Heritage-culture images disrupt immigrants’ second-language processing through triggering first-language interference

Shu Zhang a,1, Michael W. Morris a, Chi-Ying Cheng b, and Andy J. Yap a

aManagement Division, Columbia Business School, New York, NY 10027; and bSchool of Social Sciences, Singapore Management University, Singapore 178903

Edited by Richard E. Nisbett, University of Michigan, Ann Arbor, MI, and approved April 23, 2013 (received for review March 6, 2013)

For bilingual individuals, visual cues of a setting’s cultural expectations can activate associated representations, switching the frames that guide their judgments. Research suggests that cultural cues may affect judgments through automatic priming, but has yet to investigate consequences for linguistic performance. The present studies investigate the proposal that heritage-culture cues hinder immigrants’ second-language processing by priming first-language structures. For Chinese immigrants in the United States, speaking to a Chinese (vs. Caucasian) face reduced their English fluency, but at the same time increased their social comfort, effects that did not occur for a comparison group of European Americans (study 1). Similarly, exposure to iconic symbols of Chinese (vs. American) culture hindered Chinese immigrants’ English fluency, when speaking about both culture-laden and culture-neutral topics (study 2). Finally, in both recognition (study 3) and naming tasks (study 4), Chinese icon priming increased accessibility of anomalous literal translations, indicating the intrusion of Chinese lexical structures into English processing. We discuss conceptual implications for the automaticity and adaptiveness of cultural priming and practical implications for immigrant acculturation and second-language learning.

Author contributions: S.Z., M.W.M., and C.-Y.C. designed research; S.Z. performed research; S.Z., M.W.M., C.-Y.C., and A.J.Y. analyzed data; and S.Z. and M.W.M. wrote the paper.

The authors declare no conflict of interest.

1To whom correspondence should be addressed. E-mail: szhang14@gsb.columbia.edu.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1304435110/-/DCSupplemental.

See Commentary on page 11219.
of Chinese lexical structures, which we could observe with anomalous literal translations from Chinese to English.

**Study 1**

We used facial characteristics to prime culture (16, 17). The setting was a computer-mediated conversation session with a fellow student, an American undergraduate. Our Chinese foreign student participants saw their interlocutor’s photograph (varied as Chinese or Caucasian) (Fig. S1), listened to his prerecorded speech on two campus life topics in a standard American accent (constant across conditions), and then spoke in English into a microphone about each topic based on their own experience. Their speech on each topic was coded for fluency in two ways: a listener’s holistic fluency impression from the whole speech, and an objective count of words per minute, after standard pruning of extraneous words (repetitions, self-corrections, and so forth).

**Results.** Baseline proficiency was assessed by a speech sample produced before the priming manipulation, and it did not differ by condition (Chinese vs. Caucasian face) in the listener’s impression of proficiency, \( t(40) = -1.02, P = 0.31 \), or objective speech rate, \( t(40) = -1.52, P = 0.14 \). Fluency impressions for the two prepriming conversation topics were submitted to a factorial (prime: Chinese vs. Caucasian face) with a repeated measure (topic: 1 vs. 2). As a covariate, baseline proficiency impression predicted fluency impressions, \( F(1, 39) = 52.19, P < 0.001 \). As predicted, prime also predicted fluency impressions, \( F(1, 39) = 4.12, P = .049 \), in that they were lower in the Chinese face condition (\( M = 4.76, SE = 0.10 \)) than the Caucasian face condition (\( M = 5.04, SE = 0.09 \)) (Fig. 1).

In a parallel analysis, objective speech rate for the two post-priming conversation topics showed an effect of the corresponding baseline measure, \( F(1, 39) = 18.83, P < 0.001 \), as well as the predicted effect of prime, \( F(1, 39) = 5.77, P = 0.02 \), indicating that the flow of words was slower to the Chinese face (\( M = 98.77, SE = 3.30 \)) than the Caucasian face (\( M = 110.87, SE = 3.14 \)) (Fig. 1).

An alternative account could be raised in terms of expectancy violation (18). Perhaps the speech characteristics of the pictured interlocutor (e.g., standard American accent) were atypical of Chinese Americans. If so, surprise may have caused dysfluency in the Chinese face condition. If this were true, a comparison group of European American participants should exhibit the same dysfluency effect. To test this prediction, a European American sample was run through the same procedure. Again, we coded a baseline speech sample, which did not differ by condition in proficiency impression, \( t(43) = -0.41, P = 0.69 \), or speech rate, \( t(43) = 0.49, P = 0.63 \). Both baseline measures predicted corresponding fluency scores on the two topics: \( F(1, 42) = 31.59, P < 0.001 \) (impression measure), \( F(1, 42) = 43.13, P < 0.001 \) (speech rate measure). However, prime had no effect, \( F(1, 42) = 0.09, P = 0.76 \) (impression measure), \( F(1, 42) = 1.67, P = 0.20 \) (speech rate measure), weighing against the expectancy violation account.

Similar results were obtained in Study 2. Overall, a Chinese face disrupts the English fluency of Chinese foreign students, even though it elicits more positive social expectations. Although outgroup interactions can induce intergroup anxiety and result in dysfluency, any such effect was more than offset by dysfluency created by the ingroup Chinese face through the process of cultural priming.

**Study 2**

An alternative account for the dysfluency effect in study 1 is that Chinese immigrants may feel more motivated or obliged to speak English clearly to a Caucasian listener, who might not otherwise understand or accept them, than to a Chinese listener. Study 2 eliminated this audience-design account (21) by testing our hypothesis in a nonconversational context with no salient audience. Instead of faces, our Chinese participants viewed five icons of Chinese culture (e.g., Great Wall) or American culture (e.g., Mount Rushmore) (Fig. S2), which they rated as equal in familiarity, \( t(21) = 0.29, P = 0.77 \). Then they were asked to describe in English these culture-laden images (task 1) and subsequently to narrate stories from several culture-neural images (task 2) (Fig. S3). We coded baseline proficiency and speech fluency with the same procedures as in study 1.

**Results.** Baseline proficiency did not differ by condition (Chinese vs. American icons) in proficiency impression, \( t(21) = -0.61, P = 0.55 \), or objective speech rate, \( t(21) = 0.46, P = 0.65 \). Fluency impressions for cultural-icon descriptions were submitted to a factorial (prime: Chinese vs. American icons) with a repeated measure (icons: 1–5). As a covariate, baseline proficiency impression had a marginally significant effect on fluency impressions, \( F(1, 20) = 3.94, P = 0.06 \). More importantly, prime had a main effect on fluency impressions, \( F(1, 20) = 8.88, P = 0.007 \), lower in the Chinese-icon condition (\( M = 5.15, SE = 0.18 \)) than the American-icon condition (\( M = 5.91, SE = 0.17 \)). Parallel analyses on fluency impressions for descriptions of culture-neutral images yielded no effect of baseline proficiency impression, \( F(1, 20) = 1.81, P = 0.19 \), but a main effect of prime, \( F(1, 20) = 6.87, P = 0.02 \), as fluency impressions were again lower in the Chinese-icon condition (\( M = 5.20, SE = 0.22 \)) than the American-icon condition (\( M = 5.98, SE = 0.21 \)) (Fig. 2).

Consistent with these results, speech rate for cultural-icon descriptions was predicted by the corresponding baseline measure, \( F(1, 20) = 12.02, P = 0.002 \), and more importantly, by prime, \( F(1, 20) = 5.14, P = 0.03 \), as the flow of words was slower in the Chinese-icon condition (\( M = 75.06, SE = 3.32 \)) than the American-icon condition (\( M = 85.51, SE = 3.18 \)). Similarly, speech rate for descriptions of culture-neutral images was predicted by the same baseline measure, \( F(1, 20) = 10.73, P = 0.004 \), and by prime, \( F(1, 20) = 4.98, P = 0.04 \), as the flow of words was again slower in the Chinese-icon condition (\( M = 77.05, SE = 4.68 \)) than the American-icon condition (\( M = 91.56, SE = 4.48 \)) (Fig. 2).

**Study 2 Discussion.** In sum, Chinese immigrants are hindered in speaking English by exposure to icon images of Chinese culture; this effect showed in their verbal descriptions of both culture-laden...

---

**Fig. 1.** Effects of face primes on fluency impressions and speech rate (study 1, Chinese participants). Error bars represent SEs.
and culture-neutral items. Neither the expectancy violation nor audience design accounts can explain these effects, as priming was implemented through images rather than an audience.

Study 3

Although studies 1 and 2 found that visual primes of Chinese culture hinder English processing, they did not directly reveal the intrusion of Chinese linguistic structures into English processing. Our final studies aimed to do that. Of the many kinds of linguistic structures (e.g., syntactical, lexical, phonological) that may interfere to affect L2 processing, evidence for lexical structures is most straightforward to test. One way that L1 can get in the way of L2 is through anomalous literal translations (22). Our procedure showed pictures of objects (Fig. S4) that have Chinese compound names that are not mirrored in the structure of their English names (e.g., the literal translation of the Chinese name for pistachios is “happy nuts”). We used a recognition task to evaluate the accessibility of the literal translations from L1 (23, 24). We tested, for example, that a picture of pistachios would evoke the name “happy nuts” in the minds of Chinese immigrant participants more after they had been primed with Chinese icons.

Studies 1 and 2 were also unclear about whether the dysfluency effect was more about Chinese primes hindering English processing or American primes improving it, so we included control conditions without cultural primes, as well as Chinese and American conditions that each used the same icon primes as in study 2 (Fig. S2). Moreover, in addition to the literal-translation recognition trials to test effects of Chinese priming, English-name recognition trials were included to test facilitatory effects of American priming. As these two types of trials were presented in different order to test separate effects of Chinese and American priming, a matched control condition was included for each priming condition (Chinese vs. Control-Chinese, American vs. Control-American). Finally, Chinese-name recognition trials were also included and presented last.

Results. Recognition accuracy rates were 0.87, 0.88, and 0.97 for literal-translation, English-name, and Chinese-name recognition trials, respectively. None of the three types of trials differed in recognition accuracy between Chinese and Control-Chinese conditions, all r(42) < 1.32, all P > 0.19, or between American and Control-American conditions, all r(38) < 1.28, all P > 0.21.

To test the hypothesized effect of Chinese priming on accessibility of Chinese linguistic structures in English processing, we submitted the recognition latency scores on the literal-translation trials to a one-way ANCOVA (condition: Chinese vs. Control-Chinese). Two baseline measures were used as covariates: a general indicator of English proficiency provided by self-report before the priming manipulation, and a task-specific recognition latency measure obtained from the Chinese-name trials. Given the rarity of cross-language intrusion into L1 (13, 25), the latter measure should reflect participants’ baseline latency in our recognition task with minimal influence of cultural primes. Indeed, the latency scores on the Chinese-name trials did not differ by condition, F(3, 80) = 0.44, P = 0.73, nor did self-report proficiency, F(3, 80) = 0.49, P = 0.02, evidenced by faster recognition accuracy rates were 0.87, 0.88, and 0.97 for

Study 3 Discussion. Importantly, study 3 results indicate that exposure to Chinese icons heightened the accessibility of Chinese lexical structures for Chinese immigrants engaged in an English language task. To rule out the alternative account that the effects from previous studies came from facilitatory effects of American primes, we tested the Chinese prime effect relative to a control condition. We also tested for an effect of American primes fostering English fluency and found none. Overall, these findings are consistent with the dysfluency effects in prior studies reflecting inhibitory influence of Chinese primes—but not facilitatory influence of American primes—on Chinese immigrants’ English processing.
Study 4
Using the same cultural icon primes as in studies 2 and 3 (Fig. S2), study 4 tested the intrusion of Chinese lexical structures into English processing in an object-naming task. Naming tasks are widely used to test cross-language inference because when searching for a name, structures from L1 and L2 compete for selection (26, 27). As in study 3, we presented pictured objects that have Chinese compound names that are not mirrored in the structure of their English names. If Chinese primes heighten not only accessibility of Chinese lexical structures but also their selection in English production, then we may see increased use of literal translations in the object-naming task.

Results. In a task of naming five pictured objects (Fig. S4), Chinese participants produced an average of 0.81 proper English names (SE = 0.11) and 0.92 literal-translation-from-Chinese names (SE = 0.10). Mean production rates per object were 0.16 and 0.18 for English names and literal translations, respectively. These rates were lower than the recognition accuracy rates in study 3, as recall in a second language is much more challenging than recognition.

Baseline proficiency was assessed by an impression measure based on a speech sample produced before the priming manipulation, and it did not differ by condition (American vs. Chinese), \( t(83) = -0.10, P = 0.92 \). We submitted the binary variable indicating literal-translation production (0: no, 1: yes) to a hierarchical linear modeling, with naming trials nested within participants. At the participant level, baseline proficiency was included as a covariate and prime as a predictor. There was no effect of baseline proficiency on literal-translation production, \( t(82) = 1.38, P = 0.17 \). However, prime predicted literal-translation production, \( t(82) = 2.80, P = 0.007 \), as more literal translations were produced under Chinese (M = 0.24, SE = 0.03) than American priming (M = 0.13, SE = 0.03) (Fig. 4). Parallel analyses were performed on the binary variable indicating English-name production (0: no, 1: yes), yielding an effect of baseline proficiency, \( t(82) = 2.20, P = 0.03 \), but no effect of prime, \( t(82) = -0.60, P = 0.55 \).

Study 4 Discussion. Extending study 3 findings, study 4 show fuller evidence for the intrusion of Chinese lexical structures into immigrants’ English processing as a function of priming with visual cues of Chinese culture. There was no effect of priming on English-name production, suggesting again no facilitatory effect of American primes on English processing.

General Discussion
The present studies found consistent evidence that immigrants’ second-language processing can be disrupted by heritage-culture priming. Focusing on recent Chinese immigrants to the United States, we first tested that L2 fluency would be disrupted by exposure to cues of Chinese culture, such as a Chinese face (study 1) or iconic Chinese symbols (study 2). Alternative explanations, such as interaction anxiety, expectation violation, and audience design were ruled out. Then we tested that priming with such visual cues produces the intrusion of Chinese linguistic structures into English processing, evidenced by increased accessibility (speeded recognition) of Chinese-to-English literal translations (study 3) and increased use of these literal translations in an object-naming task (study 4). Although Chinese priming had these effects, American priming did not affect English processing, consistent with the interpretation of the fluency effects as reflecting the intrusion of the primed Chinese language into English processing.

This research contributes distinctive evidence that visual cues of heritage culture can affect people through a priming mechanism. Although past studies show that cultural images shift biculturals’ judgments and decisions, we provide original evidence for the theorized automaticity of cultural priming, as the effects of priming occur despite its interference with fluent performance in English (28). Whereas past cultural priming studies have used language as a cultural prime (1, 29, 30), or measured linguistic category choices and memories indicative of cultural schemas (6), the present studies are unprecedented in looking at language as a performance that can be disrupted by cultural priming.

Furthermore, the results contribute to the literature on how bilinguals manage their two languages. Cross-language interference has been studied as arising from inherent linguistic structures and from the linguistic context of a task (7, 31). Here we found that visual cues, such as faces and symbolic icons, also affect cross-language interference. This finding raises the question of what other features of one’s visual environment are salient triggers of the mother tongue and whether cues in other modalities (e.g., distinctive sounds, smells, and kinesthetic patterns) may also prime culturally associated languages.

Our findings speak to the intergroup literature as well. In study 1, Chinese participants exhibited in-group favoritism by reporting more positive expectations about a Chinese than a Caucasian in-group (32). Furthermore, unlike in studies showing greater verbal dysfluencies (in L1) during cross-group interactions (20), Chinese participants were more fluent (in L2) during same-group interactions. This finding suggests that dysfluency in L1 and L2 may be affected by different aspects of an interaction, although more research is needed to sort this out.

Our results raise new questions for several applied literatures. Immigrants who settle in ethnic enclaves acculturate more slowly (33). Moreover, immigrants to culturally mixed neighborhoods report experiences of distraction and confusion (34). These phenomena may arise in part from the priming of heritage-culture schemas and scripts that compete with newly learned host-culture schemas and scripts. For immigrants or expatriates, a visual environment with heritage-culture cues may have mixed effects, bolstering mood and felt connectedness yet hindering the process of learning the host culture.

Research on second-language learning has attributed advantages of study-abroad programs to linguistic contexts. Americans taking a Spanish course in the United States showed lower Spanish proficiency and greater accessibility of English words than a group taking the same course of Spanish in Spain (35). Although the linguistic context outside of class no doubt contributed to the United States group’s higher L1 accessibility, the cues in the visual environment may have also mattered: the everyday environment of the United States group was saturated with cues to American culture, which heightened L1 accessibility. In sum, L2 learning may
of Michael Lee (Fig. S1) while listening to the same audio recordings of him talking about two campus-life topics in a standard American accent. After listening to Michael Lee talking about each topic, participants spoke about this topic in English for 1 min. When finished, participants reported their expected enjoyment in working with Michael Lee.

**Fluency impressions.** A hypothesis and condition-naive coder listened to the recordings of participants’ self-introduction given before the priming manipulation and assessed their baseline proficiency (1 not proficient at all, 7 very proficient). The coder also listened to the recordings of their speech on each topic delivered after the priming manipulation and rated their fluency on three dimensions (39, 40): speed (1 very slow, 7 very fast), pauses (1 no pause, 7 a lot of pauses), and truncation (1 no truncation, 7 a lot of truncation). The three dimensions were averaged into an impression measure of fluency. As a reliability check, a second coder who independently coded 20% of the recordings showed high agreement, intraclass correlation coefficient = 0.78, P < 0.001.

**Speech rate.** All recordings were transcribed verbatim. A speech-rate measure was developed by counting how many “pruned words” were produced per minute, excluding self-corrected words, repetitions, false starts, nonlexical filled pauses, and asides (41, 42). This measure was correlated with the impression measure of fluency, r = 0.64, P < 0.001, consistent with previous evidence on reliability of listener-based impressions of fluency (43).

**Study 2.** Participants were 23 Chinese students (9 males) from the same university. They had lived in the United States for 14 mo on average. Participants were randomly assigned to two conditions (prime: Chinese vs. American icons).

Participants first gave a self-introduction speech as in study 1 to provide measures of baseline proficiency. Then they performed two tasks on computer. The first task showed five icon images of Chinese or American culture (Fig. S2), and participants described each icon in spoken English for 1 min. Then, with thumbnails of these icons still visible in the top margin of the computer screen, participants completed a storytelling task, making up a story explaining each of four culture-neutral images in the center of the computer screen (Fig. S3). Finally, participants indicated prior familiarity with the five cultural icons (1 not familiar at all, 7 very familiar). A holistic impression measure and an objective speech rate measure of fluency were developed as in study 1. These two measures were again correlated, r = 0.42, P < 0.001.

**Study 3.** Participants were 84 Chinese students (35 males) from the same university; they had lived in the United States for 3 mo on average. The participants were randomly assigned to four conditions, including two priming conditions (Chinese, American) and two control conditions that each matched in block order with a priming condition (Control-Chinese, Control-American).

After reporting their English proficiency (1 not proficient at all, 7 very proficient), participants in the priming conditions wrote about the same five Chinese or American icons as in study 2 (Fig. S2), and participants in the control conditions wrote about five geometric figures (44). Then participants completed three blocks of name-recognition trials: literal translations (27 trials), English names (27 trials), and Chinese names (54 trials). Each trial presented a pictured object for 2 s, followed by a target word/phrase. In a literal-translation trial, participants judged whether the target phrase identifies the pictured object. In an English-name (Chinese-name) trial, participants judged whether the target word is the correct English (Chinese) name of the pictured object. The literal-translation trials presented different objects from the English-name trials, and the Chinese-name trials presented all of the objects from the literal-translation and English-name trials. Each block included twice as many distractor trials that required a “no” response as trials that required a “yes” response. Reaction times on accurately judged trials were transformed into natural logarithms (45).

Our primary goal was to test the Chinese priming effect on recognition latency for the literal-translation trials. We were also interested in whether American priming would facilitate recognition for the English-name trials. The Chinese-name trials were included as a baseline measure of recognition latency. To minimize order effects, each priming condition, as well as its

| Table 1. Coding examples for the object-naming task (study 4) |
|------------------|------------------|------------------|------------------|------------------|
| Naming task      | Object 1         | Object 2         | Object 3         | Object 4         | Object 5         |
| English name     | Q-tips; Cotton swabs | Cotton sticks; Cotton bars | Pistachios | Happy fruits | Bulldozer |
| Literal translation | Cotton sticks; Stick candy; Sugar with stick | Happy nuts; Flying plate; Flying dish | Earth-pushing machine |
matched control condition, presented the most relevant block of trials first: Chinese and Control-Chinese conditions presented the literal-translation trials first, followed by English-name trials; American and Control-American conditions presented English-name trials first, followed by literal-translation trials. Chinese-name trials were presented last in all conditions.

To assess Chinese lexical intrusion in English following Chinese primes, we submitted the latency scores on the literal-translation trials to a 2 (prime: Chinese vs. Control-Chinese) factorial, with self-report proficiency and baseline recognition latency as covariates. Similar analyses were performed to detect the effect of American primes on literal-translation recognition latency (prime: American vs. Control-American). We further tested the effect of American priming on English processing by submitting the latency scores on the English-name trials to a 2 (prime: American vs. Control-American) factorial with the same two covariates. Similar analyses were performed to detect the effect of Chinese primes on English-name recognition latency (prime: Chinese vs. Control-Chinese).

Study 4. Participants were 85 Chinese students (32 males) from the same university. They had lived in the United States for 4 mo on average. Participants were randomly assigned to two conditions (prime: Chinese vs. American icons).