Monolingual Control Experiment

In a control experiment we tested English participants without knowledge of Japanese. If no phonological priming effect is observed for these participants, then the effect observed in the main experiment can be more confidently attributed to the Japanese-English bilinguals' knowledge of Katakana and not some unknown property of the materials. English participants should, however, show an effect of the frequency of target words.

Method

Participants

Nineteen native English-speaking students (7 female; mean age = 22.8, *SD* = 3.10) from the University of Western Ontario participated in the experiment for $20 CAD compensation. All of them reported that they do not know the Japanese language, and that they have either no experience or non-extensive experience with another language that is not Japanese.

Stimuli and Procedure

The stimuli and procedure were identical to those of the main experiment.

Results

The data from 3 participants were excluded from all analyses because of excessive noise in the ERP data (more than 50% of their trials exceeded ±75 μV at least one electrode). The analyses were therefore based on data from 16 participants (7 females, mean age = 23.0, *SD* = 3.22). Eight participants had seen each experimental list. Response latencies shorter than 300 ms or longer than 1700 ms were considered as outliers and excluded from the analysis (0.2% of all trials).

Behavioral Analyses

As in the main experiment, the mean lexical decision latencies for correct responses on the English targets were analyzed using 2 (Phonological similarity: similar, dissimilar) X 2 (Frequency: high, low) repeated measures ANOVAs. Both subject (F_1) and item (F_2) analyses were carried out. In the subject analyses, phonological similarity and frequency were within-subject factors. In the item analyses, phonological similarity was a within-item factor and frequency was a between-item factor. A list (or item group) factor was included. Analyses were not carried out on the error data because too few errors were made (< 2.0% of trials). Table 1 shows the summary of mean response latencies and error rates from the subject analyses.

Table 1. *Mean lexical decision latencies in milliseconds (and percentage errors) for monolingual English participants.*

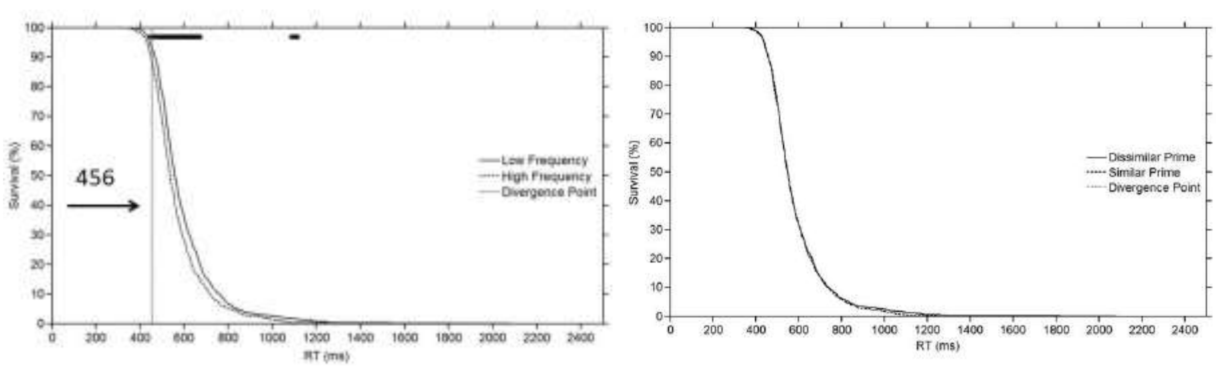
	Prime-Target Similarity		
Target Frequency	Similar	Dissimilar	Priming Effect
Low	597 (3.1)	609 (1.4)	12 (-1.7)
High	579 (1.9)	575 (1.0)	-4 (-0.9)
Overall	588 (2.5)	592 (1.2)	4 (-1.3)

In the decision latency data, there was a main effect of frequency, $F_1(1, 14) = 39.95$, $MSE = 306.4$, $p < .001$, $\eta^2 = .74$, $F_2(1, 116) = 15.01$, $MSE = 3234.4$, $p < .001$, $\eta^2 =$

.12. High-frequency targets were responded to faster (577 ms) than low-frequency targets (603 ms). There was neither a main effect of phonological similarity, *F*s < 1, nor an interaction between phonological similarity and frequency, $F_1(1, 12) = 3.33$, $MSE = 326.7$, *ns*, $\eta^2 = .19$, $F_2(1, 116) = 1.25$, $MSE = 1601.3$, *ns*, $\eta^2 = .01$.

To examine the decision latency distributions, we applied the survival analysis technique from Reingold et al. (2012) to the lexical decision response latencies, using the same procedure as in the main experiment. As can be seen from Figure 1, the divergence point for the high vs low frequency words was at 456 ms, and only approximately 10% of response latencies were below the divergence point. In contrast, he survival curves for the phonologically similar vs dissimilar Katakana primes never significantly diverged.

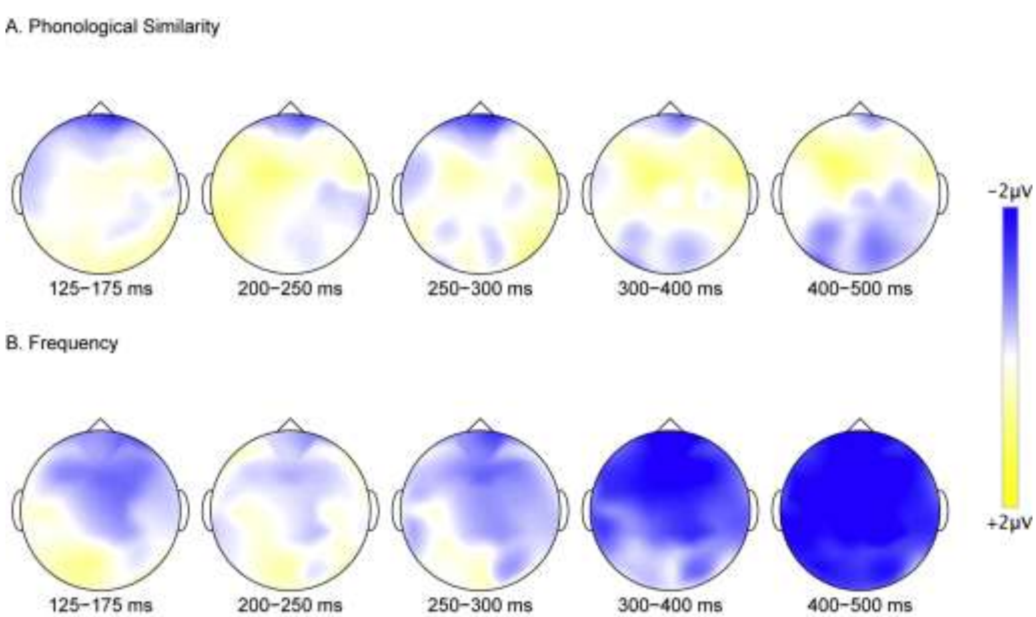
Figure 1. Survival curve distributions of lexical decision response latencies for the monolingual participants in the high and low frequency conditions (left panel) and in the phonologically similar and dissimilar prime conditions (right panel). The row of asterisks at the top the left panel indicates the time bins with a significant difference between the survival curves.



ERP Analyses

The data from 19 electrodes (AF3, AF4, F3, Fz, F4, FC5, FC1, FC2, FC6, C3, Cz, C4, CP5, CP1, CP2, CP6, P3, Pz, P4) were included in the analyses. Mean amplitudes in five time windows (125-175 ms, 200-250 ms, 250-300 ms, 300-400 ms, and 400-500 ms after the target onset) were analyzed. Separate repeated measures ANOVAs for each time window were conducted with factors of phonological similarity (related, unrelated), frequency (high, low), and electrode. A list factor was included. Analyses were first conducted with all 19 electrodes, and then were performed separately for four groups of electrodes, in the anterior left (AF3, F3, FC5, FC1), anterior right (AF4, Fz, F4, FC2, FC6), posterior left (C3, CP5, CP1, P3, Pz), and posterior right (Cz, C4, CP2, CP6, P4). Figure 2 displays voltage maps showing the spatial distributions of the phonological similarity effect and the frequency effect over the scalp.

Figure 2. Voltage maps for monolingual participants showing the spatial distributions of (a) the effect of phonological similarity and (b) the effect of frequency.



There was no main effect of phonological similarity in any of the time windows. The main effect of frequency was significant in the 300-400 ms window, $F(1, 14) = 8.78$, $MSE = 60.2$, $p < .02$, $\eta^2 = .39$, and in the 400-500 ms window, $F(1, 14) = 14.61$, $MSE = 76.2$, $p < .01$, $\eta^2 = .51$, but not in any other time windows. The interaction of similarity and frequency was not significant in any of the time windows. The analyses by regions revealed that in the 125-175 ms time window, the effect of frequency approached significance in the anterior right electrodes, $F(1, 14) = 4.15$, $MSE = 12.3$, $p = .06$, $\eta^2 = .23$. In the 300-400 ms time window, the effect of frequency was significant in the anterior right electrodes, $F(1, 14) = 16.47$, $MSE = 15.0$, $p < .01$, $\eta^2 = .54$, in the anterior left electrodes, $F(1, 14) = 18.29$, $MSE = 9.6$, $p < .01$, $\eta^2 = .57$, and in the posterior right electrodes, $F(1, 14) = 5.23$, $MSE = 21.1$, $p < .04$, $\eta^2 = .27$, but not in the posterior left electrodes, $F(1, 14) = 2.14$, $MSE = 21.3$, *ns*, $\eta^2 = .13$. In the 400-500 ms time window, the effect of frequency was significant in all regions: in the anterior right electrodes, $F(1, 14) = 16.29$, $MSE = 20.0$, $p < .01$, $\eta^2 = .54$, in the anterior left electrodes, $F(1, 14) = 17.87$, $MSE = 14.79$, $p < .01$, $\eta^2 = .56$, in the posterior right electrodes, $F(1, 14) = 10.27$, $MSE = 26.7$, $p < .01$, $\eta^2 = .42$, and in the posterior left electrodes, $F(1, 14) = 10.10$, $MSE = 25.0$, $p < .01$, $\eta^2 = .42$.

Discussion

Participants without knowledge of Japanese did not show a phonological priming effect, either in the behavioral data or in the ERP data. Therefore the phonological priming effect observed in the main experiment can be attributed to the bilingual participants' knowledge of Japanese and not some other unknown property of the materials. As expected, the participants here did show a significant effect of word frequency, both in the behavioral and in the ERP data.

In monolinguals, there was only a hint of the early frequency effect found by Sereno et al. (1998) and Hauk and Pulvermüller (2004), which appeared in the 125-175 ms time window in anterior right electrodes, and no evidence of the frequency effect seen at 250-300 ms in posterior electrodes in bilinguals. The frequency effect for monolinguals was significant in the 300-400 ms time window, whereas in bilinguals the frequency effect appeared in the subsequent time window of 400-500 ms. Furthermore, the divergence point in the lexical decision latencies for high and low frequency words was 40 ms earlier for monolinguals than bilinguals. These later frequency effects are likely a consequence of lexical processing, and the timing differences probably reflect the difference in English fluency of the monolingual and bilingual participants. Approximately 10% of monolinguals' responses were unaffected by frequency; these fastest responses were probably made based on sublexical activation.