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On the Functional Equivalence of Monolinguals and Bilinguals in "Monolingual Mode": The Bilingual Anticipation Effect in Picture-Word Processing

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Research Article

ON THE FUNCTIONAL EQUIVALENCE OF MONOLINGUALS AND BILINGUALS IN "MONOLINGUAL MODE": The Bilingual Anticipation Effect in Picture-Word Processing

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Abstract—*Previous evidence indicates that bilinguals are slowed when an unexpected language switch occurs when they are reading aloud. This anticipation effect was investigated using a picture-word translation task to compare English monolinguals and Spanish-English bilinguals functioning in "monolingual mode." Monolinguals and half of the bilinguals drew pictures or wrote English words for picture or English word stimuli; the remaining bilinguals drew pictures or wrote Spanish words for picture or Spanish word stimuli. Production onset latency was longer in cross-modality translation than within-modality copying, and the increments were equivalent between groups across stimulus and production modalities. Assessed within participants, bilinguals were slower than monolinguals under intermixed but not under blocked trial conditions. Results indicate that the bilingual anticipation effect is not specific to language-mixing tasks. More generally, stimulus-processing uncertainty prevents establishment of a "base" symbolic-system procedure (concerning recognition, production, and intervening translation) and the inhibition of others. When this uncertainty is removed, bilinguals exhibit functional equivalence to monolinguals.*

A pervasive issue found in the bilingualism literature concerns the similarities and differences between bilinguals and monolinguals. Despite arguments against making such a comparison because of multidimensional, qualitative disparities between them (e.g., Grosjean, 1985, 1997), there are many reasons to want to do so. For example, because bilinguals and monolinguals start out identically in their language-learning capacity as infants, they should share cognitive processes and structures in language processing later in adulthood. Indeed, under certain conditions, bilinguals in "monolingual mode" do function similarly to monolinguals—but not always (see, e.g., Altenberg & Cairns, 1983; Magiste, 1980; Peynircioglu & Tekcan, 1993; Ransdell & Fischler, 1987; Soares & Grosjean, 1984).

Grosjean (1997) has argued that experimentally inducing a monolingual mode in bilinguals may be problematic: Despite control of the language in which either the instructions are given, the stimuli appear, or the responses are made, even subtle clues provided to the bilingual concerning the purpose of the study (e.g., to study bilingualism) can cause activation (or alternately, prevent complete inhibition) of the nontested language. Thus, a bilingual's language mode should be viewed, more realistically, as falling along a continuum from monolingual mode to bilingual mode, depending on the activation of the two languages.

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Information processing contexts can activate a bilingual's languages to varying extents. For example, in a study by Macnamara, Krauthammer, and Bolgar (1968), bilinguals read aloud lists of numbers in only one of their languages (French or English) or in both of their languages in an intermixed fashion. When the languages were intermixed, half of the time the bilinguals were required to change languages in a predictable manner, and the other half of the time, the changes were random. Overall, the bilinguals were slower reading lists with languages intermixed than lists with a single language. Moreover, they were substantially slower reading the intermixed lists when the language changes were random than when they were predictable. Macnamara et al. concluded that bilinguals have a "switch" that determines which language is used at any given moment. When deployment of this switch is predictable, bilinguals are minimally slowed; however, when it is not, they are measurably slowed—around 180 ms. Macnamara et al. termed this slowing an "anticipation effect."

Chan, Chau, and Hoosain (1983) had Chinese-English bilinguals read passages that contained either naturally occurring, random, or regular (noun only) Chinese-English language switches. These bilinguals also read passages appearing entirely in Chinese or English. Chan et al. found that reading times were equivalent for passages with naturally occurring switches and those entirely in Chinese, even though Chinese was demonstrably the bilinguals' primary language. Reading times were slowest for passages with random switches; reading times for passages with regular switches were intermediate. Contrary to the results of Macnamara et al. (1968), these results indicated that naturally occurring code switches do not require a measurable amount of time. Nonetheless, Chan et al. still observed an anticipation effect of approximately 230 ms per random word switch.

Taking a position consistent with the results of Chan et al. (1983), Obler and Albert (1987; see also Albert & Obler, 1978) have argued that bilinguals possess a "continuously monitoring operating system" that controls which language is activated at any given moment during comprehension or production. Determinants of a particular language's activation include "circumstantial priorities" that influence the predictability of the language to be perceived or produced by the bilingual at any given moment, and thus serve to minimize the latency to switch languages when required. One example of a circumstantial priority is the *base-language effect* (Grosjean, 1997; Li, 1996; Macnamara & Kushnir, 1971). The base-language effect reflects a bilingual's expectation in a conversation that an upcoming word will most likely appear in the language of the preceding discourse. Other circumstantial priorities include the language-switching style in a bilingual community, individuals' differential fluency in their languages, and various phonetic, orthographic, syntactic, semantic, and pragmatic factors (see, e.g., Clyne, 1980; Grosjean, 1997; Pfaff, 1979; Smith, 1997). Circumstantial priorities would then serve to bias the activation (or inhibition) level of a bilingual's language knowledge. Thus, there may be situations in which bilingual task performance indicates some of the effects of knowing two languages, but not all of those effects. More generally, a monitoring system such as the one proposed by Obler and Albert could also underlie bilinguals' ability to switch between pictures and the words of their languages (and an analogous situation may also exist for monolinguals).

The present study addressed the following questions:

- Is the anticipation effect limited to language-processing tasks in which bilinguals are explicitly processing their two languages, or does it generalize to a picture-word translation task—even one in which only one of their languages is explicitly involved? The anticipation effect has been demonstrated primarily in studies involving linguistic stimuli and responses (e.g., Chan et al., 1983; Macnamara et al., 1968). However, this effect may represent a more general phenomenon concerning how bilinguals deal with situations involving uncertain symbolic format processing over a range of stimulus and response modalities.

- In a picture-word translation task, do bilinguals function equivalently to monolinguals under conditions in which the bilingual anticipation effect is not present?[1] Are there elements of this anticipation effect that are not strictly bilingual, but rather are shared by bilinguals and monolinguals alike? If bilinguals always function in bilingual mode to some degree, they may still be slower than monolinguals—even under a predictable stimulus-processing situation—because of concurrent activation of their language systems in addition to their pictorial system. Conversely, if bilinguals function in a true monolingual mode under a predictable stimulus-processing situation, then their task performance should be equivalent to that of monolinguals. There are certainly examples of (apparent) monolinguals performing picture-word-processing tasks faster under more predictable conditions than under less predictable conditions (e.g., Tversky, 1969). A direct comparison between bilinguals and monolinguals would determine whether the two groups derive similar benefits from knowing in advance the modality (picture or word) of the stimulus and response, and entailed translation demands.

Results from a previous study (Amrhein & Sanchez, 1997) provide clues to the answers to these questions. In that study, proficient, compound Spanish-English bilinguals and English monolinguals performed a drawing-writing task. Latency to begin to draw or write from a picture or word stimulus was assessed. The primary purpose of the experiments was to test current theories as accounts of bilingual and monolingual task performance in picture-word processing. Specifically investigated was whether the symmetry reported for picture-word translation latency in monolinguals (Amrhein, 1994) generalized to picture-word and language translation in bilinguals. Indeed, the magnitude of the translation latency was equivalent for bilinguals and monolinguals. These findings supported a concept-mediation model (Potter, So, Von Eckardt, & Feldman, 1984) revised to allow equivalent semantic access for pictures and words of either language, a model that is a direct extension of the picture-word-processing model of Theios and Amrhein (1989). Two other accounts, word association (Potter et al., 1984) and dual coding (Paivio, 1986), which predict differential patterns in cross-language and cross-modality translation latencies (see also Amrhein & Sanchez, 1997; Kroll & de Groot, 1997), were therefore not supported.

Amrhein and Sanchez (1997) also found that bilinguals were substantially slower than monolinguals when trial conditions (i.e., drawing from a picture or English word stimulus, writing in English from an English word or picture stimulus) were randomly intermixed. Moreover, bilinguals were substantially faster overall when the trial conditions (drawing or writing in English or Spanish from pictures or English or Spanish words) were blocked by stimulus and response modality than when they were randomly intermixed (in both cases, the actual stimulus concept was randomly selected). Thus, the bilingual anticipation effect is not limited to language-processing contexts, but rather occurs in symbolic-processing situations in general—at least when two languages are explicitly involved.

The bilinguals' performance improvement under the blocked trials was revealed in three ways: (a) a decrease in onset latency when the bilinguals knew the production task in advance (i.e., writing in English or Spanish vs. drawing), (b) an additional latency decrease when they knew in advance in which language they would be writing, and (c) an additional latency decrease when they knew in advance that they would be copying rather than translating the picture or word stimulus. Thus, when notified in advance, bilinguals can strategically employ their procedural knowledge concerning which source and destination symbolic systems will be used, and whether translation will be entailed (see also Hernandez, Bates, & Avila, 1996).

THEORETICAL FRAMEWORK AND PREDICTIONS

The current study directly investigated the nature of the bilingual anticipation effect and how it can influence similarities and differences between bilinguals (when only one language is explicitly involved) and monolinguals, in a picture-word translation task. A drawing-writing task was employed: Monolinguals and half of the bilinguals were presented with English words and pictures and drew pictures and wrote English words; the other half of the bilinguals were presented with Spanish words and pictures and drew pictures and wrote Spanish words. In this way, experimentally induced language activation was held constant for each bilingual participant, allowing for direct assessment of functional differences in stimulus-processing uncertainty for the two groups. The dependent measure was production onset latency, the time it took subjects to begin writing or drawing after a stimulus was presented.

The drawing-writing task represents a balanced version of the traditional picture-naming, word-reading task (see Cattell, 1887; Snodgrass, 1993; Theios & Amrhein, 1989). By providing observable responses in both linguistic (i.e., writing) and pictorial (i.e., drawing) modalities, this task remedies previous problems of noncomparable picture-naming and image-generation tasks (see Amrhein, 1994; Snodgrass, 1980) used to access the two directions of picture-word translation (e.g., Paivio, 1966; Paivio, Clark, Digdon, & Bons, 1989). Production onset latency for each experimental condition reflects the summed time increments for subprocesses theorized to underlie task

1. If bilinguals exhibit the anticipation effect under unpredictable stimulus-processing conditions when only one of their languages is explicitly tested, they should be slower than monolinguals. This prediction is based on the assumption that the bilingual anticipation effect is due to the activation to some degree of both language processors, as well as the pictorial symbolic-format processor.

performance (Amrhein & Sanchez, 1997); resultant equations are given in Table 1. $Draw(P_i,P_j)$, $Draw(W_{ENi},P_j)$, and $Draw(W_{SPi},P_j)$, represent the time to initiate drawing a picture (P_j) from, respectively, a corresponding (i.e., same-concept) picture (P_i), English word (W_{ENi}), or Spanish word (W_{SPi}). $Write(W_{ENi},W_{ENj})$ and $Write(W_{Pi},W_{ENj})$ represent the time to initiate writing an English word (W_{ENj}) from, respectively, a corresponding English word (W_{ENi}) or picture (P_i). Finally, $Write(W_{SPi},W_{SPj})$ and $Write(P_i,W_{SPj})$ represent the time to initiate writing a Spanish word (W_{SPj}) from, respectively, a corresponding Spanish word (W_{SPi}) or picture (P_i). Time to encode a picture or word stimulus into its corresponding symbolic-format processor—pictorial, English, or Spanish—is given by the parameter $t_E(P_i)$, $t_E(W_{ENi})$, or $t_E(W_{SPi})$, respectively.

For drawing a picture from an English (Equation 2) or Spanish (Equation 3) word stimulus, the additional time to transfer information from the English- or Spanish-format processor to the pictorial-format processor by means of a format-independent conceptual processor is given, respectively, by $t_T(W_{ENi},P_j)$ or $t_T(W_{SPi},P_j)$. Correspondingly, for writing an English (Equation 5) or Spanish (Equation 7) word from a picture stimulus, this additional transfer time is given, respectively, by $t_T(P_i,W_{ENj})$ or $t_T(P_i,W_{SPj})$. Additional latency to retrieve from the pictorial-format processor a graphic code corresponding to the picture to be drawn is given by t_{Pj}. Additional latency to retrieve from the English- or Spanish-format processor an orthographic code corresponding to the English or Spanish word to be written is given by $t_{L\text{-}ENj}$ or $t_{L\text{-}SPj}$, respectively. Additional time to prepare for and initiate a production, either writing an English or Spanish word or drawing a picture, is given by $t_O(W_{ENj})$, $t_O(W_{SPj})$, or $t_O(P_j)$, according to the corresponding production system (see Amrhein & Sanchez, 1997). As in the study by Amrhein and Sanchez (1997), values for the cross-modality transfer parameters were expected to be equivalent within and across groups.

Finally, on different days, participants performed the task under a randomly intermixed or a blocked procedure, using different stimulus sets. Each stimulus set consisted of pictures and noncognate picture names (to minimize experimentally induced activation of the nontested language in the bilingual participants; see Smith, 1997). If the bilingual anticipation effect is incurred by general stimulus-processing uncertainty, then it should occur even when the picture-word-processing task explicitly involves only one of the bilinguals’ languages. Accordingly, under the mixed-presentation mode, bilinguals should be slower than the monolinguals, if we assume that such stimulus-processing uncertainty activates knowledge concerning the nontested language (including its recognition, production, and entailed copying and translation system subprocesses), thus increasing the time for the specification of the symbolic-system procedure following stimulus presentation on each trial. However, the reduction in stimulus-processing uncertainty afforded under the blocked-presentation mode should allow bilinguals to selectively activate the tested language and inhibit the nontested language, allowing for the specification of an optimal “base” symbolic-system procedure to be used for a trial block, resulting in faster task performance and latencies equivalent to those of monolinguals.

METHOD

Participants

Sixteen proficient, compound Spanish-English bilinguals and 16 English monolinguals participated. All were right-handed and enrolled in courses at the University of New Mexico in Albuquerque. Bilinguals completed a questionnaire assessing language background, specifically, when and where their languages were learned and how they were currently used. All learned Spanish and English during childhood and had continued to use them in social, employment, and academic settings. Median participant-rated fluencies (on a scale from 1, *not fluent*, to 7, *fluent*) were as follows: speaking and understanding Spanish—6.3, speaking and understanding English—6.9, reading and writing Spanish—5.5, reading and writing English—7.0. Average ages of the bilinguals and monolinguals were equivalent, 22.63 (SD = 6.71) and 24.44 (SD = 8.96) years, respectively ($F < 1$). Years of education for the bilinguals and monolinguals were also equivalent, 14.50 (SD = 1.21) and 14.19 (SD = 1.28), respectively ($F < 1$). Bilingual fluencies and participants’ ages and years of education did not differ significantly from the corresponding values in Amrhein and Sanchez (1997), all ps > .05. Monolinguals were screened for knowledge of Spanish or any other second language.

Table 1. *Theoretical equations*

$Draw(P_i,P_j) =$	$t_E(P_i)$			+	t_{Pj}	+	$t_O(P_j)$	(1)
$Draw(W_{ENi},P_j) =$	$t_E(W_{ENi})$	+	$t_T(W_{ENi},P_j)$	+	t_{Pj}	+	$t_O(P_j)$	(2)
$Draw(W_{SPi},P_j) =$	$t_E(W_{SPi})$	+	$t_T(W_{SPi},P_j)$	+	t_{Pj}	+	$t_O(P_j)$	(3)
$Write(W_{ENi},W_{ENj}) =$	$t_E(W_{ENi})$			+	$t_{L\text{-}ENj}$	+	$t_O(W_{ENj})$	(4)
$Write(P_i,W_{ENj}) =$	$t_E(P_i)$	+	$t_T(P_i,W_{ENj})$	+	$t_{L\text{-}ENj}$	+	$t_O(W_{ENj})$	(5)
$Write(W_{SPi},W_{SPj}) =$	$t_E(W_{SPi})$			+	$t_{L\text{-}SPj}$	+	$t_O(W_{SPj})$	(6)
$Write(P_i,W_{SPj}) =$	$t_E(P_i)$	+	$t_T(P_i,W_{SPj})$	+	$t_{L\text{-}SPj}$	+	$t_O(W_{SPj})$	(7)

Note. *Write* = writing onset latency; *Draw* = drawing onset latency; t = additional processing latency; W = word input (stimulus) or output (production); EN = English; SP = Spanish; P = picture input (stimulus) or output (production); E = encoding subprocess; T = transfer subprocess (from one symbolic-format processor to another via the abstract conceptual processor); L = lexical retrieval subprocess; P = pictorial retrieval subprocess; O = output P or W subprocess; i = input (stimulus) index; j = output (production) index.

Materials and Apparatus

Stimuli were size-matched, computer-generated pictures and noncognate picture names based on the two concept sets used by Amrhein and Sanchez (1997). Stimuli were presented on a computer monitor by an accelerated Apple II+ computer. Drawing and writing responses were measured using a computer-interfaced Apple Graphics Tablet and pen stylus. Trial productions were videotaped for error analysis.

Design and Procedure

In each session (mixed or blocked), participants received 80 experimental trials: 10 stimulus-set concepts × 2 stimulus modalities (word or picture) × 2 task modalities (write or draw) × 2 replications. Each participant was assigned a different stimulus-concept set for each session. Stimulus-set assignment and session order were independently counterbalanced within group. Participants received 40 practice trials representing one replication of the experimental trial set. For the mixed session, the 40 practice trials were presented prior to the experimental trials, with trial conditions and stimulus concepts randomly intermixed within both the practice and the experimental trials. For each of the four trial blocks in the blocked session, the 10 practice trials included each stimulus-set concept and matched the stimulus and task conditions of the immediately following experimental trials. Per block, stimulus concepts were randomly intermixed within practice and experimental trials. Order of blocks was counterbalanced across participants within group. The blocked session inherently provided short breaks for the participants, so in the mixed session, participants received short breaks similarly distributed across their practice and experimental trials.

Monolinguals and half of the bilinguals received English word stimuli (and session prompts) and produced English word responses for their writing trials; the remaining half of the bilinguals received Spanish word stimuli (and session prompts) and produced Spanish word responses for their writing trials. Participants were shown the word and picture stimuli to be presented in a given session prior to the practice trials for that session. Participants therefore previewed picture names in the language in which they would appear and be written. Thus, the bilingual participants were not given the translation equivalents for the picture names prior to each session. Participants were instructed to be consistent across trials with regard to the general size and appearance of the pictures they drew and the words they wrote.

For a given trial, participants were presented with a 1.5-s "READY" (or "LISTO") prompt to place the pen on the start location on the tablet. Then, for the next 1.5 s, they received the task prompt "DRAW-PICTURE" (or "DIBUJA-DIBUJO"), "WRITE-ENGLISH" (or "ESCRIBA-INGLES"), or "WRITE-SPANISH" (or "ESCRIBA-ESPANOL"), accompanied by a 530-Hz tone. After a subsequent 2.5-s blank screen, a picture or word stimulus appeared, and the participant commenced writing or drawing as quickly and accurately as possible. Production onset latency was measured from stimulus onset until the pen-tip switch was depressed. When the response was initiated, the screen was cleared and participants received immediate, dynamic feedback of their production. When production was completed, participants pressed the pen-tip switch on the "finish" spot on the tablet, ending the trial.

RESULTS

Errors

Onset latencies from trials on which errors occurred were removed from data analysis. Errors included incomplete responses and responses in the wrong modality or expressing the wrong concept. Trials on which the participant prematurely depressed the pen-tip switch prior to stimulus presentation or abruptly suspended production after initially depressing the pen-tip switch were also counted as errors. An analysis of variance (ANOVA) was performed on the error data averaged over trial replications, using group (bilingual or monolingual) and presentation mode (mixed or blocked) as fixed factors; participants within group was the random factor. (The .05 criterion for statistical significance was used for both error and latency analyses.) Overall, bilinguals (7.11%) and monolinguals (5.20%) committed an equivalent number of errors, $F_1(1, 30) = 0.71$, $MSE = 0.6573$. The remaining effect for presentation mode and its interaction with group were likewise nonsignificant. (Because errors occurred before as well as after the task prompt or stimulus presentation, only a subjects ANOVA contrasting group and presentation mode was conducted.[2])

Production Onset Latencies

Two ANOVAs were performed on the production onset latencies averaged over trial replications, using presentation mode (mixed or blocked), group, stimulus modality, and task modality as fixed factors. These latencies are plotted in Figure 1, averaged over stimulus concepts and subjects within group. The first analysis treated participants as the random factor (F_1); the second analysis treated stimulus concepts as the random factor (F_2).

Overall, bilinguals (981 ms) were 98 ms slower than monolinguals (883 ms), a difference that was significant over concepts, $F_2(1, 19) = 83.02$, $MSE = 149{,}119.99$, but not over participants, $F_1(1, 30) = 1.70$, $MSE = 7{,}284{,}333.70$. Participants, as a whole, performed 152 ms faster under the blocked (856 ms) than under the mixed (1,008 ms) presentation mode, $F_1(1, 30) = 18.21$, $MSE = 1{,}619{,}857.10$; $F_2(1, 19) = 40.77$, $MSE = 723{,}459.91$. Also, they wrote words (860 ms) 145 ms faster than they drew pictures (1,005 ms), $F_1(1, 30) = 52.36$, $MSE = 515{,}388.92$; $F_2(1, 19) = 97.19$, $MSE = 277{,}666.05$. However, picture (932 ms) and word (932 ms) stimuli were responded to identically, $F_1(1, 30) = 0.00$, $MSE = 113{,}890.89$; $F_2(1, 19) = 0.00$, $MSE = 106{,}334.96$.

The Group × Presentation Mode interaction was significant, $F_1(1, 30) = 5.56$, $MSE = 1{,}619{,}857.10$; $F_2(1, 19) = 7.30$, $MSE = 1{,}235{,}423.00$. As can be seen in Figure 1, under the mixed-presentation mode, the bilinguals (1,099 ms) were substantially slower (182 ms) than the monolinguals (917 ms), $F_1(1, 30) = 4.05$, $MSE = 5{,}251{,}055.80$; $F_2(1, 19) = 42.93$, $MSE = 495{,}189.07$; but under the blocked-presentation mode, latencies for these bilinguals (864 ms) and monolinguals (849 ms) became equivalent, showing a difference of only 15 ms, $F_1(1, 30) = 0.04$, $MSE = 3{,}653{,}135.10$; $F_2(1, 19) = 0.15$, $MSE = 889{,}353.97$.

2. Across error and latency analyses, no significant differences were found for these factors between the bilinguals performing the Spanish and English versions of the experiment. Accordingly, the analyses presented here treat these bilinguals as a single group.

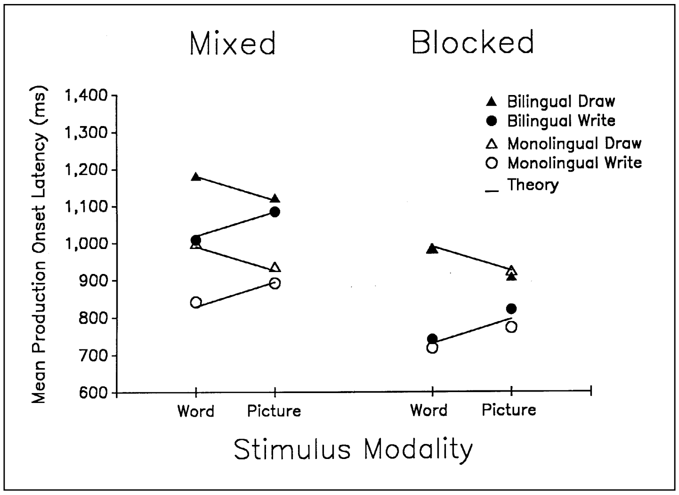

Fig. 1. Mean production onset latency as a function of group (bilingual or monolingual), presentation condition (mixed or blocked), stimulus modality (word or picture), and task modality (draw or write). Symbols show the obtained latencies; the lines show the latencies predicted by the theoretical model.

The Stimulus Modality × Task Modality interaction was also significant, $F_1(1, 30) = 12.02$, $MSE = 451{,}578.59$; $F_2(1, 19) = 47.54$, $MSE = 114{,}177.18$. Onset to draw a picture from a word stimulus (1,038 ms) was 66 ms longer than onset to draw a picture from a picture stimulus (972 ms), but onset to write a word from a word stimulus (827 ms) was 65 ms shorter than onset to write a word from a picture stimulus (892 ms). These latency increments for cross-modality translation (i.e., 66 and 65 ms) did not differ significantly, nor did they vary reliably with group or presentation mode. Finally, the Task Modality × Presentation Mode interaction was significant, $F_1(1, 30) = 7.35$, $MSE = 308{,}639.25$; $F_2(1, 19) = 19.78$, $MSE = 114{,}634.89$. This interaction is due to a 187-ms difference in onset latency between the drawing and writing tasks under the blocked-presentation mode (950 ms vs. 763 ms, respectively), but only a 103-ms difference between those tasks under the mixed-presentation mode (1,060 ms vs. 957 ms, respectively). Remaining interactions were nonsignificant.

Parameter Estimation and Model Fit

The mean production onset latencies for the bilinguals and monolinguals can be accounted for by a mathematical model based on the theoretical formulas given in Table 1. Specifically, the design of this experiment allows for the determination of five parameters:

- B_W, the base latency given by the fastest condition. This condition is either $Write(W_{ENi}, W_{ENj})$ or $Write(W_{SPi}, W_{SPj})$ under the blocked-presentation mode.
- t_T, the additional latency to carry out a transfer from one symbolic-format (Spanish, English, or pictorial) processor to another by means of the abstract conceptual processor, for both groups. This latency encompasses the parameters $t_T(P_i, W_{ENj})$, $t_T(P_i, W_{SPj})$, $t_T(W_{ENi}, P_j)$, and $t_T(W_{SPi}, P_j)$.
- t_D, the additional time to initiate a drawing response (i.e., $t_P + t_O(P_j)$) over a writing response for either group (i.e., $t_{L\text{-}EN} + t_O(W_{ENj})$ or $t_{L\text{-}SP} + t_O(W_{SPj})$).
- $t_{MW}(B_W)$, the additional latency to initiate a writing response under the mixed- relative to the blocked-presentation mode for both groups.
- $t_{MBIL}(B_W)$, the additional latency required for bilinguals to perform the drawing-writing task under the mixed-presentation mode relative to the blocked-presentation mode (i.e., the bilingual anticipation effect).

Table 2 presents how these parameters were assigned to the 16 experimental conditions (indices i and j given in Table 1 have been omitted to reflect values averaged over stimuli and productions, respectively). Parameters were estimated from the condition means according to Equations 1 through 16 using a multiple linear regression analysis (BMDP 1R). Parameter estimates were as follows: $B_W = 730$ ms, $t_T = 65$ ms, $t_D = 96$ ms, $t_{MW}(B_W) = 99$ ms, and $t_{MBIL}(B_W) = 190$ ms. These five estimates accounted for 99.14% of the variance among the 16 condition means, $F(4, 11) = 316.98$, $MSE = 210.14$, with a root mean squared error of 14.5 ms. The parameter estimate for $t_{MBIL}(B_W)$ (190 ms) falls within the range of values reported for the bilingual anticipation effect (e.g., 193 ms, Amrhein & Sanchez, 1997; 180 ms, Macnamara et al., 1968; 230 ms, Chan et al., 1983). Predicted onset latencies are plotted in Figure 1, along with the obtained onset latencies.

DISCUSSION

These results indicate that the anticipation effect revealed in earlier investigations of code switching in bilinguals (e.g., Chan et al., 1983; Macnamara et al., 1968) is not constrained to situations in which both languages are explicitly processed; rather, it can occur even when bilinguals are explicitly processing only one of their languages. Moreover, this effect is not limited to situations involving only language stimuli and responses, but instead is observed, more generally, when there is uncertainty concerning the processing of stimuli varying in symbolic format—in the present case, words and pictures (see also Amrhein & Sanchez, 1997).

Under conditions in the picture-word translation task in which the bilingual anticipation effect does not occur, bilinguals and monolinguals function equivalently. Thus, contrary to what Grosjean (1997) might expect, bilinguals can function in monolingual mode, but simply limiting which language is explicitly involved is not sufficient. Rather, providing stimulus-processing constraints concerning stimulus and response modality, and entailed processing (i.e., copying or translation), allows bilinguals to establish a facilitating base symbolic-system procedure to be used in stimulus recognition and response production.[3]

3. In an unpublished study, Chavez and Amrhein (1994) found that constraining stimulus modality alone does not remove the bilingual anticipation effect. In that study, 15 proficient, compound Spanish-English bilinguals and 15 English monolinguals, matched on age and education, performed a drawing-writing task using only picture stimuli. Whether a given picture stimulus was to be drawn or its name was to be written in English varied randomly from trial to trial. Overall, bilinguals were substantially slower (more than 200 ms) than monolinguals, even though only the pictorial-format processor was needed for stimulus recognition (and as in the current study, only one of the bilinguals' languages was explicitly involved).

Table 2. *Equations for model fit*

					Bilinguals					
Mixed presentation										
Draw(*P*,*P*) =	B_W	+	$t_{\mathrm{MBIL}}(B_W)$			+	$t_{\mathrm{MW}}(B_W)$	+	t_{D}	(1)
Draw(*W*,*P*) =	B_W	+	$t_{\mathrm{MBIL}}(B_W)$	+	t_{T}	+	$t_{\mathrm{MW}}(B_W)$	+	t_{D}	(2)
Write(*W*,*W*) =	B_W	+	$t_{\mathrm{MBIL}}(B_W)$			+	$t_{\mathrm{MW}}(B_W)$			(3)
Write(*P*,*W*) =	B_W	+	$t_{\mathrm{MBIL}}(B_W)$	+	t_{T}	+	$t_{\mathrm{MW}}(B_W)$			(4)
Blocked presentation										
Draw(*P*,*P*) =	B_W							+	t_{D}	(5)
Draw(*W*,*P*) =	B_W			+	t_{T}			+	t_{D}	(6)
Write(*W*,*W*) =	B_W									(7)
Write(*P*,*W*) =	B_W			+	t_{T}					(8)
					Monolinguals					
Mixed presentation										
Draw(*P*,*P*) =	B_W					+	$t_{\mathrm{MW}}(B_W)$	+	t_{D}	(9)
Draw(*W*,*P*) =	B_W			+	t_{T}	+	$t_{\mathrm{MW}}(B_W)$	+	t_{D}	(10)
Write(*W*,*W*) =	B_W					+	$t_{\mathrm{MW}}(B_W)$			(11)
Write(*P*,*W*) =	B_W			+	t_{T}	+	$t_{\mathrm{MW}}(B_W)$			(12)
Blocked presentation										
Draw(*P*,*P*) =	B_{W}							+	t_{D}	(13)
Draw(*W*,*P*) =	B_W			+	t_{T}			+	t_{D}	(14)
Write(*W*,*W*) =	B_W									(15)
Write(*P*,*W*) =	B_W			+	t_{T}					(16)

Note. Each equation indicates the additional latency incurred by a given set of parameters variably shared across trial conditions. *Write* = writing onset latency; *Draw* = drawing onset latency; *W* = word input (stimulus) or output (production); *P* = picture input (stimulus) or output (production); B_W = base onset latency; t_{MBIL} = bilingual anticipation effect latency; t_{MW} = latency increment for writing onset for mixed- over blocked-presentation mode; t_{T} = inter-symbolic-system transfer latency; t_{D} = latency increment for drawing over writing onset.

Some of the reductions in onset latency reported by Amrhein and Sanchez (1997) under their blocked-presentation mode are apparently not specific to bilinguals. Consider, for example, findings from the current study. Relative to the mixed-presentation mode, under the blocked-presentation mode, bilinguals and monolinguals exhibited substantial and equivalent decreases in onset latency for writing trials. Moreover, failing to find corresponding decreases in onset latency for drawing trials suggests that improvements in drawing performance are limited—even when task information is known far in advance of stimulus presentation. In addition, in contrast to the study by Amrhein and Sanchez (1997), a latency reduction for within-modality relative to cross-modality conditions was not found in the present study, indicating that their finding was likely due to the explicit testing of both of the bilinguals' languages. Such testing resulted in an imbalance of translation (67%) and copying (33%) trials—a situation that was not present in the current study.

Finally, across groups, cross-modality translation incurred the same additional latency (as denoted by t_{T} in Table 2), independent of source and destination symbolic-format processors (English or Spanish language, or pictorial), or presentation mode (mixed or blocked). This result replicates and extends the support for the revised concept-mediation model tested by Amrhein and Sanchez (1997). Accordingly, these data do not support the word-association and dual-coding models, which predict nonequivalence among specific cross-modality translation conditions (see Amrhein & Sanchez, 1997). Finding t_{T} to be equivalent in magnitude across presentation modes and groups indicates that cross-modality transfer is immune to the bilingual anticipation effect and thus operates after the base symbolic-system procedure has been established.

REFERENCES

Albert, M.L., & Obler, L.K. (1978). *The bilingual brain: Neuropsychological and neurolinguistic aspects of bilingualism.* New York: Academic Press.

Altenberg, E.P., & Cairns, H.S. (1983). The effects of phonotactic constraints on lexical processing in bilingual and monolingual subjects. *Journal of Verbal Learning and Verbal Behavior, 22,* 174–188.

Amrhein, P.C. (1994). Temporal invariance for picture-word translation: Evidence from drawing-writing and naming-reading tasks. *Memory & Cognition, 22,* 442–454.

Amrhein, P.C., & Sanchez, R. (1997). The time it takes bilinguals and monolinguals to draw pictures and write words. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23,* 1439–1458.

Cattell, J.M. (1887). Experiments on the association of ideas. *Mind, 12,* 68–74.

Chan, M.-C., Chau, H., & Hoosain, R. (1983). Input/output switch in bilingual code switching. *Journal of Psycholinguistic Research, 12,* 407–416.

Chavez, S., & Amrhein, P.C. (1994, November). *The time for bilinguals and monolinguals to draw pictures and write words.* Paper presented at the NIMH-COR Colloquium, Washington, DC.

Clyne, M. (1980). Triggering and language processing. *Canadian Journal of Psychology, 34,* 400–406.

Grosjean, F. (1985). The bilingual as a competent but specific speaker-hearer. *Journal of Multilingual and Multicultural Development, 6,* 467–477.

Grosjean, F. (1997). Processing mixed language: Issues, findings, and models. In A.M.B. de Groot & J. Kroll (Eds.), *Tutorials in bilingualism: Psycholinguistic perspectives* (pp. 225–254). Hillsdale, NJ: Erlbaum.

Hernandez, A.E., Bates, E.A., & Avila, L.X. (1996). Processing across the language boundary: A cross-modal priming study of Spanish-English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22,* 846–864.

Kroll, J.F., & de Groot, A.M.B. (1997). Lexical and conceptual memory in the bilingual: Mapping form to meaning in two languages. In A.M.B. de Groot & J.F. Kroll (Eds.), *Tutorials in bilingualism: Psycholinguistic perspectives* (pp. 169–200). Hillsdale, NJ: Erlbaum.

Li, P. (1996). Spoken word recognition of code-switched words by Chinese-English bilinguals. *Journal of Memory and Language, 35,* 757–774.

Macnamara, J., Krauthammer, M., & Bolgar, M. (1968). Language switching in bilinguals as a function of stimulus and response uncertainty. *Journal of Experimental Psychology, 78,* 208–215.

Macnamara, J., & Kushnir, S. (1971). Linguistic independence of bilinguals: The input switch. *Journal of Verbal Learning and Verbal Behavior, 10,* 480–487.

Magiste, E. (1980). Memory for numbers in monolinguals and bilinguals. *Acta Psychologica, 46,* 63–68.

Obler, L.K., & Albert, M.L. (1987). A monitor system for bilingual language processing. In M. Paradis (Ed.), *Aspects of bilingualism* (pp. 156–164). Columbia, SC: Hornbeam Press.

Paivio, A. (1966). Latency of verbal associations and imagery to noun stimuli as a function of abstractness and generality. *Canadian Journal of Psychology, 20,* 378–387.

Paivio, A. (1986). *Mental representations.* New York: Oxford University Press.

Paivio, A., Clark, J.M., Digdon, N., & Bons, T. (1989). Referential processing: Reciprocity and correlates of naming and imaging. *Memory & Cognition, 17,* 163–174.

Peynircioglu, Z., & Tekcan, A.I. (1993). Word perception in two languages. *Journal of Memory and Language, 32,* 390–401.

Pfaff, C.W. (1979). Constraints on language mixing: Intrasentential code-switching and borrowing in Spanish/English. *Language, 55,* 291–318.

Potter, M.C., So, K.F., Von Eckardt, B., & Feldman, L.B. (1984). Lexical and conceptual representation in beginning and proficient bilinguals. *Journal of Verbal Learning and Verbal Behavior, 23,* 23–38.

Ransdell, S.E., & Fischler, I. (1987). Memory in a monolingual mode: When are bilinguals at a disadvantage? *Journal of Memory and Language, 26,* 392–405.

Smith, M.C. (1997). How do bilinguals access lexical information? In A.M.B. de Groot & J.F. Kroll (Eds.), *Tutorials in bilingualism: Psycholinguistic perspectives* (pp. 145–168). Hillsdale, NJ: Erlbaum.

Snodgrass, J.G. (1980). Towards a model for picture and word processing. In P. Kolers & M. Wrolstad (Eds.), *Processing of visible language* (Vol. 2, pp. 565–584). New York: Plenum Press.

Snodgrass, J.G. (1993). Translating *versus* picture naming: Similarities and differences. In R. Schreuder & B. Weltens (Eds.), *The bilingual lexicon* (pp. 83–114). Amsterdam: John Benjamins.

Soares, C., & Grosjean, F. (1984). Bilinguals in a monolingual and bilingual speech mode: The effect on lexical access. *Memory & Cognition, 12,* 380–386.

Theios, J., & Amrhein, P.C. (1989). Theoretical analysis of the cognitive processing of lexical and pictorial stimuli: Reading, naming, and visual and conceptual comparisons. *Psychological Review, 96,* 5–24.

Tversky, B. (1969). Pictorial and verbal encoding in a short-term memory task. *Perception & Psychophysics, 6,* 225–233.

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