CUE SALIENCY EFFECTS IN SECOND LANGUAGE LEXICAL ACQUISITION AND PROCESSING

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The present study serves to demonstrate that learning new L2 vocabulary items in association with unique cues can have a rather dramatic effect on the way in which the newly learned items are processed. In the present study, participants learned new L2 vocabulary items in association with either familiar line drawings or uniquely colored pictures. It was found that new L2 words learned in association with the uniquely colored pictures were produced faster in a picture-naming task and that they were translated in a completely symmetrical fashion. L2 words learned in association with familiar line drawings, on the other hand, were translated in an asymmetrical fashion, such that they were produced much faster when the L1 was the language of production and more slowly when the L2 was the language of production. A model of bilingual lexical acquisition and processing (BILAPRO) was proposed to account for these findings in particular, as well as many of the major findings reported in the bilingual lexical processing literature.

How best to model the architecture of the bilingual lexicon has been a very popular area of investigation for several years now. Potter, So, Von Eckardt, and Feldman (1984) proposed and tested two possible models: the word association and the concept mediation models. The word association model assumes that the two lexicons are connected with form-level connections, such that L2 forms access meaning-based representations via the forms of L1 translation equivalents (see Figure 1 in Appendix). The concept mediation model assumes that each lexicon accesses directly a shared conceptual representation (see Figure 2 in Appendix).

Potter et al. (1984) pitted these two models against each other by comparing the performance of fluent bilinguals on picture naming and translation tasks. In order to name a picture, the object must be recognized, a conceptual representation that corresponds to the object needs to be activated, and then the lexical item for that concept can be retrieved and articulated. Potter et al. (1984) reasoned that if the word association model was correct, then L1-L2 translation should be much faster than naming pictures in L2. If, though, the concept mediation model was correct, then the time it took to name a picture in L2 should approximate the time it took to perform L1-L2 translation. The results confirmed the concept mediation hypothesis. This was true for both a highly proficient group as well as a group of less proficient L2 learners.

Studies by Chen and Leung (1989) as well as Kroll and Curley (1988) challenged the results of Potter et al. (1984). They argued that the less proficient group tested by Potter et al. (1984) was, in fact, quite advanced. In these studies, they found that the word association model accounted for the performance of L2 learners at very early stages of acquisition and that only the performance of more advanced L2 learners supported the predictions of the concept mediation model. In an attempt to account for this developmental shift, where models with fundamentally different architectures were required to characterize the early and latter stages of L2 lexical development, Kroll and Stewart (1994) proposed the revised hierarchical model (RHM). The RHM (see Figure 3) combines both the word association and concept mediation model into a developmental model of L2 lexical processing. Early on in development, the RHM assumes that the L2 relies on the L1 to access meaning. This results in strong asymmetric connections at both the lexical and conceptual levels. As a learner becomes more proficient, L2 forms become more capable of accessing meaning directly, which serves to diminish the degree of asymmetry over time, resulting in performance best characterized by the concept mediation model.

Kroll and her colleagues have shown the RHM to be very successful in accounting for a wide range of bilingual lexical processing data, but it too has had its challenges (see Figure 3 in Appendix). A central component of the RHM is the asymmetrical connections between the form lexicons and meaning-based representations for learners at the earliest stages of L2 lexical development: L1 forms enjoy form-meaning connections while L2 forms do not. This assumption has been called into question by vocabulary acquisition studies where learners after just one or two training sessions have exhibited conceptually mediated performance in their "L2." Altarriba and Mathis (1997) trained participants on a set of L2 words that they had had no prior exposure to and then tested them using an L2-L1 translation recognition task. They found that semantically related foils produced significantly slower reaction times compared to a condition with unrelated targets. This semantic interference effect was interpreted as an indication that the semantic properties of newly-learned L2 forms were involved directly in the translation task.

In a similar study, Finkbeiner and Nicol (2002) trained participants on a set of 32 L2 labels for familiar concepts from four different semantic categories (animals, kitchen utensils, furniture, and body parts). In one training condition, the target vocabulary was grouped according to semantic category; in the other training condition, participants learned the same labels in a random order. They found that participants who learned labels grouped into semantic sets performed both L1-L2 and L2-L1 translation production tasks significantly more slowly than participants who learned the labels in no apparent ordering. They also found that participants who had learned words in random order translated words grouped in semantic sets slower than they did the same words in no special order. Taken together, these results indicate that semantic specifications of newly learned L2 words are involved during memory encoding as well as during memory retrieval. These results, as well as those of Altarriba and Mathis (1997), present very strong evidence that after just one or two training sessions, learners are able to process the semantic properties of their new L2 words in speeded online tasks.

The ability of the RHM to account for the patterns of behavior exhibited by more fluent bilinguals has also been challenged in studies with bilinguals at varying degrees of proficiency. The RHM assumes that because L2 relied on L1 to access meaning initially, there are strong residual L2-L1 form-level connections. Even in highly proficient bilinguals, L2 words will still strongly activate their respective L1 translation equivalents, and only weakly activate meaning-based representations (Kroll, Michael & Sankaranarayanan, 1998). L1 words, on the other hand, will weakly (if at all) activate their L2 translation equivalents through form-level connections, but will strongly activate meanings. This is how Kroll and Stewart (1994) explained the presence of semantic interference effects in the L1-L2 translation direction and the absence of the same effects in L2-L1 translation. Unfortunately for the RHM, the pattern of results that Kroll and Stewart (1994) reported has not been replicated. La Heij, Hooglander, Kerling, and van der Velden (1996) found semantic interference effects in both translation directions. Contrary to the predictions of the RHM, though, the L2-L1 translation direction produced the effect with the greatest magnitude. The RHM would allow that for highly proficient bilinguals a semantic interference effect could be observed in both translation directions, but because of the strong residual asymmetries, it would never predict a larger semantic effect in the L2-L1 direction. In another study, de Groot and Poot (1997) found that nonfluent bilinguals at a very low level of proficiency were sensitive to conceptual factors (imageability) of to-be-translated words in both translation directions. More recently, Vigliocco, Lauer, Damion and Levelt (in press), using essentially the same experimental paradigm and subject pool as Kroll and Stewart (1994), found semantic category effects in the L2-L1 translation direction, where Kroll and Stewart (1994) reported none. And as mentioned above, Finkbeiner and Nicol (2002) found semantic category effects in both translation directions with participants who had only learned a limited set of L2 items for the purposes of the experiment.

An increasing amount of evidence from a wide variety of studies suggests that the assumptions of the RHM do not square well with the behavior of bilinguals. I am inclined to think that this is due to the way that the RHM has attempted to account for the developmental shift that occurs as one becomes more fluent in a second language. The RHM accounts for increased proficiency in L2 lexical processing by positing the establishment and strengthening of L2 form-meaning connections after one has already reached a certain level of proficieny. Jiang (2000) similarly accounts for L2 development by positing an initial stage where L2-L1 form-level connections subserve L2 lexical processing, followed later by the establishment and then strengthening of L2 form-meaning connections. From a strictly theoretical perspective, one must ask how this transition could ever occur. By the time that a bilingual reaches sufficient proficiency to trigger the establishment of direct L2 form-meaning connections, L2-L1 form-level connections would prima facie be strong and fast enough to effectively subserve L2 lexical processing. It is unclear in models like the RHM what the motivation would be for creating additional connections instead of just continuing to increase the speed and accuracy of the existing connections.

There is, nevertheless, clear evidence for a developmental shift in bilingual lexical processing as one becomes more proficient in a second language, and any model of bilingual lexical processing has to be able to account for this development. The nature of this development, though, as reviewed above, does not appear to be a qualitative one, where form-level processing transmutes into meaning-level processing. Rather, the strongest evidence for a developmental progression in L2 lexical processing comes from studies investigating the ability to suppress inter-language interference. Not surprisingly, there is an asymmetry between how much L1 versus L2 interference is created: the L1 interferes much more readily with L2 processing than the L2 does with L1 processing. Hence, it is much more difficult to suppress L1 interference than it is to suppress L2 interference. As one becomes more proficient in an L2, there is a clear increase in ability to suppress L1 interference. Evidence for this asymmetry comes from a variety of studies, including those which have investigated inter-language Stroop effects (Chen & Ho, 1986; Maegiste, 1984; Tzelgov, Henik & Leiser, 1990), cross-language negative priming (Fox, 1996; Neumann, McCloskey & Felio, 1999) and language switching (Meuter & Allport, 1999). It would appear, then, that a more parsimonious account of bilingual lexical processing would employ a single target architecture that is capable of capturing the developmental progression with quantitative changes to the system. In what follows I will lay out such a model, but first, let us consider in detail some of the central tenets of current models of lexical representation and processing.

Most contemporary theories of lexical representation and processing generally agree that lexical retrieval during speech production proceeds in a two-stage process: (1) the retrieval of meaning-based information and (2) the retrieval of form-based information (Dell, 1986; Garrett, 1975; Levelt, 1989; Levelt, Roelofs & Meyer, 1999). There is a large body of work that provides support for this form-meaning distinction, including speech error data (Garrett, 1975, 1988; Levelt, 1989; Levelt, Roelofs & Meyer, 1999) and reaction time experiments using the picture-word interference paradigm (Schriefers, Meyer & Levelt, 1990). The two-stage model is not without controversy in the field, but what controversy there is arises mainly over how the flow of information is regulated in the system, not its basic architecture.

For the present purposes, we are only interested in the basic architecture of the two-stage model. Figure 4 (see Appendix) presents an adaptation of one such model: the WEAVER++ model taken from Levelt et al. (1999). In WEAVER++, the phonological and orthographic specifications of a word are represented at the form stratum and comprise what is known as a lexeme. The semantic and syntactic specifications of a word comprise what is referred to as a lemma and are represented at the lemma stratum. Lemmas serve as intermediate representations between lexical concepts and word form representations, such that word form retrieval in speech production is dependent upon lemma selection. A lexical concept is activated on the basis of the speaker's intentions. Activation from the lexical concept spreads to other concepts semantically related to the target and to the corresponding abstract lexical representations (i.e. lemmas) via two-way connections. Lemma selection is a statistical mechanism, with the highest activated lemma being selected. Upon lemma selection, the syntactic properties of the word become available, followed by the activation of the word's form-level properties.

An important aspect of the language production system is its automaticity. In normal speech, we retrieve two to three words per second from a lexicon of tens of thousands of entries. Surprisingly, this high-speed process is almost completely error free. Levelt et al. (1999) report that errors of lexical selection occur approximately once every one thousand times. The speed and accuracy with which the production system works suggest strongly of processes that are highly practiced and run off automatically. It is the automaticity of the L1 language production system that poses the greatest amount of difficulty when learning L2 vocabulary.

Figure 5 (see Appendix) presents BILAPRO (Bilingual Lexical Acquisition and Processing), an adaptation of WEAVER++ designed to provide a parsimonious account of bilingual lexical development and processing. A central tenet of BILAPRO is the assumption that translation equivalent forms are conceptually mediated – there are no form-level connections. Mediation occurs at the level of the lexical concept. Lexical concepts are abstract semantic nodes that comprise only those concepts which are lexically expressible in a particular language. Because lexical concepts are abstract semantic representations that do not contain any information about the word's form or syntax, they may subserve both L1 and L2 lexical processing (it is certainly the case, though, that some lexical concepts are only expressed in one language or the other).

Each form is connected to its own language-specific lemma. A lemma is an abstract lexical representation which, once selected, serves to activate its syntactic properties (e.g. gender and grammatical class). Because words with the same meaning across languages are frequently expressed in syntactically distinct ways, BILAPRO assumes that lemmas are language specific. An example of this is seen in the different argument structures for the word "write" in English versus Chinese. In Chinese, *xie* (write) can take *gong ke* (homework) as an argument (e.g. "I need to write my homework"). This is not possible in English, despite the two words (*xie* and "write") sharing the same meaning across languages.

Architecturally, BILAPRO assumes that the connections between levels of representation in the bilingual lexicon are symmetrical at all levels of proficiency. Functionally, BILAPRO assumes that L2 processing is subject to L1 interference while L1 processing is not subject to L2 interference. That is, there is an "interference asymmetry." This is especially true at low levels of proficiency. "Proficiency," according to this model, is, among other things, an increased ability to resist L1 interference during L2 processing, which is reflected in faster memory encoding and memory retrieval times. BILAPRO uses dashed lines to show susceptibility to interference, which is a quantitative property that is reduced with increased proficiency. A final assumption of BILAPRO is that L2 lexical processing is subject to controlled processes while L1 lexical processing is subject to automatic processes. This final assumption is motivated by findings from studies which have used the cross-language masked priming procedure, as well as by our understanding of the L2 lexical acquisition process itself.

Learning new L2 vocabulary consists of establishing form-meaning connections between newly learned forms and already-established meaning representations. Given how tightly integrated the different levels of representation within the L1 lexical system are, it is not surprising that trying to incorporate new, competing information into the system is met with some resistance. Take for example a simple word-learning scenario where English speakers are learning Chinese words. A teacher presents her students with a picture of an apple and says, "*ping guo*." Picture recognition on the learner's part serves to activate the appropriate concept, and then, through spreading activation, semantically related concepts and each of their corresponding L1 lemmas are automatically activated. The learner then hears the target vocabulary item, *ping guo*, which she must associate with the picture. The establishment of this new L2 form-meaning association is unavoidably made in the presence of activated and formidable competitors: L1 lemmas. This is very different from the conditions under which L1 vocabulary items are learned. A child arguably learns both forms and meanings in parallel, or, at least, the formal specifications for meanings without associated forms. That is, the child does not need to suppress interference in order to establish an association between forms and meanings, which allows lexical acquisition and processing to proceed effortlessly and automatically for the most part. Adult L2 learners, on the other hand, *do* need to suppress interference in order to create new L2 lexical representations and connections. L2 learners must control L1 interference both to establish L2 form-meaning connections, as well as to engage L2 lexical processing once the connection has been created. This is not to say that L2 lexical processing must always be slow and effortful. On the contrary, with practice and sufficient control, L2 lexical processing may become phenomenologically indistinguishable from L1 lexical processing.

BILAPRO assumes that the strength of new L2 lexical representations, whether those be at the lemma or lexeme level, are contingent upon the level of activation of L1 competitors at the time the new representation is established. The greater the activation of L1 competitors, the more susceptible the new L2 representation will be to L1 interference during L2 lexical processing. This assumption is captured in Equation 1 (see Appendix), where the strength of a representation (*s*) is a set value (X) divided by the sum of the activation levels of L1 competitors during encoding.

The recent study by Finkbeiner and Nicol (2002) reviewed above provided substantial empirical support for this assumption. In that study, the researchers manipulated the level of activation of competing L1 lemmas by grouping target items according to semantic category in the Related Learning condition. They reasoned that just as semantic category effects are observed in picture naming experiments (items grouped according to semantic category are named slower due to increased activation of closely related competitors [Damian, Vigliocco & Levelt, 2001]), so too should category effects be observed in vocabulary learning experiments. They found that participants who learned L2 labels for items in semantically grouped sets performed significantly more slowly in translation production tasks than participants who learned the same labels in an unrelated learning condition. Finkbeiner and Nicol (2002) argued that repetitive activation of concepts and L1 lemmas within the same category led to a greater amount of interference in the Related learning condition compared to the Unrelated Learning condition, resulting in weaker L2 lexical representations just as Equation 1 would predict.

The following set of experiments was designed to elicit the opposite effect. According to the predictions of BILAPRO, reducing interference from L1 competitors during the establishment of new L2 lexical entries leads to stronger lexical representations. A further assumption of the model is that the source of the interference occurs at two levels of representation: the lemma and lexeme levels. That being the case, we reasoned that if we could make use of pictorial stimuli that delayed L1 lexical retrieval during L2 lexical learning, we would have effectively reduced the amount of interference. It is well established in the picture recognition literature that rotated pictures are recognized slower than upright pictures (Shepard & Metzler, 1971). It is also well known that uniquely colored pictures (e.g. blue apple) are named slower than black and white line drawings (Johnson, 1995).

EXPERIMENT 1 – PICTURE-WORD MATCHING

The first experiment was done in an effort to identify the best experimental items to use as stimuli in the vocabulary learning experiment. Participants performed a picture-word matching task with two different sets of stimuli: rotated black and white drawings, and uniquely colored pictures. The set of items that led to the slowest matching times were chosen to be used as training stimuli in a subsequent vocabulary learning experiment.

Method

Participants

Forty-three undergraduates at the University of Arizona participated for course credit. All of the participants were native speakers of English.

Materials

Ninety different pictures were adopted from the Snodgrass and Vanderwart (1980) set of items. Forty-five items with an inherent canonical orientation were selected and used as stimuli in the “rotated pictures” condition. For example, pictures of a chair and a giraffe were selected because they have an inherent canonical orientation. Conversely, a picture of a lemon could not be used because it does not have a canonical orientation and looks familiar at any degree of rotation. Five of the selected items were designated as practice items, with the remaining forty items used as experimental items. In the experimental condition, each item consisted of a rotated picture (at least 90 degrees) paired with a label that always appeared in the center of the screen, directly below the picture. Half of the pictures were paired with their correct labels (e.g. a picture of an airplane appeared with its correct label, "airplane") and half were not. In the control condition, each item consisted of a canonically orientated picture paired with a label that also always appeared directly below the picture.

The remaining 45 items were used in the "unique colors" condition. Five of the items were practice items. In the experimental condition, pictures were uniquely colored and paired with either a correct label (half of the time) or an incorrect label. In the control condition, the same pictures were used, but the pictures were not colored.

Design

The design of the experiment was entirely within-subjects. For each participant, half of the items were experimental and half were control. Two counterbalanced lists were constructed such that all items appeared equally across the experiment in both experimental and control conditions. For example, the items that appeared in a canonical orientation on List A appeared in a noncanonical orientation on List B, and the items that appeared in a noncanonical orientation on List A appeared in a canonical orientation on List B. Participants were randomly assigned to each list.

Procedure

The procedure was straightforward. Participants were instructed to press a "yes" button if the picture and word matched (e.g. when a picture of a chair appeared with the word "chair"), and a "no" button if they did not. Both the rotated pictures and the colored pictures were blocked and presented separately from each other (the order that the blocks appeared in was counterbalanced across subjects). The first 5 items of each block were practice items and reaction times were not recorded for them.

Results

All incorrect responses, as well as response times longer than 3000 ms or shorter than 200 ms, were counted as errors and excluded from analysis (5%).

As seen in Table 1 (see Appendix), experimental items were matched with their labels approximately 65 ms slower than control items were. It is also the case that picture-label matching times were slower overall in the rotated picture test than they were in the colored picture test. The difference of interest, though, is between control and experimental conditions in each test. Colored pictures were matched with their labels 54 ms slower than the control pictures were. This difference was found to be significant in both participant (F_1) and item (F_2) analyses: ($F_1(1, 42) = 23.99$, $p < 0.0001$; $F_2(1, 19) = 5.89$, $p = 0.025$). Rotated pictures were matched with their labels 76 ms slower than the canonically oriented control pictures. Although this difference is larger numerically, it did not reach significance in the items analysis: ($F_1(1, 42) = 21.99$, $p < 0.001$; $F_2(1, 19) = 2.84$, $p > 0.05$). Statistically speaking, then, the difference between experimental and control items in the color test was reliable while the difference observed in the rotated-pictures test was not.

Discussion

The purpose of Experiment 1 was to find for which of the two types of manipulation (colored pictures vs. rotated pictures) the participants were reliably slower to respond to the experimental items than they were to the control items. In order to perform the picture-label matching task, all one must do is check to see if corresponding concepts and lemmas are simultaneously activated – presumably no lemma selection is necessary. Because the presentation of the label served to activate its lemma directly (Levelt et al., 1999; Roelofs, 2000), the observed latency was likely due either to a delay in picture recognition or concept retrieval. In any event, it is clear that concepts (and corresponding lemmas) are activated more slowly upon viewing a colored picture (from the present experimental set) than upon viewing a black and white line drawing. A central prediction of BILAPRO is that reduced interference from the lemmas of L1 translation equivalents during L2 lexical learning will lead to L2 representations that are more resistant to interference during L2 processing. The results of Experiment 1 suggest that the colored pictures will work well in terms of delaying activation of L1 lemmas. This delay, according to BILAPRO, should lead to stronger L2 representations. We tested this hypothesis in Experiment 2.

EXPERIMENT 2 – VOCABULARY LEARNING

Experiment 2 consisted of participants coming into the lab two separate times. Each session consisted of a training and testing component. For the testing component, we used a picture-naming task, a translation task, and a word-naming task to test how well participants had learned the new vocabulary. Each participant performed only two of the tasks. All of the participants performed the translation task while half of them did the picture-naming task, and half did the word-naming task. The results for each task will be reported separately.

Method

Participants

Forty undergraduates at the University of Arizona participated for course credit. Twenty of the participants performed the picture-naming and translation tasks, while 20 performed the word-naming and translation tasks. All of the participants were native speakers of English.

Materials

Twenty novel words were created and each was paired with a picture of a familiar concept. The new L2 words obeyed English phonotactic constraints in order to reduce variance caused by differences between participants' phonological short term memory capabilities (Ellis & Beaton, 1993; Gathercole & Baddeley, 1989; Service, 1992). For variety, half of the words on each list were one syllable in length (e.g., *birk*, *plap*, *floop*), while the other half were two syllables in length (e.g., *walloon*, *dopal*, *fonteen*). The pictures used were adopted from Snodgrass and Vanderwart (1980). Control items were the original Snodgrass and Vanderwart black and white line drawings. Experimental items were the same drawings with colors and designs added to them in an effort to make them unique.[1]

Design

The design of the experiment was entirely within-subjects. Two training lists were constructed such that each participant learned 10 L2 words in association with control pictures and 10 L2 words in association with colored pictures. The items were counterbalanced so that all pictures appeared as both control and colored pictures across the experiment. For each participant items were presented consistently as either control or colored items during the entirety of the experiment.

Procedure

Individuals participated on two separate days within a 5-day span. The first day was a training session. No data were recorded for analysis from the training session. The second time that participants came to the lab was the testing session. Both the training and testing sessions were identical and consisted of: (1) vocabulary training (participants were told that they were learning a new "alien" language), followed by (2) a recognition task, then (3) either a picture naming task or a word-naming task, and finally (4) a translation task. At the beginning of the first session, participants were shown the pictures used in the experiment on flashcards and asked to name them in English. After they had named each of the pictures correctly, they were asked to write the names of the items down before beginning their training. This was done to ensure name agreement on all of the items because, although L1 labels were never present during training, the translation task did use L1 labels. Participants were then taken into a sound-resistant computer booth where they did their training and testing. All stimuli were displayed on Windows-based computers using the DMDX system developed by J. C. Forster and K. I. Forster at the University of Arizona.

During vocabulary training, participants first heard a recording of the L2 word over headphones, then saw the L2 word and its corresponding picture for 500ms on the computer monitor, and then heard a second recording of the L2 word. Participants were asked to repeat the L2 word twice into the microphone placed in front of them for recording purposes. All 20 items were blocked and presented randomly within blocks four separate times for a total of 80 training trials.

The vocabulary training was followed by a recognition task, which consisted of the presentation of a picture followed by one of the L2 labels. The 20 picture-label pairs were presented in random order four separate times: two trials were correct (the picture was paired with its new label) and two trials were incorrect (the picture was paired with the wrong label). Participants were instructed to press a "yes" button if the picture and L2 word matched and a "no" button if they did not. Participants were given feedback for each item, including whether they were correct or not, as well as their reaction times.[2] After the recognition task, participants were given either the picture-naming task or the word-naming task.

Picture Naming

Twenty of the participants performed the picture-naming task in addition to the translation task. In this task, pictures were presented on the computer monitor to participants. Each trial began with a fixation cross at the center of the monitor screen for one second, followed immediately by the picture to be named for 500 ms. Participants were instructed to speak the L2 name of the picture into the microphone as quickly as possible. Their vocal response triggered a voice key, which stopped the computer's timer. Latencies were measured from the time the picture appeared on the monitor until the voice key was triggered. All responses were recorded on tape so that they could be checked for errors. All 20 pictures were blocked and presented randomly within blocks four separate times for a total of 80 trials.

Picture Naming Results

As is typical in learning experiments of this type, several participants failed to reach the preset learning criterion (c.f. Altarriba & Mathis, 1997; Finkbeiner & Nicol, 2002). Data from 6 participants were excluded from analysis because their mean error rates exceeded the predetermined criterion of 20%. For the remaining 14 participants, all incorrect responses, including fluency errors like stutterings and "um's", as well as response times longer than 3000 ms or shorter than 200 ms, were counted as errors and excluded from analysis (7.1%). The average error rate was 3% in both the control and the salient conditions.

Figure 6 (see Appendix) displays a clear naming advantage for words learned in association with uniquely colored pictures. Separate analyses of variance (ANOVA) with participants (F_1) and items (F_2) as random variables reveal that salient pictures (M = 889.94) were named significantly faster than control pictures (M = 944.84): ($F_1(1, 13) = 5.93$, $p = 0.03$; $F_2(1, 79) = 6.84$, $p = 0.01$). Thus, the experimental manipulation of colored pictures exerted a facilitation effect on picture naming times.

Discussion

In order to name a picture, one must first recognize the picture, retrieve the appropriate conceptual representation for that picture (which in turn serves to automatically activate semantically related concepts and each of their corresponding lemmas), select the appropriate word (lemma) for that concept (which serves to activate the appropriate syntactic and form-level properties of the word), and then articulate the word. The locus of facilitation observed in the present picture-naming experiment could, theoretically, have been at any one of these stages. It may have been that uniquely colored pictures led to faster concept retrieval times, lemma selection times, or word-form encoding times. Given the results of Experiment 1, it is hard to imagine how the experimental items could have led to faster concept retrieval times. In fact, the purpose of Experiment 1 was to find those experimental items which best *inhibited* concept retrieval. But it may have been the case that the experimental items were so hard to recognize and retrieve a concept for that participants created new concepts for the pictures during the training sessions. This is a possibility that we will address in our discussion of the translation task. It may have also been the case that learning new words in association with uniquely colored items versus control items led to faster word-form encoding times in the production task. This seems unlikely, but we tested this possibility with the word-naming task.

Word Naming

Sixteen of the participants performed the word-naming task in addition to the translation task. This task was essentially the same as the picture-naming task, the only difference being that participants named words instead of pictures. Participants named each of the 20 items four separate times: twice in English and twice in 'Alien.' All 20 items were blocked and presented randomly within blocks; and the order of target languages was counterbalanced across participants. Each trial began with a fixation cross at the center of the monitor screen for one second, followed immediately by the word to be named for 500 ms. Participants were instructed to name the word as quickly as possible. Again, latencies were measured from the time the word appeared on the monitor until the voice key was triggered. All responses were recorded on tape so that they could be checked for errors.

Word Naming Results

All incorrect responses, including fluency errors like stutterings and "um's", as well as response times longer than 2000 ms or shorter than 200 ms, were counted as errors and excluded from analysis (less than 1%).

Figure 7 (see Appendix) displays a clear time advantage for words named in participants' L1 versus their "L2," as would be expected. Separate analyses of variance (ANOVA) with participants (F_1) and items (F_2) as random variables reveal a main effect for language of production, with English words (M = 500.59) being named significantly faster than "Alien" words (M = 530.63): ($F_1(1, 15) = 6.41$, $p = 0.023$; $F_2(1, 78) = 23.05$, $p < 0.001$).

Crucially, though, there was no interaction with learning condition ($F_1(1, 15) < 1$; $F_2(1, 78) < 1$), suggesting that learning words in association with salient versus control pictures has no bearing on how those words are recognized or articulated. This suggests that the locus of the saliency effect observed in the picture-naming experiment was not at the word-form encoding level, but rather at a more abstract level of representation.

Discussion

Participants named English words faster than newly learned 'Alien' words, which was not surprising. Of more interest in this experiment was whether or not the saliency effect observed in the picture-naming experiment could be elicited with a word-naming task. Because word naming arguably takes place without activating the conceptual or semantic properties of the to-be-named word (Damian, Vigliocco & Levelt, 2001), any indication of the facilitation effect with this task would serve to isolate the lexeme level of representation as a contributor in this effect. No effect was observed. Alien words were named equally as fast, regardless of what type of picture they had been associated with during learning, suggesting that the facilitation effect observed in picture naming was not due to lexeme-level properties of the target words.

Having eliminated the lexeme level of representation as a contributor to the facilitation effect in the picture-naming task, we can be fairly certain that the locus of the effect was at the lemma or conceptual level. To test this further, we used a translation task.

L1-L2 and L2-L1 Translation

A central tenet of BILAPRO is that the amount of L1 interference present during the encoding of L2 lexical entries into memory will affect both learning and subsequent L2 processing – the less L1 interference during learning, the stronger the L2 representation (see Equation 1), where "strength" means ability to resist L1 interference. According to the assumptions of BILAPRO, translation latencies should be symmetrical as long as L1 interference can be suppressed during lemma selection and word-form encoding. If L1 interference does occur, then it will adversely affect L2 production, resulting in slower L1-L2 translation times. Because L1 production processes are not susceptible to L2 interference, L2-L1 translation times are relatively unaffected by the strength of L2 lexical representations. Following from this, we would predict symmetrical translation latencies for items learned in association with colored pictures and asymmetrical translation latencies for items learned in association with control pictures.

Forty participants performed the translation task. In this task, participants were shown a row of hash marks ("#######") for one second (for orienting purposes only) followed by the word to be translated. For example, in the L1 to L2 blocks, an English word appeared and participants were asked to speak the "L2" translation equivalent into the microphone as quickly as possible. Their vocal response triggered a voice key, stopping the computer's timer. Latencies were measured from the time the word to be translated was presented until the voice key was triggered. All responses were recorded on tape so that they could be checked for errors. All incorrect responses as well as fluency errors like stutterings and “um’s” were counted as errors. In order to control for any differences that may arise due to order of translation direction, translation direction was counterbalanced such that half of the participants performed forward translation (L1 to L2) first, while the other half performed backward translation (L2 to L1) first.

Translation Results

Data from 10 participants were excluded from analysis because their mean error rates exceeded the predetermined criterion of 20%. For the remaining 30 participants, all incorrect responses, including fluency errors like stutterings and “um’s”, as well as response times longer than 3000 ms or shorter than 200 ms, were counted as errors and excluded from analysis (8.1%). The average error rate was 7.8% for items learned in association with control pictures and 8.9% for items learned in association with colored pictures.

Figure 8 (see Appendix) presents a pattern of results completely compatible with our predictions. Words learned in association with colored pictures revealed an entirely symmetrical translation pattern between L1-L2 and L2-L1 translation directions. Words learned in association with control pictures, on the other hand, were produced much faster when L1 was the language of production than when L2 was the language of production. This suggests strongly that L2 words learned in association with control pictures were weaker representations, not capable of resisting L1 interference during production.

Separate analyses of variance (ANOVA) with participants (F_1) and items (F_2) as random variables reveal no main effects of learning condition ($F_1(1, 29) = 2.08$, $p > 0.05$; $F_2(1, 78) = 2.79$, $p > 0.05$) or translation direction ($F_1(1, 29) = 3.45$, $p > 0.05$; $F_2(1, 78) = 1.70$, $p > 0.05$), but the interaction between the two was significant ($F_1(1, 29) = 7.29$, $p = 0.01$; $F_2(1, 78) = 7.83$, $p = 0.006$). Planned comparisons show that the translation latencies for items learned in association with control pictures were significantly slower when L2 was the language of production ($F_1(1, 29) = 8.69$, $p = 0.006$; $F_2(1, 78) = 6.36$, $p = 0.014$).

Discussion

This pattern of results is very interesting and, without taking cross-language interference into account, very difficult to explain. Items learned in association with control pictures exhibit the translation asymmetry predicted by the revised hierarchical model (see Figure 3). Yet the translation results for other items learned by the same participants in the same experiment support the assumptions of the concept mediation model (see Figure 2). Because accounting for this finding by positing that two different bilingual lexicon architectures were constructed in participants’ minds during a single learning session is somewhat less than parsimonious, I find an interference asymmetry account much more plausible. BILAPRO assumes that because familiar black and white line drawings do not cause a slowdown in picture recognition, concept retrieval, or L1 lemma activation, items learned in association with these pictures are learned in the presence of active L1 lemmas. This results in a weak representation (the strength of which is captured by Equation 1) that is susceptible to L1 interference during tasks which engage L2 lexical processing of that item. When L2 is the language of production, selection of the appropriate L2 lemma-level specifications will be hindered because their activation serves to activate and engage the L1 production system – the result of having been learned in the presence of active L1 lemmas. And suppressing the L1 production system so as to allow L2 production to proceed is very difficult and time consuming. This is, according to the assumptions of BILAPRO, the basis of the translation asymmetry for the control items.

The experimental items, on the other hand, were learned in association with uniquely colored pictures. These pictures caused a slowdown in both concept retrieval and automatic activation of L1 lemmas. As a result, L2 words learned in association with these pictures were learned with much less interference from L1 lemmas. Less interference during encoding led to stronger representations, which were not as susceptible to L1 interference during L2 lexical processing of these entries. Because these items were not learned in the presence of active L1 competitors, the L1 production system is not engaged when these L2 entries are activated and selected for the purposes of L2 production. This is why, according to the assumptions of BILAPRO, items learned in association with uniquely colored pictures were translated symmetrically.

The translation task also served to address a concern raised by the results of the picture-naming task. It was found in the picture-naming task that participants were able to name uniquely colored pictures faster than the control pictures. It was argued that the L2 lexical representations for words learned in association with uniquely colored pictures were less susceptible to L1 interference, which allowed faster lemma selection times during picture naming. It might have been the case, though, that the colored pictures were so unique that participants created new concepts just for those pictures during the vocabulary learning sessions. This certainly would have led to faster picture-naming times. These new concepts would be very weakly integrated (if at all) into the conceptual network, resulting in very little interference from competitors and very fast production times for L2 lexical entries associated with these isolated concepts. We know, though, that this is not a viable explanation given the results of the translation task. An isolated concept that is not integrated into the conceptual network would not be able to subserve cross-language translation, yet the symmetrical translation latencies suggest very strongly of conceptual mediation.

CONCLUSION

The present set of experiments has served to demonstrate that associating target vocabulary with unique cues during L2 lexical acquisition can have a rather dramatic effect on the way in which the newly learned items are processed. In the present study, participants learned new L2 vocabulary items in association with either familiar line drawings or uniquely colored pictures. It was found that new L2 words learned in association with the uniquely colored pictures were produced faster in a picture naming task and that they were translated in a completely symmetrical fashion. L2 words learned in association with familiar line drawings, on the other hand, were translated in an asymmetrical fashion, such that they were produced much faster when L1 was the language of production and more slowly when L2 was the language of production. A model of bilingual lexical acquisition and processing (BILAPRO) was proposed to account for these findings in particular, as well as many of the major findings reported in the bilingual lexical processing literature. A fundamental assumption of BILAPRO is that L2 lexical entries encoded into memory in the presence of active L1 competitors will be susceptible to a greater amount of interference whenever L2 lexical processing engages these entries. The set of experiments reported here was designed to demonstrate not only that learning new L2 vocabulary in association with unique cues facilitates learning and subsequent processing, but, more importantly, to provide the basis for a plausible explanation for this effect.

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ENDNOTES

[1]A sample of these items can be seen on the Internet at http://www.u.arizona.edu/~msf/example-of-items.pdf.

[2]Note that the recognition task was not designed to elicit analyzable data in the sense that the method of display (the picture appeared for 500 ms, followed by one of the L2 words) could encourage some subjects to guess what label would follow (which would facilitate responses half the time and inhibit responses the other half of the time).

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APPENDIX

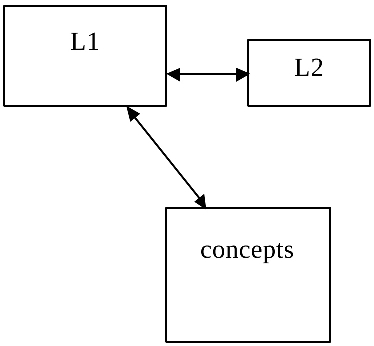

Figure 1 Word Association Model

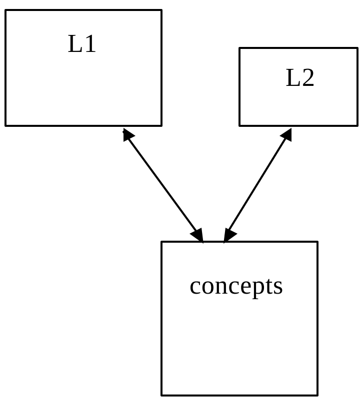

Figure 2 Concept Mediation Model

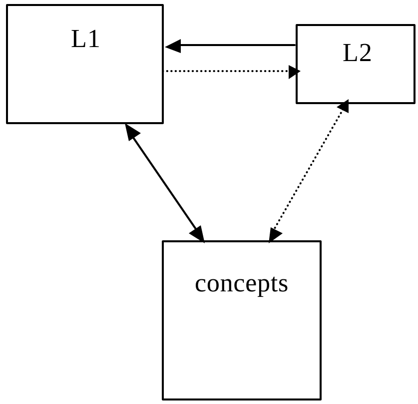

Figure 3 Revised Hierarchical Model

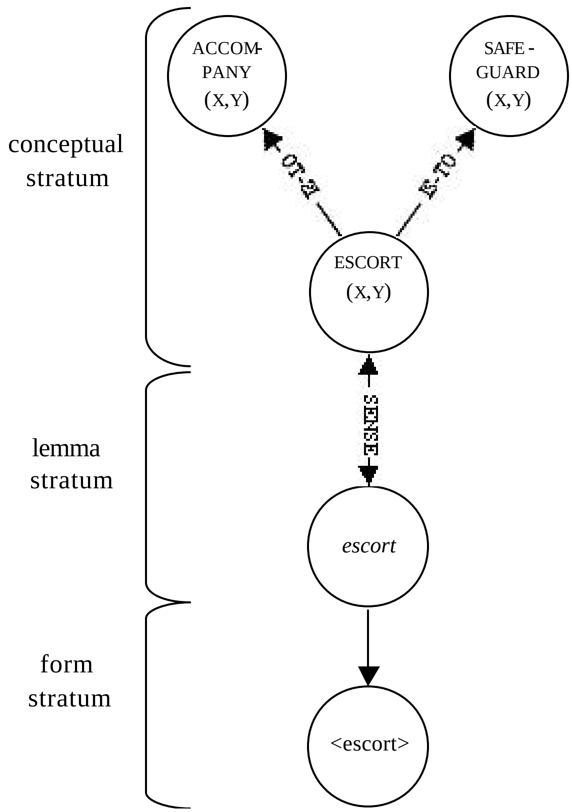

Figure 4: WEAVER++ adapted from Levelt et al. (1999)

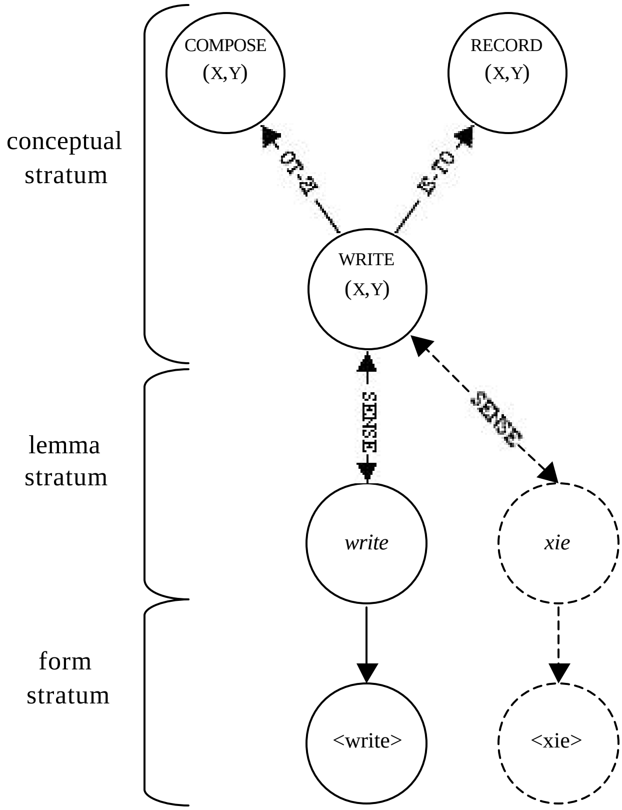

Figure 5: BILAPRO, An adaptation of WEAVER++

$$s = \frac{X}{\sum_{i=1}^{n} a_i}$$

Equation 1: Strength of New L2 Form-Meaning Connection

Testing Condition			
Type of Test	control condition	experimental condition	*mean*
colored picture test	760.38	814.04	787.21
rotated picture test	847.36	923.71	885.53
mean	803.87	868.87	

Table 1: Mean Picture-Label Matching Times for Experiment 1

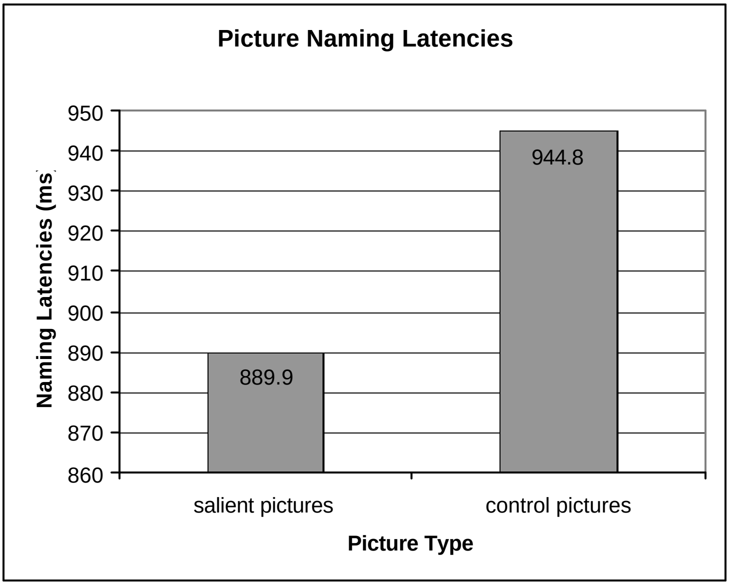

Figure 6: Response Latencies by Picture Type

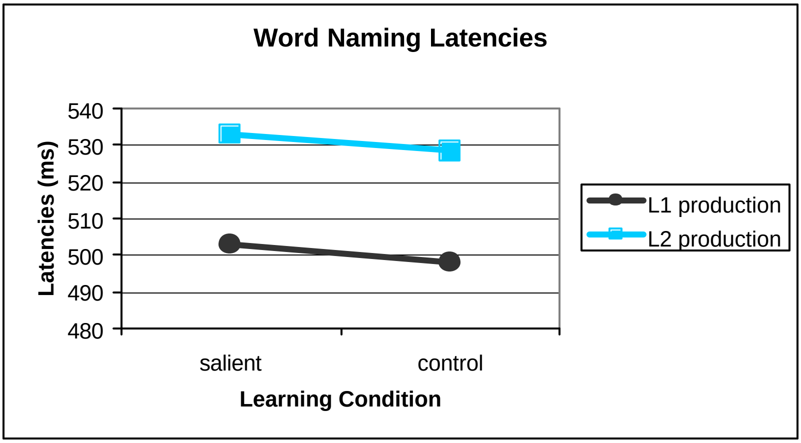

Figure 7: Word Naming Latencies According to Learning Condition and Language of Production

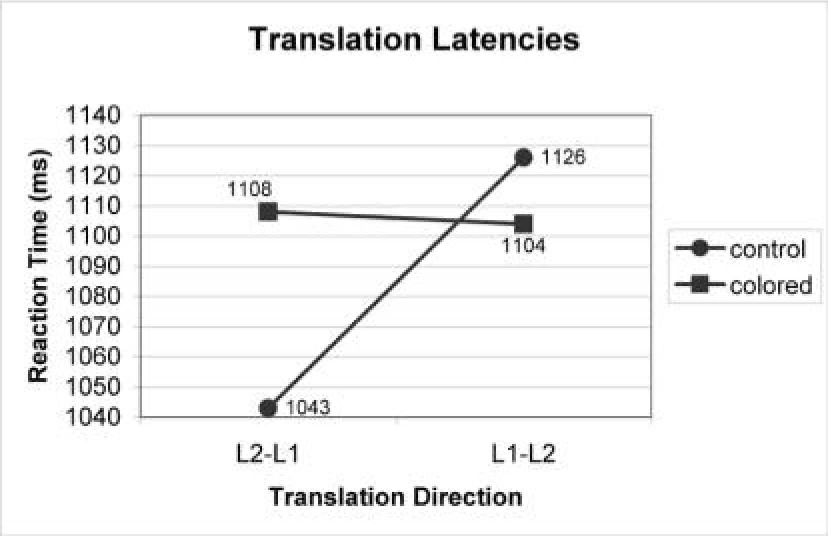

Figure 8: Translation Latencies by Translation Direction and Learning Condition.