Journal of Experimental Psychology:
Learning, Memory, and Cognition

0278-7393/11/$12.00 DOI: 10.1037/a0024828

Are Pictures Good for Learning New Vocabulary in a Foreign Language? Only If You Think They Are Not

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The current study explored whether new words in a foreign language are learned better from pictures than from native language translations. In both between-subjects and within-subject designs, Swahili words were not learned better from pictures than from English translations (Experiments 1–3). Judgments of learning revealed that participants exhibited greater overconfidence in their ability to recall a Swahili word from a picture than from a translation (Experiments 2–3), and Swahili words were also considered easier to process when paired with pictures rather than translations (Experiment 4). When this overconfidence bias was eliminated through retrieval practice (Experiment 2) and instructions warning participants to not be overconfident (Experiment 3), Swahili words were learned better from pictures than from translations. It appears, therefore, that pictures can facilitate learning of foreign language vocabulary—as long as participants are not too overconfident in the power of a picture to help them learn a new word.

Keywords: picture superiority effect, foreign language vocabulary, overconfidence

One of the more common findings in memory research is that pictures are remembered better than words. For example, when shown a list of easily named pictures versus their corresponding verbal labels, participants often have an easier time recalling the names of the pictures compared with the verbal labels (see e.g., Paivio & Csapo, 1973; Paivio, Rogers, & Smythe, 1968). This phenomenon has been referred to as the *picture superiority effect*.

The first known theoretical account of the picture superiority effect was based on Paivio's (1971, 1976) dual-coding theory. This view proposes that pictures are remembered better than words because they are more likely to be represented by both verbal and image codes. Such evidence is based in part on the finding that it is easier to name a picture than to form a mental image of a word (see e.g., Snodgrass, Wasser, Finkelstein, & Goldberg, 1974).

Consistent with levels-of-processing theory (see e.g., Craik & Lockhart, 1972), other accounts have proposed that pictures are remembered better than words because they receive a greater degree of elaborative semantic processing (see e.g., Nelson, Reed, & McEvoy, 1977). This notion has been supported by the finding that pictures can be categorized faster than words (see e.g., Potter & Faulconer, 1975) and that the picture superiority effect can be eliminated through encoding tasks that encourage semantic processing of the words (see e.g., Durso & Johnson, 1980; Smith & Magee, 1980).

Finally, Nelson's (1979) sensory-semantic model proposes that pictures have an advantage in memory because they contain a greater variety of unique visual features than do words. Supporting this view, some studies have shown that the picture superiority effect can be eliminated by increasing the visual similarity among the pictures (Nelson, Reed, & Walling, 1976).

Despite numerous studies that have examined this effect, one limitation is that the literature is based largely on tests of single-item recognition or recall. One exception is a recent study by Hockley (2008), who demonstrated that picture superiority effects can be reliably obtained on tests of associative recognition. It remains unclear, however, whether the picture superiority effect would consistently emerge on tests of *cued recall*. Exploring whether pictures have their usual advantage in this type of task is of theoretical importance in determining the boundary conditions of the effect and in shedding light on the practical question of how best to use pictures as educational tools.

One area that is of direct relevance to this issue is foreign language vocabulary learning. Understanding the meaning of the German word *der Hund*, for example, requires forming an association between this word and the familiar concept of "dog." This association could be formed by studying the German word with its English translation (e.g., *dog: der Hund*) or by studying *der Hund* with a picture of a dog. One might expect, on the basis of dozens of studies reporting mnemonic advantages of pictures, that memory for *der Hund* would be better if it were learned with a picture than with an English translation.

This idea appears to be supported by the widespread use of pictures in foreign language instruction. Indeed, current textbooks and computer-assisted language learning (CALL) programs are replete with examples of colorful pictures and illustrations that are intended to convey the meanings of concepts in a visually rich and distinctive way that words alone cannot (see e.g., Jones, 2004; Salaberry, 2001). But do these images actually promote learning?

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Portions of this study were presented at the 2011 Annual Meeting of the Midwestern Psychological Association, Chicago, Illinois, May 5–7. We thank Jill Feipel and Hana Ibrik for their valuable assistance with data collection and scoring.

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According to research on foreign language learning, pictures and videos can have a positive effect on the understanding and comprehension of text material (see e.g., Herron, Hanley, & Cole, 1995; Mueller, 1980; Omaggio, 1979). Furthermore, these visual aids often promote comprehension better than do descriptions that are purely verbal in nature, such as prereading questions or definitions that are provided in the margins (see e.g., Hudson, 1982; Taglieber, Johnson, & Yarbrough, 1988).

It is much less clear whether pictures promote vocabulary learning, however. Some studies have approached this question by giving students material to read in a foreign language and providing the meanings of unknown words in a text-only format (e.g., *der Hund: dog*), in a picture format (e.g., *der Hund* paired with a picture of a dog), or in a format that contains both text and a picture (e.g., *der Hund* paired with a picture of a dog and the word *dog*). Some studies using CALL programs have found that retention of new German vocabulary words was better when students looked up the meanings of unknown German words containing both English translations and pictures, compared with English translations alone (see e.g., Chun & Plass, 1996). However, subsequent work by Plass, Chun, Mayer, and Leutner (1998) using the same program found that retention of new German words was slightly worse if these words were learned through pictures alone compared with through English translations.

Other studies using a similar approach have failed to detect any advantage for pictures over native language translations in facilitating retention of new vocabulary in a foreign language. Kost, Foss, and Lenzini (1999) had students read a text passage in German that provided marginal definitions of new German words that consisted of either English translations, pictures, or English translations with pictures. On a subsequent test that required recall of the English translation given the German word, performance did not differ according to whether these words were learned through pictures, translations, or both. Similar results were reported by Yeh and Wang (2003), who had native Cantonese speakers learn English words through reading and consulting definitions that were text only versus text with a picture. On a subsequent vocabulary test, performance was no different according to whether new English words were learned through text definitions or text-with-picture definitions.

Other studies have paired a new foreign word with either a picture or its native language translation and then required participants to recall the foreign word in response to the same cue with which it was encoded. For example, Lotto and de Groot (1998) had native Dutch speakers learn new words in Italian by pairing the Italian word with either a picture or its Dutch translation. After encoding these items, participants were given a cued recall test over the Italian words using the same pictures or Dutch translations as they had previously seen. Accuracy of recall did not differ according to whether the Italian words were learned from pictures or from Dutch translations. Similar results were observed by Chen (1990), who found that cued recall accuracy of French words by native Cantonese speakers did not differ according to whether the French words were paired with a picture or a Cantonese translation during learning.

It appears from this research that pictures do not consistently benefit learning of foreign language vocabulary. At the least, the mnemonic effect of pictures in foreign language vocabulary learning does not appear to be as powerful and robust as is typically reported in studies of the picture superiority effect. Why might this be?

There are two important distinctions between studies that typically demonstrate the picture superiority effect and those that use pictures in the acquisition of foreign language vocabulary. First, studies that demonstrate the effect usually involve presentations of single items (pictures vs. words), whereas a foreign language vocabulary task presents a foreign word paired with either a picture or its native language translation. Second, studies of the picture superiority effect typically measure single-item recall or recognition, whereas studies of foreign language vocabulary measure cued recall of a foreign word from a picture or its native language translation (see e.g., Chen, 1990; Lotto & de Groot, 1998). Therefore, there are differences between the two tasks in how the information is both encoded and retrieved.

Encoding factors could explain why the usual advantage for pictures does not show up in foreign language vocabulary learning. In this type of task, there is more to be encoded than just an individual picture or word. Distributing encoding resources across two items could create *encoding tradeoffs* that lead to better memory for one item at the expense of the other (see e.g., Hockley & Cristi, 1996). Participants may, for example, focus too much on trying to learn the less familiar item (i.e., the foreign word) and not fully encode the picture or the association between the picture and the new word. Relative to a single-item memory task, encoding of the picture itself could therefore be impoverished.

Alternatively, the picture could be well encoded but fail to demonstrate its usual benefit because the test itself is not sensitive to the way in which the picture was encoded. Theories of the picture superiority effect converge on the assumption that pictures are remembered better than words because they receive more elaborative or distinctive processing. Memory tests that are sensitive to this type of processing would therefore be expected to demonstrate a stronger picture superiority effect.

Indeed, performance on free recall and recognition tests is enhanced by elaborative encoding (see e.g., Craik & Tulving, 1975) and are more likely to demonstrate the picture superiority effect than are cued recall tests. For example, after presenting single pictures versus words, Weldon and Roediger (1987; see also Weldon, Roediger, & Challis, 1989) obtained the typical picture superiority effect when participants were asked to free-recall the names of pictures or the words. This effect was reversed, however, when participants were asked to complete a word fragment with the names of the pictures or the words. The authors attributed this finding to the notion that free recall is more likely than word fragment completion to detect the elaborative processing advantage of pictures.

The current study explored which of these possibilities might be contributing to the apparent lack of picture superiority effects in foreign language vocabulary learning. In Experiment 1, we first set out to replicate the basic design of previous studies that have failed to report advantages of pictures over native language translations as cues for recalling foreign words (Chen, 1990; Lotto & de Groot, 1998). We also included new conditions to extend this basic design and provide greater explanatory power as to whether this finding should be attributed to encoding factors, retrieval factors, or both.

Experiment 1

Participants learned new words in Swahili by seeing the word paired with either its English translation (e.g., *dog: kelb*) or a picture (e.g., a picture of a dog paired with the word *kelb*). Half of the participants in each group were then asked to recall the Swahili words from the same cues with which they were originally learned, and half were asked to recall just the English words or names of pictures. This design allowed us to measure the picture superiority effect in its "usual way"—that is, through single-item recall of pictures versus words—and at the same time observe whether pictures produce better recall of Swahili words than do English translations.

We expected to replicate the results reported by Lotto and de Groot (1998) and Chen (1990), in that Swahili words recalled from pictures would not be better than from English translations. If this is due to the picture itself failing to receive its usual encoding advantage, then the picture superiority effect should be absent for free recall as well. On the other hand, if pictures are indeed encoded better than English words, but this advantage is detected only by tests that are sensitive to the elaborative encoding of pictures, then the picture superiority effect should be present for single-item free recall but absent for cued recall.

Method

Participants. A total of 116 undergraduate students participated to fulfill partial course requirements for an introductory psychology course at Iowa State University. Twenty-nine participants were each randomly assigned to one of the following four between-subjects conditions: (a) Participants in Condition 1 were presented with the Swahili word paired with its picture and were later asked to recall the Swahili word from the picture (e.g., responding with "kelb" to a picture of a dog); (b) participants in Condition 2 were also presented with the Swahili word paired with its picture but were later asked to free-recall the name of the picture in English (e.g., responding with just "dog"); (c) participants in Condition 3 were presented with the Swahili word paired with its English translation and were later asked to recall the Swahili word from the English translation (e.g., responding with "kelb" to the word *dog*); and (d) participants in Condition 4 were presented with the Swahili word paired with its English translation but were later asked to free-recall the English word (e.g., responding with just "dog").

Materials. Wilson's (1988) database was used to assemble a list of 43 single-syllable English nouns that were between three and seven letters, with word frequency ratings of over 30 and concreteness ratings of over 500. The Swahili translation for each word was obtained from the Kamusi Project website (Yale University, 2010). A complete list of the materials can be found in the Appendix. Pictures were black-and-white line drawings representing each of the 43 words.[1]

Design and procedure. Participants were informed at the beginning of the experiment that they would be learning Swahili words by viewing the word with a picture (Conditions 1 and 2) or its English translation (Conditions 3 and 4). All participants were instructed to try their best to learn the Swahili words and that later their memory for these items would be tested.

Each of the item pairs was presented one at a time in the center of the computer screen for 6 s, with a 1-s interstimulus interval. The Swahili word was presented below the picture (for Conditions 1 and 2) or below its English translation (for Conditions 3 and 4). The order in which the items were presented was randomized and different for each participant. Immediately following the initial presentation, participants received one more presentation that was identical to the previous one, except that the order of items was again randomized.

Participants were then given a test in which they were asked to recall the Swahili word given either the picture (Condition 1) or the English translation (Condition 3) or to recall all of the pictures (Condition 2) or English words (Condition 4) that they remembered seeing. The first two tests presented the complete list of pictures (Condition 1) or English translations (Condition 3) in a new random order and allowed participants unlimited time to type in their responses in Swahili. The picture or English translation was presented in the center of the computer screen, and participants' responses appeared below it.

For the latter two tests requiring an English response, participants were given 5 min to recall all of the names of the pictures (Condition 2) or English words (Condition 4) that they could. Participants typed their responses, one at a time, onto a blank computer screen. After pressing *ENTER*, the response disappeared from the screen to allow a new response to be typed. Feedback was not provided on any of the tests. At the end of the test, participants were thanked and debriefed. The entire procedure lasted approximately 25 min.

Results and Discussion

Scoring. Swahili responses for all experiments were considered accurate if they were an exact match to the correct Swahili word. In addition, all of the responses were examined by two independent raters who were blind to the experimental condition to which each item was assigned. Each rater assigned half credit to any items that contained minor spelling errors (e.g., *malika* instead of *maliki*). Half credit was awarded to items for which both raters agreed that half credit should be assigned.

Figure 1 presents accuracy of recall as a function of item type (Swahili words encoded with pictures vs. English translations) and test type (free recall of pictures vs. English translations, or cued recall of Swahili words from pictures vs. English translations). Results of a 2 × 2 (Type of Item × Type of Test) between-subjects analysis of variance (ANOVA) revealed a significant interaction, $F(1, 112) = 4.48$, $p = .037$, $\eta_p^2 = .038$, in that the free recall test revealed an advantage of pictures over English translations, whereas the cued recall test did not. A 2 × 2 repeated-measures ANOVA revealed that this effect was also significant by items, $F(1, 42) = 18.33$, $p < .001$, $\eta_p^2 = .304$.

A main effect for type of test emerged by participants, $F(1, 112) = 81.31$, $p < .001$, $\eta_p^2 = .421$, and by items, $F(1, 42) = 88.18$, $p < .001$, $\eta_p^2 = .677$, indicating that free recall of English

[1] All picture stimuli were pilot-tested by showing each picture to a separate group of participants and asking them to name it as quickly as possible in English. Fourteen participants were shown each line drawing (from Experiments 1 and 4), and 28 different participants were shown each color photograph (from Experiments 2 and 3). For both picture types, participants named the correct English word over 95% of the time (SD = 3%).

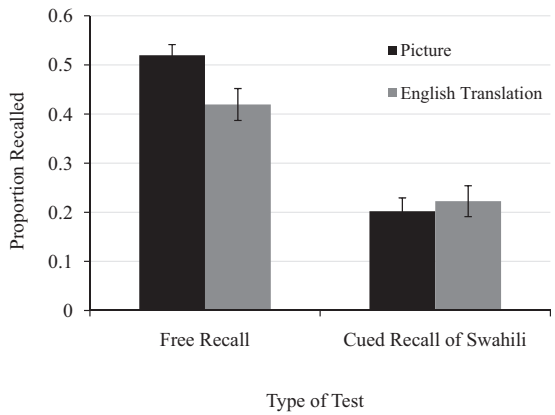

Figure 1. Proportion of items correctly recalled in Experiment 1. Participants learned either picture–Swahili pairs or English–Swahili pairs and then were asked to (a) recall the Swahili word from either the picture or its English translation (cued recall of Swahili) or (b) free-recall the names of all pictures or English words (free recall).

words was easier than cued recall of Swahili words. Although a significant advantage of pictures over English translations failed to emerge by participants ($F < 1.96$), this effect was significant by items, $F(1, 42) = 9.60$, $p = .003$, $\eta_p^2 = .186$.

The cued recall data replicated the pattern of results reported by Lotto and de Groot (1998) and Chen (1990), in that pictures were not more effective than verbal translations for recalling a new foreign word. However, the picture superiority effect was present when it was measured in its usual way—when participants were asked to recall only the pictures versus English words. Absence of a picture superiority effect in the former type of task therefore cannot be explained by the notion that the picture itself was not sufficiently encoded. Experiment 2 was designed to further explore the factors underlying the absence of a picture superiority effect in cued recall of new foreign words.

Experiment 2

If pictures themselves are easier to remember than English words, why do they not facilitate better recall of the Swahili word with which they are paired? The answer may lie in participants' perception of the mnemonic power of pictures. Recent research has reported evidence of a *multimedia* heuristic—the belief that text accompanied by photos will be remembered better than the same text that is not accompanied by photos, even though participants' own performance on a later test does not always confirm this (see e.g., Serra & Dunlosky, 2010).

Participants may have a similar type of bias for pictures in learning foreign language vocabulary. If pictures themselves are easier to remember than English translations (Experiment 1), participants may make the implicit assumption that anything paired with a picture will also be easier to remember. This could result in suboptimal processing of the association between the picture and Swahili word, explaining why picture superiority effects are typically not found in studies of foreign language vocabulary learning.

Participants encoded each Swahili word with either a picture or English translation and then made a judgment of learning (JOL) as to how likely they would be to recall the Swahili word on a future test. Participants were then tested for recall of the Swahili words from the same cues with which they were originally encoded, just as in Experiment 1. If pictures elicit greater overconfidence than do English translations, then JOL values should exceed initial recall accuracy more so for picture–Swahili pairs than for English–Swahili pairs.

On the basis of previous research demonstrating that overconfidence can be reduced through retrieval practice (see e.g., Finn & Metcalfe, 2007; Koriat, Sheffer, & Ma'ayan, 2002), we administered two tests with feedback on all of the Swahili words prior to a final third test. This allowed us to explore cued recall of picture–Swahili pairs versus English–Swahili pairs under conditions in which participants were most likely to be overconfident (i.e., at Test 1), as well as under conditions in which overconfidence was likely to be reduced (i.e., at Tests 2 and 3).

Method

Participants. Twenty-four undergraduate participants were recruited from the same participant pool as in Experiment 1. Participants were tested on individual computers.

Materials and design. The same English–Swahili pairs from Experiment 1 were used, with the exception of one item ("fence: *uwa*"), which was eliminated at random to yield 42 item pairs. For each participant, 21 items were randomly assigned to be learned as picture–Swahili pairs, and 21 as English–Swahili pairs. To generalize previous results across different types of picture stimuli, Experiment 2 used color photographs instead of black-and-white line drawings (see footnote 1).

Procedure. Participants were given the same general instructions as in Experiment 1. During encoding, each item was presented one at a time for 6 s each, in the center of the computer screen, with pictures and English translations always appearing above the Swahili word. The order of presentation of all 42 items was randomized and different for each participant.

The entire list was then presented again in a new random order for each participant, and participants were asked to make a JOL for each item. For picture–Swahili pairs they were asked, "How confident are you that in about five minutes from now you will be able to recall the Swahili word when given the picture?" For English–Swahili pairs they were asked, "How confident are you that in about five minutes from now you will be able to recall the Swahili word when given the English word?" During both judgments, all materials were displayed on the screen, and a scale at the bottom of the screen contained the following: "0% (definitely will NOT recall), 20%, 40%, 60%, 80%, 100% (definitely will recall)." Participants were asked to enter a value and then press *ENTER*.

Following the second presentation and JOL, participants were given a cued recall test in which they were asked to recall the Swahili word from the same cue with which it had been originally encoded. As soon as participants entered a response and pressed *ENTER*, their response disappeared from the screen and the correct Swahili word appeared. These items remained on the screen while participants were asked again to make a JOL about how confident they were that after 5 min they would be able to recall the Swahili word from the picture or its English translation. As soon as participants entered a JOL, the next item was tested for cued recall, followed by feedback and a JOL. This procedure continued until all 42 items had been tested.

This procedure was then repeated such that each item experienced a second cued recall test, followed by feedback, followed by a JOL. Immediately after this, participants were then tested one more time for cued recall of the Swahili word. This time, however, they were not given feedback or asked to make a JOL. Each time the list was presented, each item appeared in the same condition as before (i.e., picture–Swahili pairs were always presented as picture–Swahili pairs, and English–Swahili pairs were always presented as English–Swahili pairs), and the order of presentation was randomized for each participant. Following the third and final test, participants were thanked and debriefed. The entire procedure lasted approximately 40 min.

Results and Discussion

Table 1 displays calibration scores between JOLs and recall accuracy according to Lichtenstein and Fischhoff's (1977) measure. At Test 1, overconfidence was higher for Swahili words learned from pictures than from English translations. Following the first test, however, overconfidence was greatly reduced for both pictures and English translations, such that by Test 3, participants were actually underconfident for both types of items.

A 2 × 3 (Type of Item × Test) repeated-measures ANOVA revealed a significant interaction in that the overconfidence bias for pictures at Test 1 was eliminated at Tests 2 and 3, $F(2, 46) = 4.05$, $p = .024$, $\eta_p^2 = .150$. Overconfidence for both types of items was also significantly reduced across test trials, $F(2, 46) = 23.13$, $p < .001$, $\eta_p^2 = .501$.[2]

Figure 2 displays accuracy of recall across each of the three tests for picture–Swahili pairs versus English–Swahili pairs. As in Experiment 1, no significant advantage emerged for picture–Swahili pairs over English–Swahili pairs at Test 1, $t(23) = 1.54$, $p = .137$. However, this advantage was apparent at Tests 2 and 3 ($ts > 3.23$, $ps < .005$). A 2 × 3 (Type of Item × Test) repeated-measures ANOVA revealed that this interaction was significant by participants, $F(2, 46) = 4.70$, $p = .014$, $\eta_p^2 = .170$, as well as by items, $F(2, 82) = 8.74$, $p < .001$, $\eta_p^2 = .176$.

A significant advantage for pictures over English translations also emerged by participants, $F(1, 23) = 15.88$, $p = .001$, $\eta_p^2 = .409$, and by items, $F(1, 41) = 14.09$, $p = .001$, $\eta_p^2 = .256$, and performance improved across the three test trials by participants, $F(2, 46) = 125.02$, $p < .001$, $\eta_p^2 = .845$, and by items, $F(2, 82) = 98.85$, $p < .001$, $\eta_p^2 = .707$.[3]

Taken together with the calibration scores, it appears that when participants are overconfident in their ability to recall a Swahili word from a picture, they do not recall Swahili words significantly better from pictures than from English translations (i.e., at Test 1). Removal of this overconfidence bias through retrieval practice resulted in a significant advantage in recall of Swahili words from pictures compared with English translations at Tests 2 and 3.

Table 1
Calibration Scores as a Function of Type of Item and Test in Experiment 2

Type of item	Test 1	Test 2	Test 3
Picture–Swahili Pairs	19.83 (20.31)	−1.08 (15.52)	−4.13 (11.18)
English–Swahili Pairs	15.46 (16.44)	3.79 (14.25)	−1.18 (13.35)

Note. Standard deviations are given in parentheses.

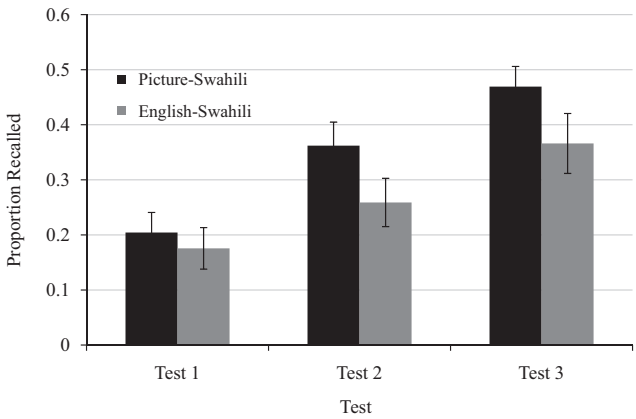

Figure 2. Proportion of Swahili words correctly recalled from pictures versus English translations across Tests 1, 2, and 3 in Experiment 2.

Experiment 3 was designed to provide further data on whether participants are typically overconfident in their ability to recall a Swahili word from a picture compared with from an English translation and whether this overconfidence bias is accompanied by an absence of the picture superiority effect.

Experiment 3

Participants learned the same 42 items as in Experiment 2, half of them as picture–Swahili pairs and half as English–Swahili pairs. As before, participants made a JOL for each item and were then asked to recall the Swahili word from the same cue with which it had been originally encoded.

This time, we attempted to reduce overconfidence through an instructional manipulation rather than through retrieval practice.

[2] Previous research demonstrating this underconfidence-with-practice effect has suggested that it may be due to the tendency for participants to base their JOLs on how well an item was recalled previously (see e.g., Finn & Metcalfe, 2007). This notion was supported by higher Goodman and Kruskal (1954) gamma correlations between Test 1 JOL and Test 1 recall, compared with Test 1 JOL and Test 2 recall. The former were greater than the latter for both picture–Swahili pairs (respectively, .91 vs. .75) and English–Swahili pairs (respectively, .96 vs. .82; $ts > 3.74$, $ps = .001$). Gamma correlations between Test 2 JOL and Test 2 recall were also higher than between Test 2 JOL and Test 3 recall for both picture–Swahili pairs (respectively, .94 vs. .77) and English–Swahili pairs (respectively, .93 vs. .85; $ts > 2.92$, $ps < .009$). No significant differences emerged between picture–Swahili pairs versus English–Swahili pairs ($ts < 2.07$).

[3] We explored whether the emergence of the picture superiority effect across tests was due to the tendency for pictures to produce superior learning or due to the tendency for participants to simply get better at recalling the material for which they were initially overconfident. Individual differences in calibration scores revealed 12 participants who expressed an initial overconfidence bias for pictures and seven who expressed an initial overconfidence bias for English translations. Results of a 2 × 2 × 3 mixed ANOVA (Item Type × Bias Type × Test) revealed the same pattern of effects as previously reported (all $Fs > 10$, $ps < .004$), with no effects of bias type ($Fs < 2.00$).

One group of participants (i.e., the warning group) was provided with instructions warning them to not be overconfident, whereas a second group (i.e., the no-warning group) was not.

We expected the no-warning group to replicate the result from the Test 1 phase of Experiment 2, in that picture–Swahili pairs would elicit greater overconfidence than would English–Swahili pairs. We expected to observe, consistent with Experiment 2, no picture superiority effect under these conditions. However, if picture superiority effects exist under conditions in which this overconfidence bias is absent, and instructional manipulations are effective in preventing this bias, then we expected to observe a picture superiority effect for the Warning group.

Method

Participants. Fifty undergraduate students were recruited from the same participant pool as before. Twenty-five participants were randomly assigned to the Warning group, and 25 to the No-Warning group. Participants were tested individually on personal computers.

Materials, design, and procedure. Experiment 3 used the same 42 items as in Experiment 2. For each participant, 21 items were randomly assigned to be learned as picture–Swahili pairs, and 21 as English–Swahili pairs.

All participants were given the same general instructions as in the previous experiments. Participants in both groups were informed at the beginning of the experiment that they would be asked to indicate how confident they were (from 0% to 100%) that they would later be able to recall the Swahili word from its picture or English translation. Participants in the warning group were given the following additional instructions:

> People are typically overconfident in how well they know something. For example, people might say that they are 50% confident that they will remember a Swahili word, but later on the test, they only remember 20% of those words. It is very important that you try to NOT be overconfident. When you see a Swahili word, try very hard to learn it as best you can. Even if it feels like the word will be easy to remember, do not assume that it will be. When you see a Swahili word with a picture, try your best to link the Swahili word to that picture. When you see a Swahili word with an English translation, try your best to link the Swahili word to that English translation.

The 42 item pairs were then presented in the same way as in Experiment 2, followed by the same JOL instructions. At this time, participants in the warning group were given these additional instructions: "Remember, try very hard to NOT be overconfident. Think about each word very carefully and choose a number only if you are sure that number accurately represents how well you will remember that word." The JOL procedure for each item was then carried out in the same way as in Experiment 2.

Immediately following, participants were given the same cued recall test as in Experiment 2. Each item was presented in a new random order, and feedback was not provided. After finishing, participants were thanked and debriefed. The entire procedure lasted approximately 20 min.

Results and Discussion

Table 2 presents calibration scores for picture–Swahili pairs versus English–Swahili pairs for both groups. Consistent with the results of Experiment 2, the no-warning group exhibited greater overconfidence for picture–Swahili pairs than for English–Swahili pairs. The warning group, however, did not. A 2 × 2 (Type of Item × Group) mixed ANOVA revealed that this interaction was significant, $F(1, 48) = 4.432$, $p = .041$, $\eta_p^2 = .085$.[4]

Table 2
Calibration Scores as a Function of Type of Item and Group in Experiment 3

Type of item	No warning	Warning
Picture–Swahili Pairs	17.74 (22.99)	4.02 (33.63)
English–Swahili Pairs	12.71 (17.39)	7.94 (24.77)

Note. Standard deviations are given in parentheses.

Figure 3 presents cued recall accuracy as a function of item type and group. The warning group demonstrated superior recall of Swahili words from pictures compared with English translations, whereas the no-warning group did not. A 2 × 2 (Type of Item × Group) mixed ANOVA revealed that this interaction was significant by participants, $F(1, 48) = 4.431$, $p = .041$, $\eta_p^2 = .085$, and a 2 × 2 repeated-measures ANOVA confirmed the same effect by items, $F(1, 41) = 7.17$, $p = .011$, $\eta_p^2 = .149$.[5]

Pictures were more effective cues overall than English translations. This effect was significant by participants, $F(1, 48) = 6.68$, $p = .013$, $\eta_p^2 = .122$, and by items, $F(1, 41) = 5.24$, $p = .027$, $\eta_p^2 = .113$. No significant effects emerged for group (Fs $< .32$).

The results of Experiment 3 confirm the same pattern that was observed in Experiment 2, in that conditions yielding an overconfidence bias for pictures failed to demonstrate a picture superiority effect. When this overconfidence bias was prevented through instructions cautioning participants to not be overconfident, a significant picture superiority effect emerged.

One question remains. Why do participants feel more overconfident in their ability to recall a Swahili word from a picture than from an English translation? Experiment 4 addressed this question by exploring what type of information is available during encoding upon which participants might be basing their memory predictions.

Experiment 4

One encoding-based heuristic that has been known to influence memory predictions is ease of processing (see e.g., Schwartz, 1994). Participants generally believe, for example, that words will be remembered better if they are easier to understand, pronounce, or imagine (see e.g., Begg, Duft, Lalonde, Melnick, & Sanvito, 1989). Evidence that participants use this heuristic in formulating memory predictions is based on the finding that items receiving higher ease-of-processing ratings from one group of participants also receive higher memory prediction ratings from another group (see e.g., Begg et al., 1989; Rawson & Dunlosky, 2002).

[4] Although the warning instructions resulted in slightly lower overconfidence for picture–Swahili pairs relative to English–Swahili pairs, this difference was not significant, $t(24) = 1.25$, $p = .222$.

[5] Although recall of English–Swahili pairs was numerically higher in the no-warning group than in the warning group, this difference was not significant, $t(48) = 0.67$, $p = .506$.

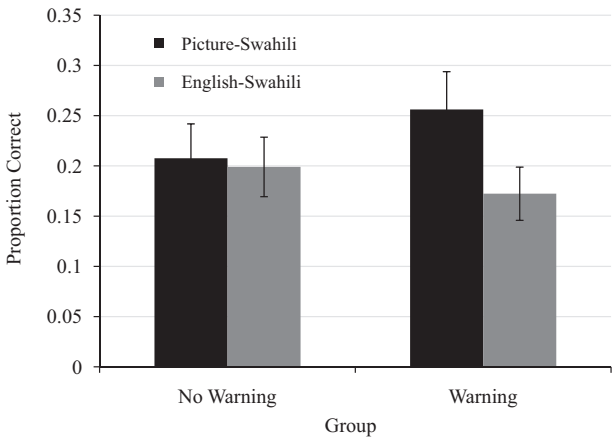

Figure 3. Proportion of Swahili words correctly recalled from pictures versus English translations in the no-warning versus warning groups in Experiment 3. The latter group received instructions cautioning them to not be overconfident, whereas the former group did not.

Experiments 2 and 3 demonstrated that participants assign higher JOLs to picture–Swahili pairs than to English–Swahili pairs. Evidence for the ease-of-processing heuristic in the overconfidence bias for pictures would therefore be obtained if a different group of participants rated picture–Swahili pairs as easier to process than English–Swahili pairs.

To test this prediction, we conducted three additional experiments in which different groups of participants were given picture–Swahili pairs and English–Swahili pairs and asked to rate them on three dimensions of ease of processing. One group was asked to rate how easy it was to *study* the Swahili word from either the picture or English translation (Experiment 4a), a different group was asked to rate how easy it was to *understand* the Swahili word from the picture or English translation (Experiment 4b), and another group was asked to rate how easy it was to *link* the Swahili word to the picture or English translation (Experiment 4c).

Method

Participants and design. A total of 64 participants were sampled from the same participant pool as before. All participants were given the same 42 Swahili words used in Experiments 2 and 3, with half of them randomly assigned to be paired with pictures and half with English translations. The pictures in this case were the line drawings used in Experiment 1. Twenty-one participants completed Experiment 4a, 30 completed Experiment 4b, and 13 completed 4c.

Procedure. Each item underwent an initial presentation phase that was identical to that in the previous experiments. Immediately following, each item was presented again in a new random order and rated for ease of studying (Experiment 4a), understanding (Experiment 4b), or linking (Experiment 4c).

For picture–Swahili pairs, participants were asked, "How easy is it to study the Swahili word with the picture?" "How easy is it to understand the Swahili word from the picture?" or "How easy is it to link the Swahili word with the picture?" For English–Swahili pairs, participants were asked, "How easy is it to study the Swahili word with the English word?" "How easy is it to understand the Swahili word from the English word?" or "How easy is it to link the Swahili word with the English word?"

For all judgments, participants used the same 0%–100% scale as in Experiments 2 and 3, this time with 0% representing "very hard to study/understand/link" and 100% representing "very easy to study/understand/link." As in Experiments 2 and 3, all items were displayed on the screen during the judgment, with the 0%–100% scale presented at the bottom of the screen.

Results and Discussion

Table 3 contains the ease-of-processing ratings for each experiment according to type of item and type of question. Relative to English–Swahili pairs, participants rated picture–Swahili pairs as significantly easier to study: by participants, $t(20) = 2.84$, $p = .010$; by items, $t(41) = 7.49$, $p < .001$; to understand: by participants, $t(29) = 2.15$, $p = .040$; by items, $t(41) = 3.70$, $p = .001$; and to link: by participants, $t(12) = 2.59$, $p < .023$; by items, $t(41) = 4.65$, $p < .001$.

Participants thus perceived Swahili words as easier to process when they were paired with pictures rather than with English translations. The fact that the former also received higher JOL values than the latter (Experiments 2 and 3) indicates that participants may be assigning higher JOL values to picture–Swahili pairs because they are perceived as easier to process than English–Swahili pairs.

General Discussion

The current study addressed the apparent lack of picture superiority effects in foreign language vocabulary learning. Across three experiments, Swahili words that were paired with pictures were not better recalled on an initial test than Swahili words paired with English translations. This replicates prior work demonstrating a lack of an advantage for pictures over native language translations in producing recall of new Italian words (Lotto & de Groot, 1998) and new French words (Chen, 1990).

Table 3
Average Median Ease-of-Processing Ratings for Picture–Swahili Pairs Versus English–Swahili Pairs in Experiment 4

Rating	Picture–Swahili pairs	English–Swahili pairs
Ease of studying (Experiment 4a)	64.33 (19.77)	51.43 (21.86)
Ease of understanding (Experiment 4b)	52.17 (24.95)	41.00 (26.79)
Ease of linking (Experiment 4c)	45.62 (31.83)	28.46 (19.83)

Note. Standard deviations are given in parentheses.

These results extend beyond prior work by showing that the picture superiority effect is present for these materials when the effect is measured in the usual way, however. That is, by asking participants to recall only the names of pictures versus the English translations, we obtained the usual advantage of pictures over words in Experiment 1. This replicates a number of studies demonstrating picture superiority effects on tests of single-item memory (see e.g., Nelson, 1979; Paivio, 1971; Paivio et al., 1968; Weldon & Roediger, 1987; Weldon et al., 1989).

Failure to observe the advantage in recall of Swahili words from pictures compared with English translations in Experiment 1 therefore could not be due to impoverished encoding of the picture itself. In fact, superior free recall of the picture compared with the English word suggests that the picture was well encoded. Lack of an advantage in recall of Swahili words from pictures compared with English translations suggests instead that participants failed to establish a sufficient association between the picture and the Swahili word.

Experiments 2 and 3 provide key evidence that failure to associate the picture with the Swahili word appears to be linked to participants' confidence. Both experiments demonstrated that participants are generally overconfident in how well they will be able to recall a Swahili word that is paired with a picture compared with its English translation. When this overconfidence bias was present, participants failed to recall Swahili words better from pictures than from English translations, just as in Experiment 1. Elimination of this bias, however (through retrieval practice in Experiment 2 and through instructions in Experiment 3), revealed a significant advantage in the recall of Swahili words from pictures compared with English translations.

These results could explain why studies of foreign language learning have not consistently reported an advantage of pictures over verbal descriptions in promoting vocabulary acquisition (see e.g., Chun & Plass, 1996; Kost et al., 1999; Plass et al., 1998; Yeh & Wang, 2003). At first blush, this finding appears to run counter to the vast literature reporting memorial advantages of pictures over words (see e.g., Hockley, 2008; Paivio et al., 1968). Importantly, however, these studies never assessed participants' confidence in their learning. A sense of overconfidence in the mnemonic power of pictures could lead to suboptimal processing of the association between the picture and the new word, leading to a deflated estimate of the benefits of pictures for learning new words. Future research on applied language learning would benefit by including assessments of participants' confidence, because the current results suggest that this may be an important determinant of the effectiveness of a given method.

Why do pictures elicit a sense of overconfidence in the first place? The results of Experiment 4 suggest that this may be because pictures are perceived as easier to process than English translations. Ease of processing can sometimes facilitate accurate memory predictions. For example, concrete words are rated as easier to process and are also remembered better than abstract words (Begg et al., 1989), and more coherent text is perceived as easier to process and is remembered better than less coherent text (Rawson & Dunlosky, 2002).

Like any heuristic, however, ease of processing can sometimes lead to inaccurate memory predictions. For example, participants rate high-frequency words as easier to process and also predict that they will be easier to recognize later (see e.g., Begg et al., 1989), despite the common finding that low-frequency words are better recognized than high-frequency words (see e.g., Glanzer & Adams, 1985). Participants also predict that words presented in larger font will be easier to remember than those presented in smaller font (presumably because larger font makes the text easier to process), even though memory accuracy is not affected by font size (see e.g., Kornell, Rhodes, Castel, & Tauber,2011; Rhodes & Castel, 2008).

The current results provide an important new example of a case in which the ease-of-processing heuristic can lead to inaccurate memory predictions. Although words in a foreign language may be perceived as easier to process when they are presented with pictures rather than with English translations (Experiment 4), they are not necessarily going to be easier to remember on an initial test (Experiments 1, 2, and 3). However, the current results demonstrate that pictures can indeed be more effective cues than English translations, as long as participants are not significantly more overconfident in the mnemonic power of pictures.

Theories of bilingual memory representation may shed additional light on the nature of associations between foreign words and pictures versus foreign words and their native language translations. For example, Kroll and Stewart's (1994) *revised hierarchical model* proposes that, as new foreign words are learned, their meanings are at first more strongly represented by native language translations than by underlying concepts. That is, the lexical association between the two words (the foreign word and its translation) is initially stronger than the conceptual association between the foreign word and its image. Novice learners as in the current study, therefore, may not be expected to demonstrate better initial recall of Swahili words from pictures than from English translations. This prediction appears to be confirmed by some of our results. Future research is needed to determine how these representations might be affected by the learning strategies that participants use (see e.g., Chen, 1990) and how those strategies might be mediated by participants' level of confidence in their learning.

The difference between picture–Swahili and English–Swahili associations may also bear some relevance to Mayes' theory of *domain dichotomy* (see e.g., Mayes, Montaldi, & Migo, 2007). According to this view, associations between items within the same domain (e.g., word–word) are largely driven by familiarity, whereas associations between domains (e.g., picture–word) are driven more by recollection. Given that cued recall tasks such as those used in the current study require recollection (see e.g., Mandler, 1980; Yonelinas, 2002), one mechanism contributing to the advantage in recall of picture–Swahili pairs over English–Swahili pairs under some circumstances could be that the former is based more on recollective processing. Future research will hopefully shed more light on the nature of this processing and how it may relate to learning new words in a foreign language.

Finally, on a practical note, the current study provides important insight into the value of pictures as educational tools in foreign language instruction. Teachers and students should be cautious that they do not fall prey to the overconfidence bias that may be induced by pictures. The current results provide specific guidance on how this bias can be overcome. When using pictures as a means of introducing a new foreign word, for example, instructors can implement the method of retrieval practice by displaying the picture and asking students to recall the foreign word that goes with it. Or, they can caution students against being too certain that

a word is already known simply because it is accompanied by a picture.

Important questions to be addressed in future research include exploring more precisely what participants do when they feel overconfident that they know something and how that affects accuracy of recall, investigating how strategies might change as a function of confidence, identifying the conditions under which overconfidence is most likely to occur, and determining how to overcome overconfidence and other metacognitive biases in order to optimize the mnemonic power of pictures in learning new languages.

References

Begg, I., Duft, S., Lalonde, P., Melnick, R., & Sanvito, J. (1989). Memory predictions are based on ease of processing. *Journal of Memory and Language, 28,* 610–632. doi:10.1016/0749-596X(89)90016-8

Chen, H.-C. (1990). Lexical processing in a non-native language: Effects of language proficiency and learning strategy. *Memory & Cognition, 18,* 279–288. doi:10.3758/BF03213881

Chun, D. M., & Plass, J. L. (1996). Effects of multimedia annotations on vocabulary acquisition. *Modern Language Journal, 80,* 183–198. doi:10.2307/328635

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11,* 671–684. doi:10.1016/S0022-5371(72)80001-X

Craik, F. I. M., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology: General, 104,* 268–294. doi:10.1037/0096-3445.104.3.268

Durso, F. T., & Johnson, M. K. (1980). The effects of orienting tasks on recognition, recall, and modality confusion of pictures and words. *Journal of Verbal Learning and Verbal Behavior, 19,* 416–429. doi:10.1016/S0022-5371(80)90294-7

Finn, B., & Metcalfe, J. (2007). The role of memory for past test in the underconfidence with practice effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33,* 238–244. doi:10.1037/0278-7393.33.1.238

Glanzer, M., & Adams, J. K. (1985). The mirror effect in recognition memory. *Memory & Cognition, 13,* 8–20. doi:10.3758/BF03198438

Goodman, L. A., & Kruskal, W. H. (1954). Measures of association for cross classifications. *Journal of the American Statistical Association, 49,* 732–764. doi:10.2307/2281536

Herron, C. A., Hanley, J. E. B., & Cole, S. P. (1995). A comparison study of two advance organizers for introducing beginning foreign language students to video. *Modern Language Journal, 79,* 387–395. doi:10.2307/329353

Hockley, W. E. (2008). The picture superiority effect in associative recognition. *Memory & Cognition, 36,* 1351–1359. doi:10.3758/MC.36.7.1351

Hockley, W. E., & Cristi, C. (1996). Tests of encoding tradeoffs between item and associative information. *Memory & Cognition, 24,* 202–216. doi:10.3758/BF03200881

Hudson, T. (1982). The effects of induced schemata on the "short circuit" in L2 reading: Non-decoding factors in L2 reading performance. *Language Learning, 32,* 1–33. doi:10.1111/j.1467-1770.1982.tb00516.x

Jones, L. (2004). Testing L2 vocabulary recognition and recall using pictorial and written test items. *Language Learning and Technology, 8,* 122–143.

Koriat, A., Sheffer, L., & Ma'ayan, H. (2002). Comparing objective and subjective learning curves: Judgments of learning exhibit increased underconfidence with practice. *Journal of Experimental Psychology: General, 131,* 147–162. doi:10.1037/0096-3445.131.2.147

Kornell, N., Rhodes, M. G., Castel, A. D., & Tauber, S. K. (2011). The ease of processing heuristic and the stability bias: Dissociating memory, memory beliefs, and memory judgments. *Psychological Science, 22,* 787–794.

Kost, C. R., Foss, P., & Lenzini, J. J. (1999). Textual and pictorial glosses: Effectiveness on incidental vocabulary growth when reading in a foreign language. *Foreign Language Annals, 32,* 89–97. doi:10.1111/j.1944-9720.1999.tb02378.x

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language, 33,* 149–174. doi:10.1006/jmla.1994.1008

Lichtenstein, S., & Fischhoff, B. (1977). Do those who know more also know more about how much they know? *Organizational Behavior and Human Performance, 20,* 159–183. doi:10.1016/0030-5073(77)90001-0

Lotto, L., & de Groot, A. M. B. (1998). Effects of learning method and word type on acquiring vocabulary in an unfamiliar language. *Language Learning, 48,* 31–69. doi:10.1111/1467-9922.00032

Mandler, G. (1980). Recognizing: The judgment of previous occurrence. *Psychological Review, 87,* 252–271. doi:10.1037/0033-295X.87.3.252

Mayes, A., Montaldi, D., & Migo, E. (2007). Associative memory and the medial temporal lobes. *Trends in Cognitive Sciences, 11,* 126–135. doi:10.1016/j.tics.2006.12.003

Mueller, G. A. (1980). Visual contextual clues and listening comprehension: An experiment. *Modern Language Journal, 64,* 335–340. doi:10.2307/324500

Nelson, D. L. (1979). Remembering pictures and words: Appearance, significance, and name. In L. S. Cermak & F. I. M. Craik (Eds.), *Levels of processing in human memory* (pp. 45–76). Hillsdale, NJ: Erlbaum.

Nelson, D. L., Reed, V. S., & McEvoy, C. L. (1977). Learning to order pictures and words: A model of sensory and semantic encoding. *Journal of Experimental Psychology: Human Learning and Memory, 3,* 485–497. doi:10.1037/0278-7393.3.5.485

Nelson, D. L., Reed, V. S., & Walling, J. R. (1976). Pictorial superiority effect. *Journal of Experimental Psychology: Human Learning and Memory, 2,* 523–528. doi:10.1037/0278-7393.2.5.523

Omaggio, A. C. (1979). Pictures and second language comprehension: Do they help? *Foreign Language Annals, 12,* 107–116. doi:10.1111/j.1944-9720.1979.tb00153.x

Paivio, A. (1971). *Imagery and verbal processes.* London, England: Holt, Rinehart & Winston.

Paivio, A. (1976). Imagery in recall and recognition. In J. Brown (Ed.), *Recall and recognition* (pp. 103–129). New York, NY: Wiley.

Paivio, A., & Csapo, K. (1973). Picture superiority in free recall: Imagery or dual coding? *Cognitive Psychology, 5,* 176–206. doi:10.1016/0010-0285(73)90032-7

Paivio, A., Rogers, T. B., & Smythe, P. C. (1968). Why are pictures easier to recall than words? *Psychonomic Science, 11,* 137–138.

Plass, J. L., Chun, D. M., Mayer, R. E., & Leutner, D. (1998). Supporting visual and verbal learning preferences in a second-language multimedia learning environment. *Journal of Educational Psychology, 90,* 25–36. doi:10.1037/0022-0663.90.1.25

Potter, M. C., & Faulconer, B. A. (1975, February 6). Time to understand pictures and words. *Nature, 253,* 437–438. doi:10.1038/253437a0

Rawson, K. A., & Dunlosky, J. (2002). Are performance predictions for text based on ease of processing? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28,* 69–80. doi:10.1037/0278-7393.28.1.69

Rhodes, M. G., & Castel, A. D. (2008). Memory predictions are influenced by perceptual information: Evidence for metacognitive illusions. *Journal of Experimental Psychology: General, 137,* 615–625. doi:10.1037/a0013684

Salaberry, M. R. (2001). The use of technology for second language learning and teaching: A retrospective. *Modern Language Journal, 85,* 39–56. doi:10.1111/0026-7902.00096

Schwartz, B. L. (1994). Sources of information in metamemory: Judgments of learning and feelings of knowing. *Psychonomic Bulletin & Review, 1,* 357–375. doi:10.3758/BF03213977

Serra, M. J., & Dunlosky, J. (2010). Metacomprehension judgments reflect the belief that diagrams improve learning from text. *Memory, 18,* 698–711. doi:10.1080/09658211.2010.506441

Smith, M. C., & Magee, L. E. (1980). Tracing the time course of picture-word processing. *Journal of Experimental Psychology: General, 109,* 373–392. doi:10.1037/0096-3445.109.4.373

Snodgrass, J. G., Wasser, B., Finkelstein, M., & Goldberg, L. B. (1974). On the fate of visual and verbal memory codes for pictures and words: Evidence for a dual coding mechanism in recognition memory. *Journal of Verbal Learning and Verbal Behavior, 13,* 27–37. doi:10.1016/S0022-5371(74)80027-7

Taglieber, L. K., Johnson, L. L., & Yarbrough, D. B. (1988). Effects of prereading activities on EFL reading by Brazilian college students. *TESOL Quarterly, 22,* 455–471.

Weldon, M. S., & Roediger, H. L., III. (1987). Altering retrieval demands reverses the picture superiority effect. *Memory & Cognition, 15,* 269–280. doi:10.3758/BF03197030

Weldon, M. S., Roediger, H. L., III., & Challis, B. H. (1989). The properties of retrieval cues constrain the picture superiority effect. *Memory & Cognition, 17,* 95–105. doi:10.3758/BF03199561

Wilson, M. (1988). MRC Psycholinguistic Database: Machine-usable dictionary, Version 2.00. *Behavior Research Methods, Instruments, & Computers, 20,* 6–10. doi:10.3758/BF03202594

Yale University. (2010). *The Kamusi Project: Internet living Swahili dictionary.* Retrieved June 13, 2010, from http://www.kamusiproject.org

Yeh, Y., & Wang, C.-W. (2003). Effects of multimedia vocabulary annotations and learning styles on vocabulary learning. *CALICO Journal, 21,* 131–144.

Yonelinas, A. P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory and Language, 46,* 441–517. doi:10.1006/jmla.2002.2864

Appendix

English–Swahili Word Pairs Used in the Current Study

English	Swahili	English	Swahili	English	Swahili	English	Swahili
arm	*papatiko*	bridge	*daraja*	eye	*jicho*	leg	*muundi*
ball	*kipira*	car	*gari*	fence	*uwa*	net	*juya*
beach	*mapwa*	chain	*riza*	fish	*samki*	nose	*pua*
bear	*dubu*	chair	*kiti*	gun	*bunduki*	phone	*simu*
bed	*kitanda*	church	*kanisa*	hand	*mkono*	plant	*jaja*
bench	*bao*	corn	*muhindi*	hat	*chapeo*	rose	*wardi*
bird	*chimbule*	cup	*kidoto*	horse	*farasi*	snake	*fia*
boat	*safina*	desk	*dawati*	house	*jumba*	sun	*chaka*
bone	*fupa*	dog	*kelb*	key	*ufunguo*	tree	*jiti*
book	*andiko*	door	*mlango*	king	*maliki*	wheel	*duwara*
box	*jaluba*	dress	*rinda*	knife	*geli*		

Note. Experiment 1 used all 43 pairs. Experiments 2, 3, and 4 used 42 of the pairs after randomly eliminating one (fence: *uwa*).

Received November 26, 2010
Revision received June 7, 2011
Accepted June 14, 2011 ■