(14)=6.64, p<0.001$) and bilingual subjects ($t(14)=3.13, p<0.01$) although the difference was significantly greater in the monolingual group as indicated by the interaction. In the exclusion condition (see ANOVA summary table in Appendix H) there was only a significant main effect of type of stimulus ($F(1,28)=11.9, p<0.005$). As expected, collapsing across all subjects in both language groups, the average proportion of incorrect "old" responses was lower for anagrams (0.18) than for read words (0.27). This result is consistent with the well documented beneficial effect of deeper processing on recognition memory and this increases our general confidence in the data obtained in the present study.

Comparison of monolinguals' and bilinguals' accuracy of read word recognition in the inclusion condition. The purpose of the second preliminary analysis performed on proportion of "old" responses was to verify Ransdell and Fischler's (1987) finding, on which the main hypothesis of this study was partly based, that there would be no difference in the accuracy of list recognition between bilinguals and monolinguals. To assess this, the performance of the two groups on read words in the inclusion condition (which was similar to the task used by Ransdell and Fischler, 1987) was compared using an independent groups t-test. The mean proportion of recognized words in the monolingual group (52.5%) was not significantly different from that for bilinguals (56%) ($t(28)=-0.69$, $p>0.5$). This result replicates Ransdell and Fischler's findings that there is no difference in accuracy between monolingual and bilingual subjects on list recognition task.

Main Analyses. *Comparison of monolinguals with bilinguals on overall estimates of Familiarity and Recollection.* For each language group familiarity and recollection were estimated separately for *read* words and *anagrams* using the formulas proposed by Jacoby (1991). The resulting estimates are presented in Tables 2a and 2b for monolingual and bilingual groups respectively. Due to the

Table 2a.

Estimated probability of recognizing an item based on Recollection and Familiarity in Monolingual group

	STIMULI	
	ANAGRAM	READ
ESTIMATES of :		
RECOLLECTION	.66	.23
FAMILIARITY	.50	.38

Table 2b.

Estimated probability of recognizing an item based on Recollection and Familiarity in Bilingual group

	STIMULI	
	ANAGRAM	READ
ESTIMATES of :		
RECOLLECTION	.54	.31
FAMILIARITY	.35	.36

specific aspects of Jacoby's (1991) paradigm, these overall estimates cannot be compared using standard significance tests. This is because conventional between-subjects ANOVA approach would require estimates of recollection (or familiarity) for individual subjects. To obtain such estimates using Jacoby's (1991) formulas, each subject would have to be tested both in the inclusion and in the exclusion condition since, for example, the contribution of recollection is calculated as a difference between proportion of "old" responses in the two conditions. Repeated testing of the same subject, however, would violate the requirement that in Phase 1 of the experiment, in either condition, the subject should not be aware that a memory test would follow. Therefore, these data will be compared descriptively as was the case in Jacoby's (1991) original study. A re-formulation of the data that allows for formal significance testing is presented later.

As expected, the probability of an item being recognized based on recollection was higher for *anagrams* than for *read* words, both in the monolingual (0.66 vs 0.23) and bilingual (0.54 vs 0.31) groups. It should be noted that this advantage of anagrams over read words in conscious recollection is considerably greater for monolingual (0.43) than for bilingual subjects (0.23). If these differences between anagrams and read words are attributed to a beneficial effect from the more extensive elaboration required by the anagram task, this effect seems stronger in the monolingual group. The fact that this beneficial effect is stronger in the monolingual group cannot be attributed to more extensive elaboration of anagrams as there was no difference between the two groups in the proportion of anagrams solved in Phase 1. Therefore a different mechanism must be responsible for the observed difference. One possible explanation is that knowing a second language reduces efficiency (benefit from elaboration of the stimuli) of intentional processes involved in the elaboration of first language stimuli. This finding would be parallel to that of Segalowitz (1991) who reported a negative effect of increasing second language skills on the efficiency of intentional processing in the context of recognition of first language words. Further research is necessary to investigate the relationships between intentional processes involved in the two types of task and to establish whether a general conclusion about the impact of bilingualism on the efficiency of controlled cognitive processing in the first language is warranted.

The probability of recognition based on familiarity in the bilingual group was virtually identical for *anagrams* and *read* words (0.35 vs 0.36) while in the monolingual group it was higher for anagrams (0.50 vs 0.38). This greater role played by familiarity for anagrams which were not seen in their normal form in Phase 1 seems unexpected given that familiarity is believed to rely on perceptual matching of stimuli in study and test phases (Mandler, 1980). The same pattern of results, however, was obtained by Jacoby (1991) who suggested that familiarity may partly depend on other than perceptual processes.

More relevant to the main hypothesis of this study is the comparison between the two language groups. Bilinguals had a higher probability of recognizing a *read* word based on recollection compared with monolingual subjects

(0.31 vs 0.23) while for recognition based on familiarity bilinguals showed only a very slightly lower probability (0.36 vs 0.38). For anagrams, the monolingual subjects had higher estimates of recollection (0.66 vs 0.54) and familiarity (0.50 vs 0.35) than bilingual subjects.

In general descriptive terms, the results for overall estimates of familiarity and recollection of read words tend to support the idea that the contribution of intentional processing is higher for bilingual than for monolingual subjects. The evidence on the contribution of automatic processing only weakly suggests, if at all, that the contribution of automatic processing may be lower for bilinguals than for monolinguals.

The overall estimates of recollection and familiarity discussed above were subsequently corrected for a guessing bias which was calculated, following the procedure used by Jacoby (1991), separately for each group and each condition, as the probability of calling a new item "old". The procedure involved first subtracting the corresponding guessing bias from the observed probability of calling an item "old" in each condition and, next, applying Jacoby's (1991) formulas (3) and (4) to these corrected probabilities. These corrected estimates are presented in Table 3a and 3b for monolinguals and bilinguals respectively. For *read* words, the trends observed previously in the uncorrected estimates, become more apparent. For bilingual subjects recollection is higher (0.31 vs 0.16) and familiarity is lower (0.10 vs 0.20) than in the monolingual group. For *anagrams* the substantial advantage for monolingual subjects revealed in the previous,

Table 3a.

Estimated probability of recognizing an item based on Recollection and Familiarity in Monolingual group as CORRECTED for GUESSING

	STIMULI	
	ANAGRAM	READ
ESTIMATES of :		
RECOLLECTION	.59	.16
FAMILIARITY	.12	.20

Table 3b.

Estimated probability of recognizing an item based on Recollection and Familiarity in Bilingual group as CORRECTED for GUESSING

	STIMULI	
	ANAGRAM	EAD
ESTIMATES of :		
RECOLLECTION	.52	.31
FAMILIARITY	.00	.10

uncorrected estimates is retained in terms of familiarity (0.12 vs 0.0) but inconsiderably reduced in terms of recollection (0.59 vs 0.52).

Estimates of Familiarity and Recollection for individual items. As noted earlier, it is not possible to apply conventional between-subjects ANOVA tests to compare monolinguals and bilinguals on Jacoby's (1991) estimates of familiarity or recollection. One way around this difficulty is to re-arrange the data so that an individual item (word or anagram), rather than the individual subject, is used as the unit of analysis. Therefore, in order to allow formal significance testing of the difference between the two language groups, familiarity and recollection probabilities were estimated for individual words and anagrams using the same formulas as for overall estimation. In Appendix I and J the estimates of familiarity and recollection of individual items are listed separately for monolingual and bilingual groups. In 3 among 60 cases (*read* words : PAPER and GRASS in the monolingual group; CHILD in the bilingual group) the item's estimated recollection turned out to be slightly negative (from -0.07 to -0.13 ; this presumably reflects sampling error involved in estimating proportions from only 15 subjects) as the proportion of "old" responses in the inclusion condition was lower than the corresponding proportion in the exclusion condition. Since these estimates are interpreted as the probability of recognition based on recollection, negative values are uninterpretable. In these instances it was assumed that item's recollection equals 0 and consequently when estimating familiarity value of zero was entered in the formula (4).

Individual items differed largely with respect to their estimated familiarity and recollection. Recollection of individual anagrams ranged from 0.40 to 0.87 in the monolingual group and from 0.13 to 0.87 in the bilingual group. For read words recollection varied from 0.00 to 0.80 in the monolingual group and from 0.00 to 0.73 in the bilingual group. Familiarity of anagrams ranged from 0.00 to 1.00 in the monolingual group and from 0.15 to 1.00 in the bilingual group. For read words familiarity ranged from 0.08 to 1.00 in the monolingual group and from 0.09 to 0.78 in the bilingual group.

To verify the reliability of differences between individual items with respect to their recollection and familiarity, the correlation between corresponding estimates in monolingual and bilingual groups was assessed. Since, as explained earlier, it was not possible to estimate familiarity or recollection for individual subjects but only for groups of subjects, the between-groups correlation may be seen as an approximation to a measure of between-rater reliability of the estimates. For read words, the linear correlation coefficient was significant both for familiarity ($r=0.61$, $p<0.01$) and recollection ($r=0.64$, $p<0.01$). The correlation between corresponding estimates of familiarity for anagrams obtained in both groups was significant ($r=0.53$, $p<0.02$) and recollection of anagrams showed marginally significant correlation ($r=0.40$, $p<0.1$). These results indicate that items that have relatively higher contribution of automatic (intentional) processing in the monolingual group tend to have higher contribution of the same type of processing in the bilingual group. Thus, the observed differences between familiarity (recollection) of individual items are reliable and suggest that some word characteristics may explain a portion of the variance in these estimates. I will present later an attempt to assess independent effects of word concreteness and frequency on familiarity and recollection.

In contrast to Jacoby's (1991) study where only overall estimates were calculated, it was possible here to assess the correlation between the estimates of recollection and familiarity derived for each item. This correlation might be relevant to assumptions about the independence between recollection and familiarity as the two bases for recognition memory (Jacoby, 1991). For both monolingual and bilingual subjects, a significant positive correlation between recollection and familiarity of individual read words was observed ($r=0.65$, $p<0.01$ and $r=0.52$, $p<0.05$, respectively). For anagrams, the correlations between recollection and familiarity were weaker and not significant ($r=-0.05$, $p>0.5$ for monolinguals; $r=0.39$, $p>0.1$ for bilinguals). These results do not allow one to determine whether the observed correlation between estimates of familiarity and recollection is spurious in the sense that it reflects correlation of either estimate with a third variable. This issue will be partly examined later when the effects of word frequency and concreteness on familiarity and recollection are assessed (in fact significant negative correlation was found between word frequency and both familiarity and recollection). In any case the significant correlation between familiarity and recollection of individual read words suggests that the *a priori* assumption that the contribution of automatic and intentional processing to recognition are independent may not be entirely correct. Further research is necessary to establish whether this assumption is systematically violated and, if so, to identify the reasons.

Effects of Bilingualism on Recollection and Familiarity in the first language. The main issue of this study was the effect of knowing a second language on the processes used in recognition memory in the first language. To assess the impact of bilingualism on automatic and intentional processing, a two-way mixed ANOVA with language group (monolinguals vs bilinguals) as a repeated factor (within-words) and type of stimulus (anagrams vs read words) as a between-words factor was carried out separately for recollection and familiarity. Language group was considered as repeated factor since individual items (*read* words and *anagrams*) served as units of analysis and the same items were responded to by each group.

The analysis of estimates of familiarity (see ANOVA summary table in Appendix K) yielded a non-significant main effect of monolingual vs bilingual group ($F(1,28)=2.46$, $p>0.1$) where the mean probability of recognition of an item based on familiarity was 0.46 for monolinguals and 0.39 for bilinguals. There was also no significant difference between familiarity of anagrams and read words ($F(1,28)=0.15$, $p>0.50$). The interaction (see Figure 1) between language group and the type of stimulus was not significant ($F(1,28)=0.29$, $p>0.50$). Given statistical nonsignificance of the language group effect, this experiment failed to provide evidence of a reduced contribution of automatic processing in the bilingual group. However, the pattern of differences in mean values of estimated

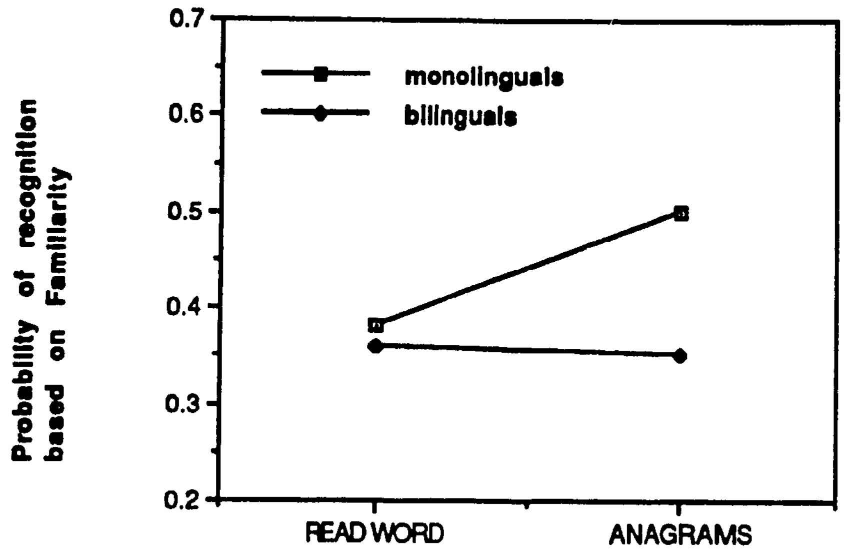

Figure 1. Mean probability of recognition based on Familiarity for two language groups and two types of stimuli.

contribution of automatic processing is consistent with the idea that bilingualism may have slightly detrimental effect on familiarity (see Table 2a & 2b, p.27)

The second main concern was whether the probability of recognition based on recollection would be different for the two groups. A mixed two-way ANOVA based on estimates of recollection (see ANOVA summary table in Appendix L) revealed a significant main effect of stimulus type ($F(1,28)=21.13$, $p<0.0001$) and a significant interaction (see Figure 2) between the language group factor and stimulus type ($F(1,28)=5.11$, $p<0.05$). While in both language groups the contribution of intentional processing to the recognition was higher for anagrams than for read words, post hoc analyses (Tukey HSD test) revealed that this difference was significant for monolingual subjects ($p<0.05$) but not for bilinguals ($p>0.1$). Thus, post hoc comparisons between monolinguals and bilinguals suggest that the effect of bilingualism on recollection may go in the opposite direction for anagrams and read words. Monolinguals exhibited better recognition for anagrams based on recollection than bilinguals while for read words recollection tended to be higher in bilingual group although both differences are not significant. Though not significant, the trend for read words was in agreement with the expectation that bilingual subjects would rely more on intentional processing than monolinguals.

Effect of concreteness and frequency on familiarity and recollection. The existence of systematic differences between individual items in terms of the estimated contribution of familiarity and recollection to their recognition suggests that it might be useful to search for the responsible stimulus characteristics. If

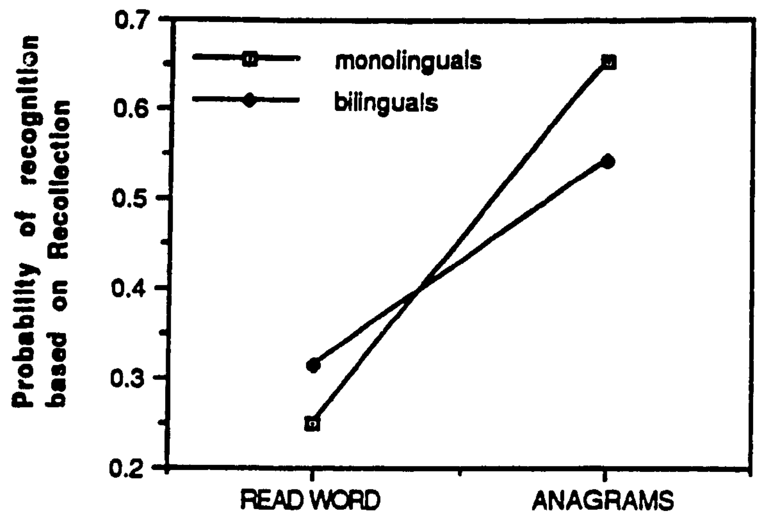

Figure 2. Mean probability of recognition based on Recollection for two language groups and two types of stimuli.

some correlates of word familiarity and recollection could be identified it would be interesting to see whether their effect is different for bilingual and monolingual subjects. Since word frequency and concreteness belong to the most studied characteristics of verbal stimuli, their independent effects on familiarity and recollection were examined using multiple linear regression. Separate analyses were conducted for monolingual and bilingual subjects as well as for anagrams and read words (see summarized results in Appendix M). The most prominent finding was that word frequency, when adjusted for concreteness, had a consistent negative correlation with both recollection and familiarity of read words regardless of language group. In contrast, a significant negative correlation between concreteness and familiarity of read words was observed in the bilingual group ($p<0.05$) but not in the monolingual group ($p>0.50$). No significant effects were observed for anagrams in either group with the exception of a marginally significant positive correlation between frequency and recollection in bilingual group ($p<0.1$).

Together, in the bilingual group, frequency and concreteness explained 51% of the variation in the familiarity (versus 28% for monolinguals) and 31% of the variation in the recollection of individual read words (versus 18% for monolinguals).

Discussion

The purpose of this study was to investigate how bilingualism affects automatic and controlled processing in the recognition of words in the first language. This question arises because it might be thought that advanced knowledge of the second language could reduce familiarity (automatic processing) in the first language and that this reduction in automaticity would be compensated for by greater reliance on recollection (intentional aspects of memory). It might be expected, therefore, that bilinguals, when compared with monolingual subjects on the list recognition task in their first language, would exhibit less familiarity and more recollection. Alternatively, following Segalowitz (1991), one could argue that advanced second language skills might be associated with reduced efficiency of intentional rather than automatic processing in the first language.

Effect of bilingualism on recollection and familiarity in the first language. The results, in terms of overall formulas used by Jacoby (1991), lean in the direction consistent with the expectation that advanced second language skills may reduce automaticity and increase reliance on intentional processing in first language recognition memory tasks. Thus, in the bilingual group the mean probability of recognizing a read word based on recollection was higher by 0.15 (after correcting for guessing) while the overall estimate of familiarity of read words was lower by 0.10 (after correcting for guessing) than in the monolingual group. (Of course, the concept of correcting for guessing in the context of the process dissociation paradigm remains to be explored. Jacoby (1991), without much discussion of the issue, applies a correction for bias to the results of his preliminary experiment but not to his main results obtained in the process dissociation task).

Statistical analyses of the estimates of the probability of recognition based on familiarity and recollection for individual read words revealed non-significant differences between bilingual and monolingual subjects (p-values in the 0.13 to 0.22 range). This result suggests the conclusion that bilinguals and monolinguals do not differ in their reliance on automatic and intentional processing. However, it should be recognized that the differences were in the direction predicted based on Ransdell and Fischler's (1987) results using conventional interpretation of slower performance as indicating reduced automaticity (Lambert, 1955). It is possible that the relatively low sample size reduced the statistical power of these tests as the analysis of the difference between two groups is based on 15 words only. Thus, it may be the case that there is a systematic difference between monolinguals and bilinguals and that this difference could be detected in further research.

The (non-significant) trend, observed here, for bilinguals to have reduced automaticity in their first language is consistent with Magiste's (1979) conclusions based on her observation that the speed of elementary level information processing gradually decreased with increasing second language skills. Following Lambert (1955), Magiste considered the speed of response to be a measure of automaticity. The impact of improving one's second language skills on the performance in the first language was also studied by Segalowitz (1991) who compared fluent different-rate bilinguals whose reading rate was slower in their second language than in the first language with fluent same-rate bilinguals whose reading rate in both languages was the same. Using a primed lexical decision task he found that the same-rate bilinguals, who had received more exposure to their second language, were slower overall in the first language reading compared to different-rate bilinguals, but nevertheless actually exhibited more automaticity. The slower reading speed of the same rate bilinguals was attributable to their less efficient controlled processing (Segalowitz, 1991).

Different findings and conclusions regarding the effect of bilingualism on automaticity in the first language may be attributed partly to the differences in the respective measures of automaticity and partly to differences in the nature of the tasks. On one hand overall response latency, taken by itself, is an inappropriate measure of automaticity because, following Segalowitz (1991) and Segalowitz and Segalowitz (1993), it should be noted that increasing speed may sometimes reflect increased efficiency of controlled processing rather than enhanced automatization. On the other hand, more elaborated measures of automaticity based on Neely's (1977) paradigm as used by Favreau and Segalowitz (1983) and Segalowitz (1991), and on Jacoby's (1991) process dissociation framework applied in this study, may be more task-specific and their generalization may be limited. If, for example, a detrimental effect of bilingualism on automaticity is found in a recognition memory test (Jacoby's paradigm) but not in a lexical decision task (Neely's paradigm), these results should not be considered contradictory as different aspects of performance are measured. Current research does not provide sufficient evidence to establish whether a single generic concept of automaticity could be applied to different tasks so that a consistent effect of experimental manipulation can be expected for all tasks (Stanovich, 1991). It seems also likely that bilingualism could have a differential effect on automaticity in the first language, depending on the specific demands of the situation. In some tasks knowing a second language may enhance automaticity of processing in the first language. This may be, for example, the case of letter recognition if both languages use the same alphabet (for a general discussion about the role of letter recognition in reading see the volume by Tzeng & Singer, 1981, and the paper by Favreau, Komoda & Segalowitz, 1980). In other tasks, such as encoding tasks involving naming colours, digits or pictures knowing a second language may interfere with the retrieval of verbal information in the first language, reducing its automaticity. Further studies, using a range of tasks and a variety of measures, will be necessary to provide more conclusive answers to the above questions.

To recapitulate, the results of this study are consistent with the idea that achieving proficiency in the second language may have a negative effect on automatic processing in recognition memory and that, in contrast, reliance on recollection may be stronger for bilingual than for monolingual subjects, although both effects were statistically non-significant. If a reduction in automaticity occurs, it may be due to possible interference effects from the second linguistic code (Magiste, 1979) whereas greater involvement of controlled processes may support the hypothesis that the second language provides an additional path for retrieval (Ransdell & Fischler, 1987). The possibility that the disadvantage of bilinguals in automatic processing may be compensated by enhanced controlled processing (recollection) can be explained in terms of the conditional search model of recognition memory discussed by Mandler (1980). This model assumes that controlled processes are initiated only if an item fails to be recognized on the basis of its familiarity. The model would predict that bilinguals, for whom automatic processing is less successful, will have greater involvement of controlled processes based on recollection than monolingual subjects.

It should be noticed that the main hypotheses of this study focus on the effects of bilingualism on the performance in the recognition memory tasks where read words, and not anagrams, are used as standard experimental stimuli. Only read words were used in the list recognition task by Ransdell and Fischler (1987) on whose findings the hypotheses of the present study were partly based. Accordingly, only results related to read words were discussed in detail above. The inclusion of anagrams was necessary to apply the process dissociation paradigm as originally described by Jacoby (1991). The memory processes involved in recognition of anagrams are probably more complex and definitely less studied in the research on bilingualism than processes involving read words. Some support for the existence of differences in the effects of bilingualism on recognition of read words and anagrams was obtained from the analysis of the accuracy of responses in the inclusion task. The absence of any evidence of a difference between bilingual and monolingual subjects in the mean proportion of correctly recognized read words was consistent with the results of a similar task reported by Ransdell and Fischler (1987). In contrast, for anagrams the proportion of correct responses in the monolingual group was marginally significantly higher than in the bilingual group. This difference cannot be attributed to the effect of performance in Phase 1 of the experiment as the mean proportions of anagrams solved in the two groups were practically identical.

Although no *a priori* hypothesis was formulated regarding the effect of bilingualism on recognition memory for first language anagrams, the interesting pattern of results that was obtained is worth commenting upon. Comparison of overall estimates indicated that the better recognition of anagrams by monolinguals reflected higher contributions of both intentional and automatic processing than for bilinguals (contribution of recollection was higher by 0.05 and that of familiarity higher by 0.16, after correcting for guessing). Analysis of probabilities of recollection for individual items revealed a significant interaction between language group and the type of stimulus. While for both groups the role of intentional recollection processes was greater in the recognition of anagrams than in the recognition of read words, this difference was greater for monolinguals than bilinguals. This suggests that more elaborated processing of anagrams in Phase 1, compared to read words, had a more beneficial effect on controlled memory processing in the monolingual than in the bilingual group. This effect, if interpreted as an indication of better efficiency of intentional elaboration of the first language stimuli by monolingual subjects, would parallel Segalowitz's (1991) finding of the impact of very high level second language skills on the efficiency of intentional processes involved in the visual recognition of the first language words. Further research is necessary to replicate this finding and to investigate how bilingualism affects efficiency of intentional elaboration.

Effects of concreteness and frequency on Familiarity and Recollection. The results obtained in this study also reveal a difference between bilingual and monolingual subjects in the effects of concreteness on the familiarity of read words. Whereas concreteness did not influence familiarity in the monolingual group, a significant negative correlation between concreteness and familiarity of read words was observed in the bilingual group. This indicates that for bilinguals the recognition of concrete words may rely on automatic processes to a lower degree than does recognition of abstract words. This seems consistent with the theoretical model of bilingual memory proposed by Paivio and Desrochers (1980) based on dual-coding theory (Paivio, 1971). According to this model, concrete words are stored with an imagery code that for bilingual subjects is common to both languages whereas abstract words are stored in verbal codes, i.e. in two different linguistic codes in the case of bilinguals. Ransdell and Fischler (1987) argue that this common storage of concrete words increases the risk of interference from the second language and they predict that in a list recognition task performance of bilinguals will be worse on concrete words than on separately stored abstract words. It should be noted that this prediction was not confirmed by the data collected in the experiment of Ransdell and Fischler (1987) who found that bilingual subjects were significantly slower than monolinguals in recognizing abstract words but the latencies in the two groups were not significantly different for concrete words. In contrast, the results of the present study are consistent with Ransdell and Fischler's *a priori* prediction.

The fact that concreteness is negatively correlated with automaticity in the bilingual but not in the monolingual group can be explained also by combining Paivio and Desrochers' (1980) model with the assumption that automatic processes of recognition memory rely on the perceptual match between stimulus characteristics at the study and test phases (Jacoby, 1991). A concrete word presented at the study phase is represented with an imagery code that, for a bilingual subject, at the test phase can evoke either of two different verbal representations, corresponding to two different languages of which only one matches perceptually item presented at the test. This interference from the second linguistic code may be expected to result in lower reliance on automaticity for bilinguals on concrete words than on abstract words that are stored in a language-specific verbal code. In contrast, for monolingual subjects there is a one-to-one correspondence between verbal and imagery representations of a given concrete word, as well as of an abstract word.

Implications for research on Recollection and Familiarity in recognition memory. Some additional findings of this study, not directly related to the cognitive effects of bilingualism, may be of interest for the broader area of research on recognition memory. First, the presence of a marked significant positive correlation between the word's recollection and familiarity estimates indicates that the two factors may not be completely independent. Thus, in contrast to the independence assumption underlying the process dissociation framework (Jacoby,1991) and adopted from an earlier model by Mandler (1980), complete separation of the effects of recollection and familiarity may be not possible. It should be noticed, however, that the correlation discussed here was calculated across words since, as explained earlier, it was not possible to estimate the contributions of familiarity and recollection for individual subjects. Thus, it remains unknown whether there is also a correlation across subjects which would be more relevant to assess the validity of the Jacoby's assumption of independence between familiarity and recollection. Further studies are necessary to establish whether familiarity and recollection are interdependent and if so, what would be the implications for the process dissociation framework proposed by Jacoby (1991).

Another finding of potential relevance for the Jacoby's (1991) model and its applications in research on recognition memory concerns the substantial variation in the familiarity and recollection of individual read words obtained here. While Jacoby (1991) reported only overall estimates, representing the contributions of familiarity and recollection averaged across the items used in his experiments, the existence of systematic differences should be taken into account when reporting and comparing the results of different studies. Some discrepancies may occur due to differences in relevant characteristics of experimental stimuli. For example, in the present study word frequency was found to have a significant negative effect on both recollection and familiarity. The fact, however, that word frequency and concreteness fail to explain a large proportion of observed variation in familiarity and recollection calls for further research to identify other correlates.

It is interesting to interpret the consistent negative effect of frequency of a read word on its probability of recognition based on recollection as well as on familiarity in the context of some results reported in other studies. Several authors have found that in list recognition tests, similar to the task used in the inclusion condition in the present study, low-frequency words are recognized more accurately than high-frequency words (Glanzer & Bowles, 1976; Kinsbourne & George, 1974). Results of the present study offer an insight into this phenomenon by indicating that increasing word frequency has a detrimental effect on both types of processes involved. Since recollection and familiarity have additive positive effects on the probability of correct recognition in the inclusion condition, frequency will have negative effect on accuracy regardless of the relative contributions of the two processes.

Finally, whereas the probability of recollection for anagrams was consistently and very significantly higher than for read words, no effect of the type of stimulus on familiarity was found. Taking into consideration the fact that Phase 1 of the experiment required extensive elaboration (finding the solution of an anagram) for one type of item and just reading for the other type, the above findings may be interpreted as indicating that more elaborated processing of anagrams enhanced their recollection but not familiarity. From this perspective, the results of this study seem to confirm those of Gardiner (1988) who reported that the level of processing of items in the study phase had an effect on controlled memory processes ("remember") but not on automatic processes ("know") involved in the subsequent recognition memory test. The replication of Gardiner's results may be seen as evidence of the concurrent validity of Jacoby's process dissociation paradigm.

Conclusion. The main question addressed in this study was whether high second language skills affect automatic and intentional uses of memory involved in recognition of verbal stimuli presented in first language. Previously reported findings that there is no difference in the proportion of correctly recognized read words between monolinguals and bilinguals has been replicated. However, application of a recently proposed paradigm which allowed for separating contribution of automatic and intentional processing offered an opportunity for more detailed comparisons of the two groups of subjects. The results indicated that monolinguals and bilinguals may differ in their reliance on specific processes. It seems that bilingual subjects when compared with monolinguals in their first language rely less on automatic and more on intentional processing. Since,however, both these trends were statistically nonsignificant,replication of these results with a larger sample of stimuli would be, advisable.

In addition, the analysis of estimates of contribution of recollection revealed a significant interaction between language group and type of stimulus. In both groups the reliance on intentional processing was stronger for anagrams than for read words but this difference was significantly greater for monolinguals. This indicates that advanced second language skills may be associated with reduced effect of depth of elaboration on the efficiency of intentional processing.

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Appendix A

List of words used as Anagrams, Read only words ,New words and Heard words.

ANAGRAMS n=15	READ n=15	NEW n=30	
1. DRAMA (A R A M D)	1.GRIEF	1.THORN	16.MAKER
2. JUDGE (E U J G D)	2.BOSOM	2.BRUTE	17.TRUCE
3. SHAME (A H S M E)	3.STEAM	3.ARRAY	18.CANDY
4. MONTH (N O H T M)	4.LEMON	4.SHOCK	19.VENOM
5. BOARD (A O B R D)	5.IRONY	5.STONE	20.FLESH
6. APPLE (E P A L P)	6.PLANK	6.HONOR	21.HOTEL
7. SPRAY (Y P S A R)	7.FOLLY	7.WATER	22.GEESE
8. ANKLE (E N A L K)	8.CHILD	8.AGONY	23.SLUSH
9. JELLY (L E Y L J)	9.PRIDE	9.STYLE	24.CHAIR
10.FLASK (A L F S K)	10.SKULL	10.PLAIN	25.ANGLE
11.OPIUM (M P O U I)	11.FIORD	11.SHOES	26.WORLD
12.METAL (T E M A L)	12.POWER	12.ABODE	27.DEMON
13.GREED (D R G E E)	13.CABIN	13.SUGAR	28.GLORY
14.CHIEF (I H F E C)	14.PAPER	14.PUPIL	29.CHARM
15.OWNER (N W O E R)	15.GRASS	15.CLOCK	30.ELBOW

List of words used in auditory task (Heard words, n=60)

1. DRESS	16.QUEST	31.BLOOD	46.CHAOS
2. SPREE	17.DREAM	32.MORAL	47.EARTH
3. TOAST	18.PIANO	33.SALAD	48.SWAMP
4. PROXY	19.CRIME	34.FLOOD	49.DEATH
5. THIEF	20.WHEAT	35.BARON	50.RIVER
6. PARTY	21.WENCH	36.BLOOM	51.EVENT
7. BRAIN	22.HORSE	37.GHOST	52.SNAKE
8. PANIC	23.VIGOR	38.SPIRE	53.STAIN
9. NYMPH	24.MERCY	39.YACHT	54.DEVIL
10.VAPOR	25.BEAST	40.WOODS	55.WOMAN
11.PLANT	26.WHALE	41.ARROW	56.CIGAR
12.TRUCK	27.DUMMY	42.HUMOR	57.TRUTH
13.QUEEN	28.OCEAN	43.IDIOM	58.STORM
14.SLAVE	29.FAULT	44.MONEY	59.ROSIN
15.PEACH	30.TOWER	45.COAST	60.ANGER

Appendix B

Mean (s.d.) of Frequency and Concreteness for experimental stimuli.

	STIMULI			
	ANAGRAM n=15	READ n=15	HEARD n=60	NEW n=30
FREQUENCY:	47.1 (35.5)	47.2 (35.2)	47.7 (35.1)	48.5 (34.6)
CONCRETENESS:	5.50 (1.86)	5.22 (2.19)	5.30 (1.98)	5.32 (1.93)

Appendix C

Instructions for Phase 1

You are going to be asked to perform a series of tasks in which you will have to either read a word or solve an anagram. An anagram is a word with some letters scrambled. Only one item will be presented on the computer screen at a time.

If the word is presented in its normal form, please read it aloud as quickly as possible. After you have read the word the next item will appear on the screen.

If the word is presented as an anagram, please rearrange its letters to find out which word this anagram represents. The **second** and **fourth** letters of each anagram are in their **correct** positions and are **underlined**. Thus, only the three letters that are not underlined have to be rearranged to solve the anagram.

You will have up to 30 seconds to solve the anagram once it appears on the screen. As soon as you find the solution to the anagram, please say it aloud as quickly as possible. If your answer is correct, the experimenter will press a key to present the next word or anagram. If your answer is not correct and the 30 seconds have not yet elapsed, the experimenter will advise you about it, and will ask you to continue looking for a correct solution.

If you have not solved the anagram in 30 seconds, the computer will "beep" and the experimenter will tell you the correct word. You will be asked to verify the correctness of this solution by comparing the word with the anagram. After this the next item will be presented.

EXAMPLE : If an item presented on the screen reads as a normal word, for example "CROWN" you just have to read this word aloud as quickly as possible.

However, if an anagram is presented, it will not look like any known word and will have its second and fourth letters underlined, for example "A T R I S". In this situation you will have to find as soon as possible the solution to this anagram. By rearranging the three letters that are not underlined you may find the word "STAIR". This word is the correct solution. Please compare the word "STAIR" to the anagram "A T R I S".

If you have any questions, please do not hesitate to ask.

Appendix D

Instructions for Phase 2

You are going to listen to a list of words recorded on a tape. Please repeat each word aloud as soon as you hear it.

Please try to remember each word. In a later phase of the experiment your memory for these words will be tested.

If you have any questions, please do not hesitate to ask them.

Appendix E

Instructions for Test : Inclusion condition

You are going to be shown a list of words presented one at a time on the screen. Some of these words were presented in the earlier phases of the experiment, as an anagram to solve, a word to be read or a word that you heard on the tape recorder. Other words that will be presented will be entirely new as they have not been either seen or heard earlier in this experiment.

For each word you are asked to answer the question "**OLD or NEW**" that will be printed on the screen several lines below the word. If, earlier in the experiment, you **read** the word, solved it as an **anagram**, or **heard** it on the tape recorder, please press the button marked "**OLD**" on the keyboard. If, however, you did **not encounter** the word in this experiment, please press the button marked "**NEW**".

EXAMPLE : For example, you may see on the screen the word "TABLE" and several lines below it the words "**OLD or NEW**" will appear. If you solved earlier an anagram for which the correct solution was "TABLE", or if you either read or heard this word in the previous phases of the experiment, you would be expected to press the button marked "**OLD**". Otherwise, if the word was not encountered earlier in the experiment, the button "**NEW**" should be pressed.

Please do not hesitate to ask any questions related to this experiment.

PRESS :

Anagram	-	**"OLD"**	**New**	-	**"NEW"**
Read	-	**"OLD"**			
Heard	-	**"OLD"**			

Appendix F

Instructions for Test : Exclusion condition

You are going to be shown a list of words presented one at a time on the screen. Some of these words were presented in the earlier phases of the experiment, as an anagram to solve, a word to be read or a word that you heard on the tape recorder. Other words that will be presented will be entirely new as they have not been either seen or heard earlier in this experiment.

For each word you are asked to answer the question **"OLD or NEW"** that will be printed on the screen several lines below the word. If, earlier in the experiment, you **heard** the word on the tape recorder, please press the button marked **"OLD"** on the keyboard. If, however, you did **not encounter** the word in this experiment or you did encounter it as word to **read** or as an **anagram** to solve, please press the button marked **"NEW"**.

EXAMPLE : For example, you may see on the screen the word "TABLE" and several lines below it the words **"OLD or NEW"** will appear. If you heard this word on the tape recorder, in a previous phase of the experiment, the button marked **"OLD"** should be pressed. If, however, you solved earlier an anagram for which the correct solution was "TABLE", or if you read this word or, finally, if the word was not presented in the previous phases of the experiment, you would be expected to press the button marked **NEW"**.

Please do not hesitate to ask any questions related to this experiment.

PRESS :

Heard	-	**"OLD"**	**Anagram**	-	**"NEW"**
			Read	-	**"NEW"**
			New	-	**"NEW"**

Appendix G

Results of two-way mixed ANOVA for proportion of "old" responses in the Inclusion condition.

BETWEEN SUBJECTS (Monolinguals versus Bilinguals)

SOURCE	SS	DF	MS	F	P
LANGUAGE GROUP	6.667	1	6.667	0.768	0.388
ERROR	242.933	28	8.676		

WITHIN SUBJECTS (Read versus Anagrams)

SOURCE	SS	DF	MS	F	P
TYPE OF STIMULUS	166.667	1	166.667	47.749	0.000
INTERACTION	21.600	1	21.600	6.188	0.019
ERROR	97.733	28	3.490		

Appendix H

Results of two-way mixed ANOVA for proportion of "old" responses in the Exclusion condition.

BETWEEN SUBJECTS (Monolinguals versus Bilinguals)

SOURCE	SS	DF	MS	F	P
LANGUAGE GROUP	2.400	1	2.400	0.326	0.573
ERROR	206.333	28	7.369		

WITHIN SUBJECTS (Read versus Anagrams)

SOURCE	SS	DF	MS	F	P
TYPE OF STIMULUS	35.267	1	35.267	11.878	0.002
INTERACTION	0.600	1	0.600	0.202	0.657
ERROR	83.133	28	2.969		

Appendix I

<u>Source table for Read words used as stimuli in Monolingual and Bilingual group with estimates of Recollection, Familiarity, Concreteness and Frequency.</u>

READ	MONOLINGUALS		BILINGUALS		CONCRETENESS	FREQUENCY
	REC.	FAM.	REC.	FAM.		
1.GRIEF	.47	.63	.27	.45	1.86	45
2.BOSOM	.80	1.00	.73	.50	6.09	27
3.STEAM	.47	.25	.33	.40	6.41	50
4.LEMON	.07	.22	.20	.17	6.96	27
5.IRONY	.00	.47	.27	.64	2.10	4
6.PLANK	.13	.54	.33	.40	6.96	19
7.FOLLY	.53	.28	.33	.30	2.63	29
8.CHILD	.07	.08	.00	.20	6.87	100
9.PRIDE	.20	.50	.40	.78	1.49	50
10.SKULL	.27	.64	.33	.40	6.96	13
11.FIORD	.53	.71	.67	.60	6.96	2
12.POWER	.20	.42	.00	.33	2.73	100
13.CABIN	.00	.20	.20	.25	6.96	50
14.PAPER	.00	.27	.27	.09	6.89	100
15.GRASS	.00	.33	.40	.33	6.96	100

Appendix J

Source table for words used as Anagrams in Monolingual and Bilingual group with estimates of Recollection, Familiarity, Concreteness and Frequency.

ANAGRAMS	MONOLINGUALS		BILINGUALS		CONCRETENESS	FREQUENCY
	REC.	FAM.	REC.	FAM.		
1.DRAMA	.73	1.00	.60	.67	3.66	23
2.JUDGE	.80	.65	.87	1.00	6.25	100
3.SHAME	.47	.38	.73	.25	1.70	50
4.MONTH	.67	.00	.67	.20	3.20	100
5.BOARD	.40	.55	.60	.17	6.87	100
6.APPLE	.73	.48	.67	.20	7.00	50
7.SPRAY	.67	.61	.40	.22	6.21	22
8.ANKLE	.80	.35	.73	.75	7.00	21
9.JELLY	.87	.00	.73	.25	6.73	19
10.FLASK	.40	.45	.07	.36	7.00	4
11.OPIUM	.80	1.00	.53	.57	6.44	7
12.METAL	.40	.33	.40	.22	6.76	50
13.GREED	.53	.85	.27	.45	1.73	3
14.CHIEF	.73	.74	.73	.50	5.87	100
15.OWNER	.80	.00	.13	.15	5.90	50

Appendix K

Results of two-way mixed ANOVA for estimates of contribution of Familiarity to recognition memory of Read words and Anagrams.

BETWEEN WORDS (Read versus Anagrams)

SOURCE	SS	DF	MS	F	P
TYPE OF STIMULUS	0.016	1	0.016	0.153	0.699
ERROR	2.876	28	0.103		

WITHIN WORDS (Monolinguals versus Bilinguals)

SOURCE	SS	DF	MS	F	P
LANGUAGE GROUP	0.076	1	0.076	2.457	0.128
INTERACTION	0.009	1	0.009	0.289	0.595
ERROR	0.862	28	0.031		

Appendix L

Results of two-way mixed ANOVA for estimates of contribution of Recollection to recognition memory of Read words and Anagrams.

BETWEEN WORDS (Read versus Anagrams)

SOURCE	SS	DF	MS	F	P
TYPE OF STIMULUS	1.492	1	1.492	21.126	0.000
ERROR	1.977	28	0.071		

WITHIN WORDS (Monolinguals versus Bilinguals)

SOURCE	SS	DF	MS	F	P
LANGUAGE GROUP	0.008	1	0.008	0.334	0.568
INTERACTION	0.118	1	0.118	5.108	0.032
ERROR	0.646	28	0.023		

Appendix M

Effect of Frequency and Concreteness on Recollection and Familiarity of Read words and Anagrams in Monolingual and Bilingual groups

MONOLINGUALS	FREQUENCY	CONCRETENESS
	Partial correlation (p - value)	
RECOLLECTION of:		
Read words	-.39 (p=.16)	-.13 (p=.63)
Anagrams	-.04 (p=.89)	+.20 (p=.50)
FAMILIARITY of:		
Read words	-.51 (p=.06)	-.11 (p=.66)
Anagrams	-.20 (p=.48)	-.13 (p=.66)

BILINGUALS	FREQUENCY	CONCRETENESS
RECOLLECTION of:		
Read words	-.54 (p=.04)	+.18 (p=.48)
Anagrams	+.49 (p=.07)	-.04 (p=.89)
FAMILIARITY of:		
Read words	-.48 (p=.04)	-.49 (p=.03)
Anagrams	-.02 (p=.95)	+.03 (p=.92)