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Conceptual and Non-conceptual Repetition Priming in Category Exemplar Generation: Evidence from Bilinguals

Wendy S. Francis and Norma P. Fernandez

University of Texas at El Paso

Robert A. Bjork

University of California, Los Angeles

Corresponding Author:

Wendy S. Francis
Department of Psychology
University of Texas at El Paso
500 W. University Ave.
El Paso, TX 79968
Phone: (915) 747-8956
Fax: (915) 747-6553
Email: wfrancis@utep.edu

Abstract

One measure of conceptual implicit memory is repetition priming in the generation of exemplars from a semantic category, but does such priming transfer across languages? That is, do the overlapping conceptual representations for translation equivalents provide a sufficient basis for such priming? In Experiment 1 (N = 96), participants carried out a deep encoding task, and priming between languages was statistically reliable, but attenuated, relative to within-language priming. Experiment 2 (N = 96) replicated the findings of Experiment 1 and assessed the contributions of conceptual and non-conceptual processes using a levels-of-processing manipulation. Words that underwent shallow encoding exhibited within-language, but not between-language, priming. Priming in shallow conditions cannot, therefore, be explained by incidental activation of the concept. Instead, part of the within-language priming effect, even under deep-encoding conditions, is due to increased availability of language-specific lemmas or phonological word forms.

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The degree to which memory processes transfer between languages is an indicator of both the extent to which a memory measure relies on conceptual-level processing and the extent to which episodic representations of translation equivalents are shared across languages. The present study compares repetition priming within and between languages in an implicit memory task that has been classified as conceptually driven. Two experiments measured the extent of transfer between languages and the impact of non-conceptual processes on repetition priming in category exemplar generation.

Dissociations among various implicit memory tasks have revealed that implicit memory has multiple cognitive and neural bases (see, e.g., Gabrieli, 1998). In the present investigation, instead of comparing patterns of priming for different tasks, the component processes within a single priming paradigm were isolated to reveal multiple mechanisms of priming. Implicit memory is exhibited in several behaviorally observable transfer or priming phenomena. Repetition priming can be measured as an increase in accuracy, a decrease in response time, or a response bias based on previous exposures to specific items. Several repetition priming paradigms have been developed to measure the bias to produce items presented at encoding, including category-exemplar generation, word-stem completion, word-associate generation, and homophone spelling. In the present study, category exemplar generation priming was the paradigm used.

Category Exemplar Generation Priming

The category-exemplar-generation priming procedure, developed by Graf, Shimamura, and Squire (1985) to measure conceptual implicit memory, involves an encoding phase and a test phase. In the encoding phase, participants make judgments about words that are members of different semantic categories. In the test phase, participants are given the name of one category at a time and asked to generate the first several exemplars that come to mind. Some of the tested categories corresponded to exemplars that appeared in the encoding phase, and others to new categories for which no exemplars appeared in the encoding phase. Given appropriate counterbalancing across participants, evidence of conceptual priming consists of exemplars being produced more often when they appeared in the encoding phase then when they did not. Evidence that this effect depends on implicit rather than explicit memory comes from studies showing that category-exemplar-generation priming is preserved in both amnesic patients (Graf et al., 1985; Keane et al., 1997) and older adults (Light & Albertson, 1989; Light, Prull, & Kennison, 2000; Monti et al., 1996), whereas category-cued recall is impaired in these populations.

Two main sources of evidence support a conceptual basis for the category-exemplar-generation priming effect. First, the magnitude of the priming effect depends on the degree of semantic processing during initial encoding of the category members. Priming has been shown to be sensitive to depth-of-processing manipulations, exhibiting a greater magnitude of priming with a semantic encoding task than with a non-semantic encoding task (Hamann, 1990; Keane et al., 1997; Kinoshita, 1989; Monti et al., 1996; Mulligan, Guyer, & Beland, 1999; Srinivas & Roediger, 1990; Vaidya et al., 1997; Weldon & Coyote, 1996). The priming effect is also greater for words generated at encoding rather than simply readwhen the basis for generation task is semantic (Mulligan, 2002; Srinivas & Roediger, 1990), but not if the basis is non-semantic (Kinoshita, 1989; Mulligan, 2002). Manipulations that make semantic associations among the stimuli more salient also increase priming. For example, blocking the encoding sequence by category tends to increase priming (Mulligan & Stone, 1999; Mulligan et al., 1999; Rappold & Hashtroudi, 1991), as does instructing participants to use a categorical strategy with a randomly ordered sequence of exemplars (Rappold & Hashtroudi, 1991).

The second source of evidence for the conceptual basis of category-exemplar-generation priming is the high degree of transfer observed between different perceptual forms of the category members. The standard implementation of the procedure is with visual encoding and spoken responses at test, meaning that the standard effect is cross-modal, and when category exemplars were presented in picture format at encoding, priming was substantial and typically did not differ reliably from priming obtained with words (McDermott & Roediger, 1996; Weldon & Coyote, 1996; but see Vaidya & Gabrieli, 2000).

Considerations that Motivate the Present Research

Because auditory word, visual word, and picture formats share a common concept, such transfer is often taken to indicate a conceptual contribution to priming. A problem, however, with this logic is that these forms also share non-semantic attributes. A particular word, whether presented in the auditory or the visual modality retains the same identity in terms of its syntactic, phonological, and orthographic word forms. Similarly, a picture and the word that names it are tied to common word-form information. In contrast, non-cognate translation equivalents have distinct word forms, so any transfer between these forms must be based on their common meaning rather than the word form. Both of the present experiments examine priming between translation equivalents in category exemplar generation.

Although the findings reviewed above indicate a conceptual contribution to priming, they do not indicate that category-exemplar-generation priming has an exclusively conceptual basis. On the contrary, several studies have shown substantial priming following read-only or shallow processing instructions at encoding (Light et al., 2000; Mulligan, 2002; Mulligan & Stone, 1999; Rappold & Hashtroudi, 1991; Srinivas & Roediger, 1990; Vaidya & Gabrieli, 2000; Vaidya et al., 1997). These effects are smaller than those obtained with semantic processing at encoding and less consistent (i.e., their reliability was not consistent across experiments within a study).

The attenuated, yet substantial, priming effects observed even in non-semantic conditions suggest that there is also a substantial non-semantic component to category exemplar generation priming, perhaps based on increased availability of the word forms associated with the target exemplars. An alternative explanation is that the priming observed following read-only or shallow processing instructions is due to conceptual activation that may occur automatically when a word is read. It is premature, however, to dismiss these effects as artifacts of uninstructed semantic processing without having countervailing evidence. A bilingual design allows for a test of this explanation. To the extent that shallow encoding elicits priming *between languages*, the explanation based on incidental conceptual activation would be supported. In contrast, if shallow encoding did not elicit priming between languages, the idea that non-semantic factors contribute to the standard effect becomes a more plausible explanation. This issue is addressed in Experiment 2.

Bilingual Representations of Translation Equivalents

In Experiments 1 and 2, bilingual materials were used to facilitate the separation of different components of priming. Using bilingual materials allows using two alternative labels (translation equivalents) to refer to a single object or concept, but these labels have distinct word forms. The cognitive experimental literature on bilingual memory and language processing shows that for highly proficient bilinguals, translation equivalents of concrete nouns have shared conceptual representations (de Groot, 1992; Francis, 1999, 2005)[1]. This evidence is sufficient to justify using bilingual translation equivalents as alternate paths to a single conceptual representation.

One strategy used to assess whether representations are shared or separate has been to examine memory transfer between languages. This approach, based on the principle of *transfer-appropriate processing* (Morris, Bransford, & Franks, 1977; Roediger & Blaxton, 1987), assumes that the degree of transfer from encoding to test depends on the degree of processing similarity from encoding to test. Thus, if an encoding task leads to facilitation in a test task, we can conclude that the tasks have processes in common or activate common mental representations. In the bilingual case, memory transfer between languages is taken as evidence for shared (i.e., language-general) episodic representations, and this evidence is, in turn, typically interpreted as evidence for shared representations in semantic memory (see Francis, 1999, 2005 for further elaboration of this distinction and inferential step).

In using transfer between languages to reason about the extent to which bilingual representations are shared across languages, direct tests of memory can be problematic because participants may adopt translation strategies at test, thereby undermining the between-language nature of the task. In contrast, with indirect testing procedures, participants do not realize that their memory for the encoding phase is being tested, and there is, hence, no motivation to use translation as a strategy to encode or retrieve information.

The question of whether bilinguals inadvertently or automatically use translation strategies can also be addressed. First, although there is evidence that reading a word in one language automatically activates its translation equivalent (e.g., Schwartz & Arêas da Luz Fontes, 2008), the effects have only been observed for immediate processing on the order of a few seconds or less. These effects do not last across intervals of several minutes, and proficient bilinguals do not intentionally translate word stimuli and word responses in the absence of instructions to do so (Francis, Corral, Jones, & Sáenz, 2008; Francis et al., 2010).

Prior Relevant Bilingual Research

Between-language tests of conceptual repetition priming have been used in a small number of bilingual studies. The first demonstration was when highly conceptual and associative processing of words in one language at encoding (induced by having participants read words in the context of sentences or generate based on sentences) led to higher accuracy in word fragment completion in the other language at test (Smith, 1991)[2]. Semantic decisions (concrete-abstract, animacy, or natural-manufactured) in one language at encoding led to speeded semantic decision times at test for repeated concepts in the other language relative to new concepts (Francis & Goldmann, 2010; Li, Mo, Wang, & Luo, 2006; Zeelenberg & Pecher, 2003). Conceptual repetition priming between languages was extended to verbs by showing that generation of verbs to noun stimuli at encoding led to speeded generation of repeated verbs at test (de la Riva López, Francis, & García, 2010; Seger, Rabin, Desmond, & Gabrieli, 1999). The present study is the first to examine between-language transfer in a form of repetition priming where the measure of priming is a bias to produce items presented at encoding.

Experiment 1

As explained in the introduction, there is strong evidence in the literature that translation equivalents have shared conceptual representations in episodic and semantic memory. However, phonological and orthographic representations of non-cognate translation equivalents are distinct across languages. Therefore, between-language transfer, if observed, would provide stronger evidence of the conceptual nature of category exemplar generation priming than did previous demonstrations of transfer from visual to auditory modalities or from picture to word modalities.

To the extent that between-language priming is attenuated relative to within language priming, the contribution of non-conceptual components to priming would be supported. In Experiment 1, bilingual participants performed a deep encoding task with category exemplars presented in English or Spanish and later performed the category generation task in English or Spanish. The degree of priming within and between languages was assessed.

Method

Participants. The participants were 96 self-identified Spanish-English bilinguals (30 men, 66 women), 48 from the University of California, Los Angeles and 48 from the University of Texas at El Paso. They participated for research credit or as unpaid volunteers, and they ranged in age from 17 to 40 (*Mdn* = 19). According to self-reported proficiency questionnaire responses, 72% were English dominant and 28% were Spanish dominant. The first language learned was Spanish for 75%, English for 10%, and both for 15%. The median age of second language acquisition was 5 years.

The participants reported their usage over the preceding month to be 60% English, 30% Spanish, 10% a mixture, and less than 1% other languages, a pattern that corresponds to using the dominant and non-dominant languages 61% and 29% of the time, respectively. Four additional participants were excluded either for failure to follow instructions or for poor performance on the translation test (i.e., too many of their trials had to be excluded from analysis), and they were replaced to maintain counterbalancing.

Design. The design was a 2 (language match) x 2 (language of test) x 2 (item status) mixed design. The match between encoding and test languages and the test language (English or Spanish) were manipulated between subjects, and item status (repeated/new) was manipulated within subjects. The dependent measure was the number of target items from each category that were produced during the test phase.

Materials. Exemplars from 10 experimental categories were chosen from the Battig and Montague (1969) norms. The categories were *articles of clothing*, *parts of the body*, *fruits*, *vegetables*, *natural earth formations*, *weather phenomena*, *four-legged animals*, *insects*, *occupations*, and *relatives*. Six exemplars were chosen from each category, with the restrictions that none were among the six most frequent in the norms, all were relatively easy vocabulary items, meanings were relatively unambiguous in both languages, and there were no identical cognates. The categories and exemplars used are given in Appendix A. (Because no Spanish-language norms were available, the typicality of the items for English and Spanish could not be precisely compared. Instead, generation rates for control conditions provided some information about the relative baseline availability of the exemplars in the two languages.) Six additional categories that did not fit all of the criteria were used as practice and filler categories. The 10 experimental categories were randomly assigned to two groups. For each participant, exemplars from 5 of the categories were presented at encoding (repeated condition), and exemplars from the other 5 categories were not (new condition). The assignment of category sets to repeated or new status was counterbalanced across participants.

Procedure. Participants were randomly assigned to the four language combinations and were tested individually by a bilingual experimenter in sessions lasting approximately 30 minutes. Instructions for each task were given in the assigned response language. The procedure consisted of an encoding phase and a test phase. In the encoding phase, participants rated the pleasantness of the 30 experimental words that were assigned to the repeated condition. The words were presented visually on index cards one at a time in a block-randomized sequence, with one word per category appearing in each block of six items. Three filler words (not from any experimental category) were inserted at the beginning and end of the sequence to control for primacy and recency effects and make it less likely that the participant would notice the categorical nature of the stimuli. Participants were told that we wanted to find out how pleasant or unpleasant people thought the words were. The pleasantness of each item was rated on a scale from 1 (very unpleasant) to 7 (very pleasant). Presentation of items was self-paced; after each rating was made, the participant turned over the next card to reveal the next word to be rated.

In the test phase, with no reference made to the encoding phase, participants were asked to generate exemplars to all of the experimental and filler categories. They were told that we wanted to see how quickly they could come up with examples in each category. Four filler categories were used at the beginning of the sequence for practice and to reduce the probability that participants would guess the purpose of the experiment. The 10 experimental categories followed, with 2 additional filler categories inserted to balance the retention interval for repeated and new categories. For each category, the experimenter named the category and asked the participant to generate members of the category aloud as quickly as possible, and the experimenter would stop the participant after the 8th exemplar generated. The experimenter marked the exemplars generated on a pre-printed worksheet containing both the most common exemplars and the experimental exemplars. The test phase was recorded to provide backup verification of experimenter notes about exemplars generated.

Upon completion of the test task, participants completed a translation task, the purpose of which was to determine which items were in each participant’s vocabulary, providing a basis to exclude from consideration those items that were not translated correctly, regardless of the condition in which they had appeared. This test consisted of a randomized list of all experimental stimuli in the opposite language from the category generation task; participants were asked to write the translation of each word in the language of the category task. (For example, participants who generated category exemplars in English had to translate all the experimental stimuli from Spanish to English.) Participants also completed a questionnaire about their language background and proficiency.

Results

For each category, the first 6 items produced were used in scoring.[3] The number of target items produced was scored separately for primed and control categories and the scores were transformed to percentages. The denominator in these percentages was the total possible score, or number of target items (i.e., 6 per category and, therefore, 30 per condition). These percentages were adjusted by excluding from consideration (in both score and total possible) items that were not in a participant's vocabulary in one or both languages. The translation task was used to verify knowledge of the experimental words. Participants who scored less than 50% on the translation task were replaced.

The percentages of target exemplars generated in each condition are shown in Table 1 as a function of whether the language in the encoding and test phases matched or mismatched and whether target words or did not appear in the encoding phase. Because some participants were more proficient in English and others more proficient in Spanish, participants were re-classified as to whether they had performed each task in their dominant language or their nondominant language (as indicated by self-report questionnaire classification). This aspect of the analysis allows us to test the possible impact of language proficiency on priming within and between languages. The rate of target exemplar generation for items not presented at study was higher in the less fluent language, $F(1, 92) = 5.527$, $MSE = .006$, $p = .021$, but there was no effect of language match and no interaction of language match and test language (ps > .10). Priming relative to control was significant for every language combination (ps < .05). A significant effect of language match on priming, $F(1, 92) = 5.252$, $MSE = .014$, $p = .024$, indicated stronger priming within than between languages. Test language did not affect priming, nor did it interact with the effect of language match, Fs < 1.

Discussion

Both within-language and between-language priming were reliable, but the between-language priming effects were attenuated relative to the within-language effects. The substantial priming between languages relative to non-presented items indicates that the representations of translation-equivalent concepts in episodic memory are shared and that at least half of the within-language priming effect is conceptual in nature. The attenuation of priming between languages relative to priming within languages indicates, however, that the priming within a language is not based exclusively on conceptual processing. From that perspective, however, the conditions under which a shallow encoding task produces priming in category exemplar generation remains a puzzle, a puzzle that is the focus of Experiment 2.

Experiment 2

As cited in the introduction, category-exemplar-generation priming within a language has been found to be stronger for words processed conceptually at encoding than for words processed in a more superficial manner. Even when target words are merely named, viewed, or processed under shallow encoding instructions, however, there remains a substantial bias to produce studied words. The most straightforward explanation of this effect is that the priming observed in these conductions has a non-conceptual basis. An alternative possibility, however, is that even under non-conceptual encoding instructions, sufficient conceptual processing occurs at encoding to produce conceptually based priming, albeit at a weaker level than that observed following conceptual encoding. It is also possible that priming elicited by shallow encoding in the target language is based on a combination of the intended phonological or orthographic processing and incidental conceptual processing. Even if a concept is automatically activated during a task that does not require conceptual access, that activation does not necessarily lead to long-term priming. For example, lexical decision exhibits priming from non-cognate translation equivalents presented immediately before the target word, but such priming does not last across an interval of several minutes (see Francis, 1999, for a review of this evidence).

Experiment 1 demonstrated that when the target words were encoded conceptually in a different language, some facilitation occurred, but it was less than that observed for conceptually encoded words in the same language. The basis of the between-language facilitation must be conceptual, because the translation equivalents do not share phonology or orthography. Therefore, a critical condition in the present study was a between-language condition with shallow encoding. If shallow encoding produces priming at the conceptual level, then it should transfer across languages. A within-language shallow condition was included as a manipulation check to make sure that the shallow encoding task actually produced priming within a language in our sample because of the inconsistent nature of the effect in the literature. A second manipulation check was a between-language deep condition to make sure that priming would transfer across languages, replicating the between-language conditions of Experiment 1.

A second goal for Experiment 2 was to clarify contributions of conceptual and non-conceptual priming in the standard within-language effect. To examine this issue, language and levels of processing manipulations were crossed. The strategy was to try to reduce priming relative to the standard same-language deep-encoding condition by changing the language to selectively eliminate non-conceptual priming and by using shallow processing to selectively reduce the amount of conceptual processing relative to the deep condition. The combination of these selective reductions is the different-language shallow-encoding condition. Thus, the main analysis is based on a 2 x 2 factorial design with language match and levels of processing as independent variables. A final condition of interest was one in which the same-language shallow and different-language deep conditions were performed on the same item on different trials. This condition allowed a test of whether the effects of same-language shallow encoding, thought to be non-conceptual, and different-language deep encoding, thought to be conceptual, would interact.

Method

Participants. Participants were 96 self-identified Spanish-English bilingual students (60 women, 36 men) recruited primarily from introductory psychology classes at the University of Texas at El Paso. The first language learned was reported as Spanish for 91%, English for 2%, both for 7%. The median age of second language acquisition was 6 years. According to self-ratings of relative proficiency, 52% were classified as English dominant and 48% were classified as Spanish dominant. Usage over the preceding month was reported as 45% English, 42% Spanish, 13% a mixture of English and Spanish, and less than 1% other languages; a pattern that corresponds to using the dominant language 54% and the non-dominant language 33% of the time. Seventeen additional students completed the experimental protocol but were excluded for poor performance on the translation test (see section on scoring) and replaced to preserve counterbalancing.

Apparatus. Stimuli were presented on the monitor of a Macintosh computer, and the sequence and timing of presentation were programmed using PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993). For the category generation task, participants said the names of category members aloud. These responses were recorded using a tape-recorder and transcribed for scoring.

Stimuli. From the Battig and Montague norms (1969), 21 categories were selected. The categories included the ten categories used in Experiment 1 and eleven additional categories, including *birds*, *fish*, *parts of a building*, *furniture*, *weapons, sports*, *kitchen utensils*, *substances for seasoning food*, *units of time*, *colors*, and *parts of speech*. Six exemplars were chosen from each category with the requirement that (1) they were not in the top 3 in the norms (2) they had relatively unambiguous meanings in both languages , and (3) the translations were not identical cognates. The categories and exemplars used are given in Appendix B. Encoding conditions were manipulated within categories as follows. Each of the 6 encoding conditions had 21 items, one from each category. The 6 items in each category were randomly assigned to 6 groups corresponding to the 6 experimental conditions. The assignment of groups to conditions was counterbalanced across participants using a Latin Square to control for specific item effects.

Design. A 6 (encoding condition) x 2 (test language) mixed design was used. Encoding conditions, manipulated within subjects, included same-language deep processing, same-language shallow processing, different-language deep processing, different-language shallow processing, a combined condition (same-language shallow and different-language deep), and a control condition. The control condition consisted of the one target item per category that was assigned to be not presented at study. Test language (English or Spanish) was manipulated between subjects, with half of participants randomly assigned to each language.

Procedure. Participants were tested individually by a bilingual experimenter in sessions lasting approximately 50 minutes. Half of the participants were randomly assigned to the English testing condition and half to the Spanish testing condition. The procedure consisted of an encoding phase and a category exemplar generation phase. The computerized encoding phase consisted of 4 blocks of trials, a shallow processing block in each language and a deep processing block in each language. The blocks for different-language shallow and same-language deep each had 21 trials. The blocks for same-language shallow and different-language deep each had 42 trials, with 21 of those items being presented in both blocks for the combined condition. The deep encoding task was pleasantness rating on a scale from 1 (very unpleasant) to 7 (very pleasant). The shallow encoding task was counting the number of vowels in each word. In both cases, participants responded by pressing the appropriate number key on the computer keyboard. Task and language orders were counterbalanced across participants.

In the test phase, participants performed the category exemplar generation task. The experimenter explained that we wanted to see how many examples they could think of for each category. Participants were given an example using a category not represented in the experimental stimuli (i.e., colors) to explain the task. The experimenter named each of the 21 experimental categories, one at a time in random order, and the participant was asked to generate exemplars aloud for one minute per category. The category generation task was recorded to allow later verification of experimenter notations. As in Experiment 1, upon completion of the category generation task, participants were given a translation test to enable identification of items that a participant did not know in both languages and items that were interpreted differently than expected. The final task was a questionnaire to collect language background information.

Results

Participants who translated less than 75% of target items as expected were replaced (as indicated in the participants section). After replacement, on average, 87.7% of items were translated as expected. As in Experiment 1, scores were based on the number of target responses given within the first six items generated at test. Percentages of target items generated were calculated by dividing the number of target items generated in a condition by the total number of target items in that condition, with an adjustment based on translation performance. Specifically, the generated items incorrectly translated were excluded from both the numerator and denominator, and non-generated items incorrectly translated were excluded from the denominator.

The percentages of target items generated in each condition are shown in Table 2. As in Experiment 1, inferential analyses were performed using a recoding of English and Spanish languages to each participant's dominant or nondominant language, as determined from the language background questionnaire responses. For new items, the overall target response rate was 22.6%, and this rate did not differ for the dominant and nondominant languages, $t(94) = .620$, $p = .537$. Priming scores were obtained by subtracting the response rate of the new-item condition from the response rate of each repeated-item condition and are illustrated in Figure 1. Priming was statistically reliable in every repeated condition (*p*s $< .01$) except for the different-language shallow encoding condition ($F < 1$).

A 2 (language match) x 2 (encoding task) x 2 (test language) mixed ANOVA was performed using the priming scores from all conditions except for the combined condition. Priming effects were larger when the language matched from encoding to test than when the languages mismatched, $F(1, 94) = 6.151$, $MSE = 114$, $p = .015$. Priming effects were larger following deep encoding than following shallow encoding, $F(1, 94) = 19.087$, $MSE = 118$, $p < .001$. The effects of language match and encoding task did not interact, $F < 1$. The main effect of test language was not significant, $F < 1$. The interaction of test language and language match approached significance, $F(1, 94) = 3.122$, $MSE = 114$, $p = .081$, in the direction of a smaller effect of language match when the test was in the nondominant language. Test language did not interact with encoding task, and there was no three-way interaction, *F*s < 1.

The mean priming score for items encoded in both the same-language shallow and different-language deep tasks was 5.9%. An interaction based on the presence or absence of the two component encoding tasks approached significance, $F(1, 94) = 3.484$, $MSE = 139$, $p = .065$, in the direction of subadditivity. In fact, the combined condition did not show significantly more priming than either of its component conditions, *p*s > .3.

Discussion

The between-language priming effects observed in Experiment 1 were replicated in Experiment 2, and they were again attenuated relative to within-language priming. The within-language levels-of-processing effect seen in previous studies was also replicated. A levels-of-processing effect was also observed in between-language conditions. In fact, shallow encoding did not produce reliable between-language priming, which suggests that shallow encoding does not produce conceptual priming. The lack of priming in the between-language shallow encoding condition together with the greater priming for within-language than for between-language priming in shallow-encoding conditions, $t(95) = 2.101$, $p = .038$, provides evidence against the conceptual artifact explanation of within-language priming obtained with shallow encoding in monolingual studies. Therefore, the priming seen in within-language shallow encoding conditions is non-conceptual in nature.

The manipulations of language and levels of processing did not interact; that is the effects of manipulations meant to reduce concept availability and reduce word form availability did not interact. This pattern is consistent with the idea that concept availability and word form availability make independent contributions to priming. However, another aspect of the data appears to be at odds with this characterization. The combined condition did not turn out as expected, because the second presentation, which was meant to affect availability of representations complementary to those affected by the first presentation, did not lead to a substantial increase in priming. In previous research using the category exemplar generation priming paradigm, increases in priming due to a second identical conceptual encoding exposure were variable (McDermott & Roediger, 1996; Weldon & Coyote, 1996). We cannot explain conclusively the reasons for the combined-condition results in the present experiment.

General Discussion

The most important result from this research is that, with deep encoding, the priming of category exemplar generation transferred between languages (Experiments 1 & 2). This result converges with a small number of other studies showing between-language conceptual priming (de la Riva López et al., 2010; Francis & Goldmann, 2010; Seger et al., 1999; Smith, 1991; Zeelenberg & Pecher, 2003). This study is the first to demonstrate, however, repetition priming between languages using a paradigm in which bias to generate previously presented items was the indicator of priming. The finding is consistent with the conclusion based on a range of memory phenomena that the episodic representations of word concepts are shared across languages (Francis, 1999, 2005), and it implies further that the core concepts are shared across languages in semantic memory.

A second important finding is that between-language priming was attenuated relative to within-language priming (Experiments 1 & 2). This shortfall implies that non-conceptual factors contribute to the standard effect. An alternative explanation is that the episodic representations of translation equivalent concepts in bilinguals are only partly shared. However, there is a large body of evidence suggesting that, at least for concrete nouns, conceptual representations overlap nearly completely across the two languages of a bilingual (for reviews, see Francis, 1999, 2005).

The third key finding is that shallow encoding led to priming within, but not between, languages (Experiment 2). The failure of shallow encoding to produce between-language priming indicates that the incidental conceptual processing that may occur during shallow encoding is insufficient to produce conceptually based priming. Therefore, the priming observed in the present and previous studies for shallow encoding under typical within-language conditions is based on non-conceptual factors. The fact that the procedure in the present study (and in most previous studies) is cross-modal, with visual presentation of words at encoding and spoken production of exemplars at test, also rules out the possibility that priming was based on low-level perceptual processing or articulation. Instead, priming elicited by shallow encoding must be based on language-specific word-form representations.

Because language-specific word-form representations exist at different levels, we considered whether each could be a possible locus of the priming observed in category exemplar generation following shallow encoding. At a level that is modality general (i.e., not tied specifically to the visual or auditory modality), there are syntactic word forms, known as lemmas, which are language-specific for non-cognate translation equivalents. In the visual modality, there are orthographic word forms, known as graphemes. In the auditory modality, there are phonological word forms, known as lexemes. In the present study and others in which category exemplar generation at test is spoken, it is unlikely that orthographic word forms would play a role. Similarly, with visual presentation of words at study, the only way that phonological word forms would play a role is if the visual words underwent sufficient phonological processing to elicit long-term priming. The most likely locus of priming in shallow encoding conditions therefore appears to be the amodal lemma level of representation.

Concluding Comments

The standard within-language category-exemplar priming effect is obtained under conditions of deep encoding with visual presentation at encoding and spoken production at test. During deep encoding, comprehension processes are required in order to access the concept. These processes would include perceptual processes, accessing the grapheme, accessing the lemma, and finally the concept and associated information relevant to the deep processing task. At test, production of exemplars includes conceptual processes needed to select an appropriate exemplar concept, retrieval of the lemma, retrieval of the lexeme, and articulation of the response. Because the standard task is cross modal, the representations that must be accessed at both encoding and test are the lemmas and the concepts. Although it is certainly possible that the visual word form spreads activation to the phonological form, such activation may not produce lasting facilitation. Therefore, the priming advantage for within-language conditions over between-language conditions is more likely due to access to the lemma, which is language-specific. Thus, category exemplar generation priming is based on two distinct mechanisms, increased availability of a language-general concept and increased availability of a language-specific but modality-general word form.

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Author Note

Wendy S. Francis and Norma Patricia Fernandez, Department of Psychology, University of Texas at El Paso; Robert A. Bjork, University of California, Los Angeles.

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Address correspondence to Dr. Wendy S. Francis, Department of Psychology, University of Texas at El Paso, 500 W. University Ave., El Paso, TX 79968 or e-mail wfrancis@utep.edu.

Footnotes

[1]Note, however, that the degree of conceptual overlap for other word types, such as verbs and abstract nouns, is a subject of some debate; e.g., van Hell & de Groot, 1998.)

[2]It should be noted that in word fragment completion, when individual words were presented with incidental encoding instructions, priming between languages was small to nonexistent in both the Smith (1991) study and another study that using that paradigm (Durgunoglu & Roediger, 1987). Other studies of word fragment completion priming between languages used intentional encoding instructions, thereby calling into question the implicit nature of the results.

[3]It is standard practice to limit either the number of exemplars generated or the number that can contribute to the score in this paradigm (e.g., Gabrieli et al., 1999; Graf et al., 1985; Light et al., 2000; Mulligan & Stone, 1999). The reasons for this practice are to avoid ceiling effects and to keep the number of chances to generate target exemplars constant across categories, and here across languages. A limit of six was chosen because that was the number of exemplars presented in each category at study in both experiments.

Table 1

Mean (SD) Percent Target Exemplar Generation Rates in Experiment 1 as a Function of Language Match and Test Language

Language Match Status	Exemplar Encoding History		
Encoding/Test Language	Presented	Not Presented	Priming[a]
Matched Languages			
Dominant/Dominant	27.3 (1.7)	15.1 (1.3)	12.2 (1.8)
Non-Dominant/Non-Dominant	33.5 (1.3)	21.1 (2.0)	12.4 (2.7)
Mismatched Languages			
Non-Dominant/Dominant	26.8 (1.9)	19.1 (1.6)	7.7 (2.8)
Dominant/Non-Dominant	26.6 (1.3)	20.9 (1.5)	5.8 (2.2)

[a]The measure of repetition priming is the difference in generation rates when exemplars were and were not presented during the encoding phase.

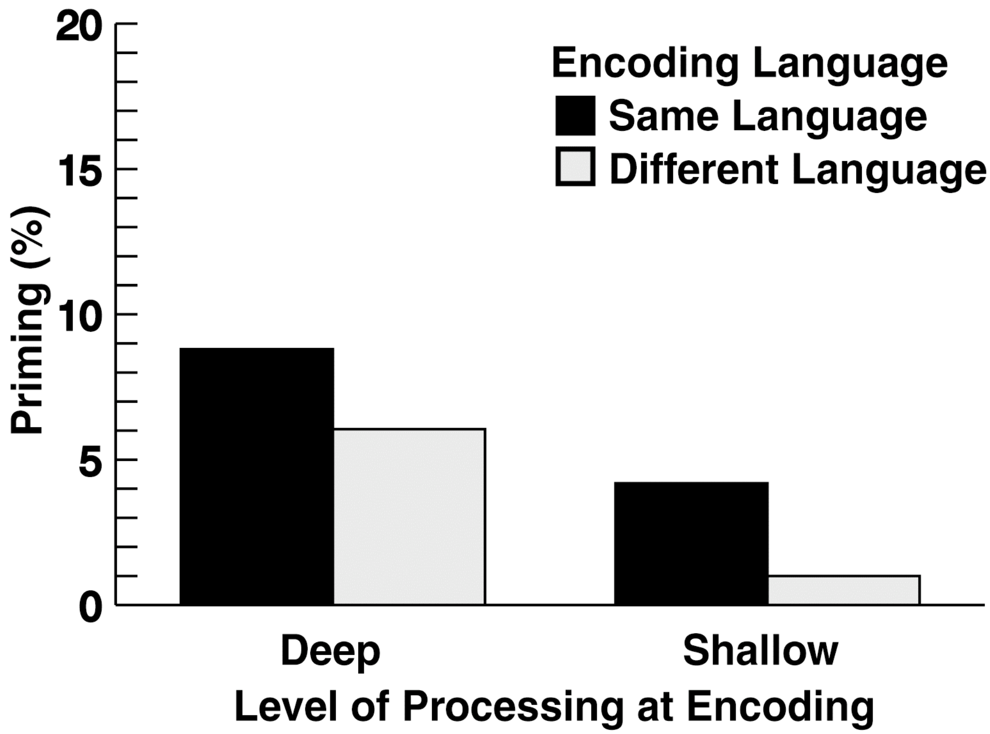
Table 2

Target Exemplar Generation Rates (%) in Experiment 2 as a Function of Encoding Condition and Language

	Language of Test				
Encoding Task	English (N = 48)	Spanish (N = 48)	L1 (N = 54)	L2 (N = 42)	Overall (N = 96)
Same-Language Deep Processing	31.1	31.5	30.8	32.0	31.3
Same-Language Shallow Processing	26.5	26.9	26.0	27.6	26.7
Different-Language Deep Processing	28.8	28.4	25.8	32.1	28.6
Different-Language Shallow Processing	22.9	24.1	21.6	26.0	23.5
Same-Language Shallow Processing & Different-Language Deep Processing	27.5	29.3	26.8	30.5	28.4
Not Presented	20.6	24.5	22.0	23.2	22.5

Figure Caption

Figure 1. Repetition priming in Experiment 2 as a function of encoding language and levels of processing.


20
15
10
5
0
Priming (%)
Encoding Language
Same Language
Different Language
Deep
Shallow
Level of Processing at Encoding