

Do Idiomatic Constructions Always Aid Language Learning?

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Kaschak and Saffran (2006) reported that the presence of an idiomatic syntactic construction (i.e., a construction whose structure violates the rules that govern the structure of the other sentences in the language) in training had a positive effect on participants' ability to acquire the phrase structure of an artificial language, but only when the idiomatic construction was given a distinctive prosodic feature. The present study extends this finding by exploring whether the distinctive meanings that accompany idiomatic constructions also influence their effect on language learning. We report two experiments in which Kaschak and Saffran's paradigm is replicated with one important change: whereas the previous study provided participants with only auditory training, the current studies added a visual reference world (i.e., semantics) to the training. Our experiments failed to reproduce the beneficial effects of the idiomatic construction on the acquisition of the phrase structure of the language. This result places important limitations on the role that idiomatic constructions play in language acquisition.

Chomsky (1965) famously argued that children's linguistic input does not contain sufficient information to properly constrain the acquisition of the grammar of their native language (i.e., the *poverty of the stimulus* argument). Since that time, an important research agenda in the area of language acquisition has been to explicate the nature of the cues to syntactic structure that are present in a child's linguistic input, and to determine when and if these cues play a role in language learning (e.g., MacWhinney & Bates, 1989). Statistical learning approaches to language acquisition have received considerable attention in this regard (e.g., Saffran, Aslin, & Newport, 1996; Aslin, Saffran, & Newport, 1998; Gomez & Gerken, 1999, 2000). The statistical learning approach suggests that language learners are able to exploit the statistical properties of their linguistic environment in order to solve a number of language acquisition problems. For example, it has been shown that infants can use transitional probabilities between syllables (i.e., the likelihood of one syllable transitioning into another) to segment words from a fluent stream of speech (e.g., Saffran et al., 1996; Thiessen & Saffran, 2003), and that children can use the distribution of words and morphemes to learn the rudiments of syntax (e.g., Saffran & Wilson, 2003; Gomez & Gerken, 1999; Gerken, Wilson, & Lewis, 2005).

Explorations of the statistical learning approach to language acquisition have largely followed from the tradition of using artificial languages to study the acquisition process in both children and adults (e.g., Braine, 1966; see Gomez & Gerken, 2000, for a review). As this research paradigm has developed and the linguistic stimuli employed in such experiments have become more complex, a counterintuitive finding has emerged: linguistic complexity (particularly, syntactic complexity) tends to improve language learning (e.g., Morgan, Meier, & Newport, 1989; Kaschak & Saffran, 2006; Thompson & Newport, 2007; c.f., Cleermans & McClelland, 1991). Thompson and Newport (2007) demonstrated that participants were more successful learning an artificial language that had several properties that produced syntactic complexity (e.g., optional phrases and phrase movement) than learning artificial languages that had fewer such properties (and thus were less complex). Morgan et al. (1989) similarly report that artificial languages containing features such as phrase movement and pronominalization (e.g., replacing a multiword phrase in one sentence with a single word in a subsequent sentence) produced better learning than languages that did not contain these added features.

Kaschak and Saffran (2006) explored the possibility that sentences with unusual syntactic properties, referred to as idiomatic syntactic constructions (e.g., Fillmore, Kay, & O'Connor, 1988), could provide similar benefits to language learners. The notion of an idiomatic syntactic construction is rooted in the long-held linguistic distinction between *core* and *peripheral* elements of grammar (e.g., Fillmore et al., 1988; Kay & Fillmore, 1999). Core elements of a grammar are the general, productive rules that govern the phrase structure of the language. Peripheral elements represent a set of syntactic oddities whose structure and function cannot easily be explained through the core principles of the grammar. Idiomatic syntactic constructions are sentence types governed by peripheral elements of grammar. These constructions contain structural features that violate the core rules of the language. Such sentences are often (though not always) associated with specific pragmatic functions (see Fillmore et al., 1988, for a discussion).

Sentences (1a), (1b), and (1c) are examples of idiomatic constructions from English (see Fillmore et al., 1988; Kay & Fillmore, 1999; and Kay, 1997, for a discussion of these and several other such constructions):

- (1) a. . . . all of a sudden . . .
 b. The more you eat, the sicker you'll feel.
 c. Bill didn't get to Chicago, let alone New York!

Example (1a) has an atypical prepositional phrase (there is no noun in the phrase *of a sudden*) that is unique to this particular idiom. Example (1b) has several unusual features. For instance, whereas *the* is virtually always used to introduce a noun phrase (*the car*), here *the* introduces the phrase *more you eat* producing a phrase type not found in other English sentences. Example (1c) employs the coordinating conjunction *let alone*, which acts differently than other such conjunctions (e.g., *and* or *or*) both pragmatically and syntactically (see Fillmore et al., 1988, for a thorough treatment of this construction). Idiomatic syntactic constructions pair unique syntactic features with specific pragmatic or semantic functions, and such constructions can exhibit a range of properties. Some, such as the *let alone* construction illustrated in (1c), are productive (i.e., the construction rules can be used to generate an infinite number of unique sentence tokens), but some are not (e.g., *all of a sudden*). In addition, whereas some idiomatic constructions can be used with only a particular prosodic structure (e.g., the Incredulous Response Construction: *Him be a doctor?*; Lambrecht, 1990), others do not have a distinctive prosodic feature (e.g., examples

1b and 1c above). In this paper, we focus on the observations that idiomatic constructions are 80 often used to convey special meanings (pragmatic functions) and that they can exhibit a distinctive prosodic feature.

Kaschak and Saffran (2006) examined the effect of an idiomatic syntactic construction on the acquisition of an artificial language. They presented adult participants with a modified version 85 of the artificial grammar used by Morgan and Newport (1981) and Saffran (2001; see below for details). In one condition (*Core only*), participants were trained on the basic core grammar without any exposure to the idiomatic construction. In the other conditions (*Idiomatic Construction;* *Idiomatic Construction+Prosody*), participants were trained on the core grammar and also 90 heard a small number of tokens of the idiomatic construction. The idiomatic construction employed word and phrase types found in the core constructions of the language, but the words and phrases were ordered in a way that violated the rules governing the core sentences. Kaschak and Saffran report two main findings. First, when the idiomatic construction was not marked with special prosody, the presence of the construction did not affect learning of the core rules of the language and participants also did not appear to acquire the structure of the idiomatic construction. Second, when the idiomatic construction was marked with a distinctive prosodic 95 feature (*Idiomatic Construction+Prosody* condition), participants were able to learn the structure of the idiomatic construction, and the presence of the idiomatic construction improved learning of the core rules of the language.

Kaschak and Saffran's (2006) second finding appears to be counterintuitive at first—the presence of an idiomatic construction that violates the core rules of the language should make it 100 harder, not easier, to learn the core rules. They argue that the idiomatic construction benefited learners' efforts to learn the core rules of the language by highlighting the presence of certain phrase types within the language. Two elements of the language (C-phrases and E-words; see below for an extensive description of the language used during training) were present in both the core and idiomatic sentences heard during training. By presenting these elements of the language 105 in essentially the same form across two different sentence types (where C-phrase precede E-words in the core sentences and follow E-words in the idiomatic sentences), learners were provided with evidence that these elements were important structural units in the language (c.f., Morgan et al., 1989). As such, learners were provided with information about the structure of the language that could aid them in acquiring the rules that govern the core and idiomatic 110 sentence types.

Kaschak and Saffran's (2006) results suggest that a low-frequency idiomatic construction can affect the learning of the core rules of a language (and can be learned itself) provided it is given a distinctive prosodic marker. The work presented in this paper extends on Kaschak and Saffran's findings by examining an important property of idiomatic expressions: their special meaning. To 115 do this, we examined the extent to which the presence of a visual reference world during training affects the role that idiomatic constructions play in the acquisition of language. There are at least three reasons for doing so. First, as we have already noted, idiomatic constructions typically represent cases where a particular syntactic form is associated with a specific meaning and context of use, and in some cases the form is also paired with a specific prosodic structure (Fillmore et al., 1988; Kay & Fillmore, 1999; Lambrecht, 1990). Kaschak and Saffran showed that prosodically marked idiomatic constructions affect language learning, and the present studies go beyond this by asking whether similar results can be obtained with an idiomatic construction that is associated with a particular meaning. That is, will similar effects be observed when the artificial language

contains an idiomatic structure that more closely matches the way that idiomatic constructions appear in natural languages? 125

Second, whereas the work on the statistical learning approach to language acquisition initially focused on the question of whether learners could use the statistical features of their linguistic input to learn linguistic structure, there has been increasing interest in the question of how other factors interact with these statistical features of the input in shaping language acquisition (e.g., Thiessen & Saffran, 2003; Toro, Sinnett, & Soto-Faraco, 2005). The present work adds to this literature by asking whether learners' ability to use the cues to the phrase structure of the language provided by the idiomatic construction is affected by the presence of a visual reference world during training, and a special meaning placed on the idiomatic construction. 130

Third, previous work on the influence of visual reference worlds on artificial language learning suggests that reference affects language learning in both positive and negative ways (e.g., Valian & Coulson, 1988; Valian & Levitt, 1996). On the positive side, it has been shown that adding a visual reference world to training produces better learning of an artificial language (Valian & Coulson, 1988; Valian & Levitt, 1996). On the negative side, the presence of a visual reference world may distract learners from other cues that are present in their training, particularly cues to phrase structure that are signaled by prosody (Valian & Levitt, 1996). Thus, there is reason to believe that the presence of a visual reference world could alter the patterns of learning observed by Kaschak and Saffran (2006). 135 140

How will the visual reference world, and in particular one in which a particular referent is associated with an idiomatic construction, affect learning of Kaschak and Saffran's (2006) language? Based on the work of Valian and colleagues (Valian & Coulson, 1988; Valian & Levitt, 1996), one possibility is that the visual reference world will present the learner with another set of cues to the structure of the language and will therefore improve the acquisition of the language both in general terms and in terms of the benefits provided by the idiomatic construction. A second possibility is that, whereas the visual reference world may benefit learners overall, the effects of the idiomatic construction on language learning will be attenuated. Valian and Levitt (1996) demonstrated that the presence of a visual reference world reduces participants' sensitivity to the prosodic cues that are present in a language with only core rules. Their participants were trained on an artificial language that included a prosodic cue to phrase structure that marked the boundaries between phrase types. They found that, whereas the prosodic cues aided language learning when participants were given auditory training on the language alone, the prosodic cues did not aid language learning when the auditory input was accompanied by a visual reference world (although, as noted above, the visual reference world did benefit learning overall). Given that the beneficial effects of the idiomatic construction in Kaschak and Saffran's (2006) experiments seem to rely on the presence of a prosodic marker for the idiomatic sentences, it is possible that the visual reference world will hinder participants' use of this cue and therefore reduce the beneficial effects of the idiomatic construction. This result would suggest a limitation on the circumstances under which idiomatic constructions aid in language acquisition. 145 150 155 160

EXPERIMENT 1

We began our exploration of the extent to which a visual reference world affects the role of idiomatic constructions in language learning with an experiment that closely followed Kaschak and 165



FIGURE 1 Example training materials from Experiment 1.

Saffran’s (2006) paradigm. Learners in Experiment 1 were presented with the same artificial grammar (and subsequent test of knowledge of the language) as was used in Kaschak and Saffran’s Experiment 1. As in Kaschak and Saffran’s (2006) experiment, participants were given auditory training on the artificial grammar. Participants were also shown a visual reference world of the sort that has been used in previous artificial grammar learning studies (e.g., Morgan et al., 1989). The visual reference world corresponded to the sentences that were being presented (see Figure 1). By adding semantics (i.e., the visual reference world) to the training set used by Kaschak and Saffran, we aimed to assess the extent to which semantically marking the idiomatic construction in the language affects the acquisition of the language above and beyond the effects observed when the idiomatic construction was marked only prosodically.

Experiment 1 had two training conditions. In the *Core only* condition, participants were trained on sentences generated from the core rules of the language only. In the *Core + IC* condition, participants were trained on both the core sentences from the *Core only* condition and the idiomatic construction. The idiomatic construction was given the same prosodic marker as in Kaschak and Saffran’s (2006) experiments: whereas the core sentences were presented with descending prosody, the idiomatic construction was presented with an ascending prosodic contour. The idiomatic construction was also given a special meaning by pairing the obligatory lexical component of the construction (i.e., the word *wug*; see description below) with a visual referent that never appeared in conjunction with the core sentences. Although the special meaning assigned to the idiomatic construction is somewhat impoverished relative to the kinds of meanings that such constructions employ in natural languages, the meaning that is employed here is similar in spirit to what might be seen in naturally occurring constructions that have obligatory lexical components (e.g., the *let alone* construction described earlier; Fillmore et al., 1988).

Method 190

Participants. The participants were 44 introductory psychology students from Florida State University. All were native speakers of English and received course credit for participation.

Materials. The training phase of this experiment used sentences generated from the “core” production rules of the artificial grammar. The structure of the core sentences of the language is identical to that used in Kaschak and Saffran (2006):

- (A) S = A-phrase (AP) + C-phrase (CP) + E-word
- (B) AP = A-word + optional D-word
- (C) CP = C-word + optional G-word

Each word class consisted of a set of nonsense syllables. Sentences were created by inserting a nonsense syllable into the appropriate place in the sentence formula. To create a visual referent for each nonsense syllable simple geometric figures were assigned to each word category

(i.e., A-word, C-word, D-word, etc.). Nonsense syllables within each word category were differentiated by an arbitrary color assignment to blue, green, red, or yellow. There were four A-words (circle; bif: red, hep: blue, mib: yellow, rud: green), four C-words (triangle; cav: blue, lum: yellow, neb: green, sig: red), two D-words (square; klor: yellow, pell: green), two G-words (pentagon; tiz: blue, pilk: red), and four E-words (cross; jux: green, vot: red, loke: blue, dupp: yellow). In this way the nonsense syllable *cav* would be presented aurally, visually, and accompanied by a blue triangle just above the visually displayed letters (see Figure 1). The following sequences of word categories were acceptable as core sentence patterns:

A-C-E
 A-D-C-E
 A-C-G-E
 A-D-C-G-E

The idiomatic construction included one nonsense syllable not found in the rest of the language (*wug*). This syllable was marked with a colorless five-point star. Thus, the obligatory lexical component of this sentence type was given a special semantic referent that stood out from the rest of the referents employed in the language in that it was colorless (and, thus, the idiomatic construction would be the only sentence type to appear with a colorless referent). The rules to create an idiomatic construction were as follows:

- (D) S = E-word + CP + *wug* + C-word
- (E) *wug* was a lexical item that is fixed in the construction
- (F) The C-word at the end of the sentence never appears with a G-word

These rules generated the following types of sentences:

E-C-*wug*-C
 E-C-G-*wug*-C

The idiomatic construction violates several aspects of the core grammar. First, the idiomatic construction does not have an A-phrase. Second, the E-word appears before the C-phrase. Third, the C-word at the end of the idiomatic construction is prohibited from appearing with a G-word. Because idiomatic syntactic constructions in natural languages are of low relative frequency as compared to sentences generated from core rules, one additional constraint was put on the appearance of construction in the language: idiomatic sentences made up only 14% of the training set.

Appendix A presents all of the training and test materials used in this experiment. Sentences were presented visually and auditorily and accompanied by a string of color-filled shapes that corresponded to their assigned nonsense syllable. The string of shapes appeared approximately one-half inch above the visual sentences. The nonsense words were presented in black bold-faced 18-point Courier New font on a white background on an LCD monitor. The screen resolution was 640 × 480. The shapes were all approximately 2.5 cm in width and height. In this configuration shape strings were all approximately the same length as the letter strings. The sentences used in the training set were identical to those used in Kaschak and Saffran's (2006) Experiment 1. We used the same training set to make sure our experiment was maximally comparable to theirs.

For the *Core only* condition (which served as a baseline to observe how participants would learn the core of the grammar without exposure to the idiomatic construction), the training string consisted of the 50 core sentences, spoken at a rate of approximately one word per second.

The visual components were displayed at the onset of the first spoken syllable such that the shapes and nonsense syllables were visible throughout the duration of the auditory presentation. The sentences were spoken with a descending sentential prosody (i.e., each word was produced with a pitch lower than the previous word). We used a uniform rate of presentation and prosodic structure to ensure that the predictive dependencies between word classes (i.e., the regularity with which particular classes of words appear together in the training input) were the only cues to the phrase structure of the language. For the *Core + IC* condition (in which participants heard the core sentences, plus the idiomatic construction), the full set of 58 sentences was recorded in the same manner. The core sentences were presented in the same order as in the control condition, with the idiomatic sentences randomly interspersed. However, following Kaschack and Saffran (2006), idiomatic sentences were spoken with ascending prosodic structure in order to provide a cue that something is “different” about these sentences. The length of the training set was between 7 and 7.5 min for all training conditions. The training set was repeated five times to produce just over 30 min of training.

Participants in all training conditions received an identical test following training. The test was almost identical to the one used in Kaschack and Saffran’s (2006) Experiment 1 (the only change was that we deleted two items testing both Rules 6 and 7 in order to shorten the test a bit). The test items were designed to assess the participants’ knowledge of five core rules, as well as two rules for the idiomatic sentences:

Core Rules 265

- Rule 1: All sentences must have an A-phrase.
- Rule 2: In an A-phrase, A-words precede D-words; in a C-phrase, C-words precede G-words.
- Rule 3: Sentences must have an E-word.
- Rule 4: C-phrases must precede E-words.
- Rule 5: If there is a G-word, there must be a C-word. 270

Idiomatic Construction Rules

- Rule 6: An E-word and a C-phrase (in that order) precede *wug*.
- Rule 7: The final C-phrase must be a C-word only (no G-words in sentence final position).

Each test item consisted of a pair of auditorily presented sentences. One sentence was grammatically correct, whereas the other violated the rule being tested. Items testing core rules were presented with descending prosody, and idiomatic items were presented with ascending prosody. There were 6 items for each of the five core rules (30 test items) and 10 items for each of the two idiomatic rules (20 items). The test items were recorded in the same manner as the training exposure and were presented to all participants in the same random order. Note that participants in the *Core only* training condition were presented with items assessing their knowledge of the idiomatic construction rules. Although we did not expect control participants to have any knowledge of the construction, we included idiomatic construction items on their test to obtain a baseline of how participants would respond to the test items absent any exposure to the construction. If the *Core only* participants perform at chance on these test items (i.e., if they average about 5 out of 10 for each of the idiomatic construction rules), it will show that participants cannot use their

knowledge of the core of the grammar to distinguish good idiomatic sentences from bad ones. Thus, if participants in the other training conditions show above-chance performance on the idiomatic construction items, it suggests that they have learned something about the idiomatic sentences themselves.

Procedure. The participants were tested in pairs in a normally lit room in individual test 290
carrels. Auditory stimuli were presented via headphones. Each participant was merely informed that
they were going to see and hear a presentation of nonsense syllables accompanied by color-filled
geometric shapes. They were also told to pay as close attention to the presentation as possible. No
mention was made that the nonsense syllables constituted a language or that any pattern whatso- 295
ever was imbedded in the presentation. The training presentation was viewed five times in direct
succession. Participants were not informed that information was to be repeated.

After the training session participants were automatically presented instructions informing
them that they would now be presented with pairs of phrases that were similar to the ones that
they had heard in the training session. The instructions asked them to decide which of the two 300
phrases sound like it could have come from the previous training presentation. Participants
responded that the first or second phrase sounded like it came from the previous presentation by
pressing keys on a standard keyboard that corresponded to the first or second phrase presented.
The phrases were presented in succession with a short pause between them. The first and the
second positions were correct an equal number of times and presented as one randomized 305
sequence such that all participants received the same order of test items. This was done to assure
that, like the training phrases, no two syllables occurred in succession more than two times in a
given session. The entire procedure took approximately 40 minutes.

Results

The proportion of correct responses for each training condition and each rule type are presented 310
in Table 1. These data were analyzed with a 2 (Rule type: core or idiomatic) \times 2 (Training: *Core
only*, *Core + IC*) mixed-factor ANOVA, with Training as a between-participants factor. There
was a main effect of Rule type, $F(1, 42) = 23.98, p < .001$, with participants performing better
on the core rules ($M = .66$) than on the idiomatic rules ($M = .55$). There was also a main effect
of Training, $F(1, 42) = 7.38, p < .05$, with participants performing better in the *Core + IC* 315
condition ($M = .64$) than in the *Core only* condition ($M = .57$). The Rule type \times Training interaction
was significant, $F_{(1, 42)} = 16.53, p < .001$. Whereas the proportion of correct answers for the
core rules remained unchanged across conditions, $F < 1$, the proportion of correctly identified
idiomatic phrases was higher in the *Core + IC* condition ($M = .63$) than in the *Core only* condition
($M = .47$), $F(1, 42) = 22.28, p < .001$. The main effect of Training replicates Kaschak and Saffran's 320
(2006) result, but the Rule type \times Training interaction makes it clear that the overall pattern of
data observed here is distinct from that seen in the earlier study. Whereas Kaschak and Saffran's
participants improved their performance on both the core and idiomatic rules, the current set of
participants improved only on the idiomatic rules. Analysis of performance on individual rule
conditions across training conditions revealed no effects for the core rules (all F s < 1), and signifi- 325
cant differences for the idiomatic rules, Rule six: $F(1, 42) = 8.29, p < .01$; Rule seven: $F(1, 42) =$
 $14.87, p < .01$, with performance on these rules being superior in the *Core + IC* condition than in
the *Core only* condition.

TABLE 1
 Mean Proportion of Correct Responses by Rule Type
 and Training Condition in Experiment 1
 (Standard Deviations in Parentheses)

	<i>Training Condition</i>	
	<i>Core Only</i>	<i>Core + IC</i>
Core Rules	.67 (.11)*	.65 (.12)*
Idiomatic rules	.47 (.08)	.63 (.14)*
Rule 1	.58 (.22)	.62 (.22)*
Rule 2	.63 (.23)*	.58 (.20)
Rule 3	.82 (.25)*	.78 (.21)*
Rule 4	.80 (.16)*	.75 (.24)*
Rule 5	.52 (.20)	.53 (.18)
Rule 6	.47 (.17)	.63 (.19)*
Rule 7	.47 (.15)	.64 (.14)*

Note. Means marked with an asterisk (*) are significantly above chance.

Analysis of sentence characteristics. In addition to the analyses reported above, we also 330
 conducted an analysis to determine the extent to which the effects detailed above could be explained
 by differences in the surface characteristics of the grammatical and ungrammatical member of each
 test pair. We examined seven surface variables: length of the test item, legality of the first word of
 the item, legality of the last word of the item, chunk strength (the average of the input frequencies
 for all word pairs in each item), anchor strength (the composite of the input frequencies for the initial 335
 and final word pairs in each item), uniqueness (the number of word pairs in each item that never
 appeared in the training input), and similarity (the number of words by which each item differed
 from the most similar sentence in the input). All variables were continuous except legality of the
 first word of the item and legality of the last word of the item. We calculated values for these vari- 340
 ables for both members of each test pair. Then, for each test pair, we subtracted the values generated
 for the ungrammatical member of the pair from the values generated for the grammatical member of
 the pair. For the purposes of this analysis, we considered there to be 100 test items (50 test items in
 each of the two training conditions). Using the difference scores for each of the 100 test items, we
 performed a regression analysis in which the seven surface variables discussed above (length of test 345
 item, legality of the first word of the test item, legality of the last word of the item chunk strength,
 anchor strength, uniqueness, and similarity) were used as predictors in the analysis, as were Train-
 ing condition, Rule type, and the Training \times Rule type interaction. The dependent measure was the
 proportion of times that the item was answered correctly (i.e., the “grammatical” member of the test
 pair was selected as correct). The results of this analysis are presented in Table 2.

The regression model was significant, $F(10, 89) = 3.30, p < .01, r^2 = .27$. None of the seven 350
 surface variables significantly predicted the proportion of times that the test items were endorsed
 as correct. Training was also not a significant predictor of performance ($p = .18$), indicating that
 some of the variance explained by this variable in the main analyses presented above may in fact
 be explained in part by the surface variables. Rule type ($p < .001$) and the Training \times Rule type
 interaction ($p < .01$) were significant predictors. Thus, the overall picture that emerges from this 355

TABLE 2
Results of Regression Analyses for Experiments 1 and 2 (*B* values and *t* values)

	<i>Experiment 1</i>		<i>Experiment 2</i>	
	<i>B</i> value	<i>t</i> value	<i>B</i> value	<i>t</i> value
Legality (First)	-.047	<1	-.052	-1.18
Legality (Last)	.014	<1	.066	1.56
Length	-.051	-1.29	-.013	<1
Chunk Strength	-.030	<1	-.068	-1.73
Anchor Strength	.053	1.50	.068	2.30*
Uniqueness	.048	1.59	.015	<1
Similarity	.019	<1	.024	<1
Rule Type	-.549	-3.72*	-.297	-2.42*
Training	-.060	-1.37	-.057	-1.54
Rule × Training	.236	3.05*	.095	1.47

Note. Legality (First) = legality of the first word of the item; Legality (Last) = legality of the last word of the item; *t* values marked with an asterisk (*) are significant ($p < .05$).

analysis is that participants' ability to distinguish grammatical from ungrammatical members of each test pair is not entirely explained by the fact that the members of the test pairs differ on a number of surface variables.

Discussion

There are two important results from this study. First, the main effect of Training condition (with participants in the *Core + IC* condition outperforming participants in the *Core only* condition) replicates Kaschak and Saffran's (2006) finding that participants perform better on the test of rule knowledge when the idiomatic construction has been added to the training. Second, whereas the main effect of Training replicates Kaschak and Saffran's result, the significant interaction of Training and Rule type shows that performance in our experiment did not follow the same pattern as seen in the previous studies. Whereas participants in the *Core + IC* condition performed better than their counterparts in the *Core only* condition on the idiomatic rules, they did not outperform participants in the *Core only* condition on the core rules. Experiment 1 therefore failed to replicate Kaschak and Saffran's finding that idiomatic constructions can benefit the acquisition of the core rules of an artificial language.

Why did the addition of a visual reference world remove the beneficial effects of the idiomatic construction on the acquisition of the core rules of Kaschak and Saffran's (2006) language? One possibility is that our failure to replicate Kaschak and Saffran's result is due to the visual world adding to the overall difficulty of the learning task, but this does not appear to be the case: performance in our *Core only* condition was at approximately the same level as in the parallel conditions of Kaschak and Saffran's Experiments 1 and 2 (see Table 4)¹. Assuming that having

¹Our failure to replicate the benefits of an idiomatic construction in the training set does not seem to depend on the level of learning exhibited by the participants. In an unpublished study (reported by Jones & Kaschak, 2007), we replicated the current Experiment 1 with a shorter training duration. The overall level of learning was somewhat lower than in Kaschak and Saffran (2006), and the benefits of the idiomatic construction failed to emerge here as well.

a prosodic marker on the idiomatic construction is key to the effects observed by Kaschak and Saffran, another possibility is that the visual reference world drew participants' attention away from the prosodic cue (as in Valian and Levitt, 1996). Although there is nothing in the data to rule this possibility out, we feel that this explanation is unlikely. When the idiomatic construction was not marked with prosody in Kaschak and Saffran, not only did it not affect learning of the core rules, but participants also did not appear to learn the structure of the idiomatic construction itself. It seems that the idiomatic construction needed to stand out from the rest of the language in order to be noticed, and its benefits for the learning of the core rules followed from this. In the current study, although the idiomatic construction did not affect performance on the core rules, participants nonetheless demonstrated acquisition of the idiomatic rules. It therefore seems that the failure to replicate Kaschak and Saffran is not due to participants not noticing the idiomatic construction—participants were clearly aware of its presence in the language, even if this did not translate into better performance on the core rules.

A third possible explanation for our failure to replicate Kaschak and Saffran (2006) is related to the semantics provided by the visual reference world. The special meaning assigned to the idiomatic constructions comes from the referent assigned to the word *wug*. Since all of the words in the language were paired with a specific referent, it may be that participants did not interpret the referent assigned to *wug* as a special meaning. Rather, it may have appeared to be just another referent within the experiment. Indeed, the word *wug* and its accompanying referent appeared in the training set about as often as any particular D- or G-word, and as such may have simply been interpreted as one of several low-frequency lexical items. Thus, participants may have been aware of the presence of the idiomatic construction in the language (see discussion above) but may not have taken full advantage of the structural information provided by the contrast between the core and idiomatic sentences because they were not interpreting the idiomatic construction as conveying a different kind of meaning than the core sentences.

A fourth possible explanation for our failure to replicate Kaschak and Saffran (2006) is that, whereas the addition of a visual reference world did not change performance on the core rules overall, the addition of the visual reference world may have affected the acquisition of particular core rules in different ways across studies. We will examine this issue in more detail later in the paper, but a comparison between the Experiment 1 results for the *Core only* condition (see Table 1) and the results of Kaschak and Saffran's data from the same condition (see Table 4) suggest some interesting differences. Kaschak and Saffran's data show that the idiomatic construction provided benefits in learning the core rules on two rules in particular: Rule 3 and Rule 5. Participants in the *Core only* condition in our study performed at 82% correct on Rule 3, which is just below the level of performance seen in Kaschak and Saffran's *Idiomatic Construction + Prosody* condition (85% correct). Thus, there was little room for the idiomatic construction to improve performance on this rule. Participants in both of our conditions failed to perform above chance on Rule 5, and this absence of learning in general perhaps explains why the presence of the idiomatic construction did not boost learning on this rule.

The preceding discussion suggests that our failure to replicate Kaschak and Saffran (2006) may be attributed to either a lack of specialness or distinctiveness in the meaning of the idiomatic construction, or the fact that the visual reference world seemed to change performance on the core rules in a way that precluded the specific benefits that the idiomatic construction could provide to learners. Experiment 2 employs a modified version of the visual reference world in an effort to investigate these possibilities.

EXPERIMENT 2

Our tentative conclusion about Experiment 1 is that the addition of a visual reference world to Kaschak and Saffran's (2006) paradigm either failed to provide a distinctive meaning for the idiomatic construction, or changed the participants' approach to learning the artificial language in such a way that the potential effects of the idiomatic construction on the learning of the core rules was obscured. Experiment 2 replicates the basic design of Experiment 1 with an important change: whereas the visual reference world in Experiment 1 included a visual referent for every word in the language, the reference world used in Experiment 2 provided a visual referent for whole phrases rather than individual words (see Figure 2). Thus, there would be one symbol for an A-phrase or C-phrase regardless of whether the phrase contained one or two words.

Our motivation for changing the visual world in this regard was threefold. First, by marking phrase types rather than individual words, we aimed to give the learners a stronger cue to the structural elements (i.e., phrase types) of the language. We hoped that this change would improve learning of the C-phrases and perhaps allow the beneficial effects of the idiomatic construction seen in Kaschak and Saffran (2006) to emerge. Second, Kaschak and Saffran argued that the influence of the idiomatic construction on the acquisition of the core rules of the language depended on making comparisons of the use of different phrase types across the two sentence types in the language (c.f., Morgan et al., 1989). By making the visual reference world a stronger cue to the existence of phrase types, we hope to facilitate this cross-sentential comparison in an effort to reproduce Kaschak and Saffran's results. Third, by eliminating the one-word-one-referent relationship between the artificial language and the visual reference world for all words except *wug*, we hope to make the special meaning assigned to the idiomatic construction more distinctive, and thereby make this meaning a more effective learning cue within the language.

Method

Participants. The participants were 42 introductory psychology students from Florida State University. All were native speakers of English and received course credit for participation.

Materials. The materials were the same as those used in Experiment 1, except that the visual world mapped onto the artificial language in such a way that whole phrases (A-phrases, C-phrases, and E-words) were represented by a single colored shape (rather than every word being represented by a shape, as in Experiment 1). In cases where a phrase contained two words, the shape was centered above the two words. The color used in each shape was determined by the A-word, C-word, or E-word used in each phrase (i.e., the optional D- and G-words did not modulate the color given to the shape).

Procedure. The procedure was identical to that of Experiment 1.



FIGURE 2 Example training materials from Experiment 2.

Results

The proportion of correct responses for each training condition and each rule type is presented in Table 3. These data were analyzed with a 2 (Rule type: core or idiomatic) × 2 (Training: *Core only*, *Core + IC*) mixed-factor ANOVA, with Training as a between-participants factor. There was a main effect of Rule type, $F(1, 40) = 20.04, p < .001$, with participants performing better on the core rules ($M = .68$) than on the idiomatic rules ($M = .55$). The main effect of Training was not significant, $F < 1$. The Rule type × Training interaction was significant, $F(1, 40) = 5.88, p < .05$. Whereas the proportion of correct answers for the core rules remained unchanged across conditions, $F(1, 40) = 1.66, p = .21$, the proportion of correctly identified idiomatic phrases was higher in the *Core + IC* condition ($M = .59$) than in the *Core only* condition ($M = .50$), $F(1, 40) = 4.30, p < .05$.

Analysis of performance on individual rule conditions revealed hints of an interplay between the participants' knowledge of core and idiomatic rules, but the interplay was in the opposite direction as that seen in Kaschak and Saffran (2006). There were no significant differences in performance for the *Core only* and *Core + IC* conditions for Rules 1, 2, and 3. The difference between conditions for Rule 4 ($p = .066$) and Rule 5 ($p = .097$) approached significance, and in both cases participants performed worse on the rule items in the *Core + IC* condition than in the *Core only* condition. There were no differences across training conditions for both idiomatic rules, Rule 6: $F(1, 40) = 1.44, p = .24$; Rule 7: $F(1, 40) = 2.57, p = .12$. The fact that performance on core Rules 4 (C-phrases come before E-phrases) and 5 (if there is a G-word, there must be a C-word) was worse when participants' training included the idiomatic construction, and that performance on idiomatic Rules 6 (E-words precede C-words) and 7 (sentence-final C-words are not accompanied by G-words) did not improve given exposure to the idiomatic construction, suggests that the presence of the idiomatic construction at training produced some confusion about the relationship between C-phrases and E-words, and between C and G words.

TABLE 3
Mean Proportion of Correct Responses by Rule Type
and Training Condition in Experiment 2
(Standard Deviations in Parentheses)

	Training Condition	
	Core Only	Core + IC
Core Rules	.71 (.17)*	.65 (.12)*
Idiomatic rules	.50 (.14)	.59 (.12)*
Rule 1	.65 (.24)*	.69 (.22)*
Rule 2	.67 (.20)*	.60 (.20)*
Rule 3	.79 (.22)*	.81 (.16)*
Rule 4	.81 (.29)*	.66 (.22)*
Rule 5	.62 (.24)*	.49 (.24)
Rule 6	.45 (.14)	.51 (.17)
Rule 7	.56 (.25)	.67 (.19)*

Note. Means marked with an asterisk (*) are significantly above chance.

Analysis of sentence characteristics. As in Experiment 1, we performed a regression analysis to determine whether test performance could be explained by the fact that the members of each test pair differed on a number of surface variables. The results of this analysis are presented in Table 2. The regression model was significant, $F(10, 89) = 4.60, p < .001, r^2 = .34$. Whereas most of the surface variables were again not significant, anchor strength ($p < .05$) was a significant predictor of test performance, and chunk strength approached significance ($p = .09$). Rule type was a significant predictor ($p < .05$), but neither Training nor the Training \times Rule type interaction reached significance. Thus, it appears that surface variables are playing more of a role in determining test performance in this experiment than in Experiment 1.

In cases where analyses of artificial language learning data show that surface variables are significant predictors of test performance, it raises the question of what exactly the participants are learning about the language. In our view, what participants acquire in experiments such as these is a mixture of both knowledge about particular training strings (and other surface features of the language) and knowledge about more abstract features of the language (such as the hierarchical structure of phrase types). This knowledge most likely has implicit and explicit features (e.g., Perruchet & Pacteau, 1990; Dienes, Broadbent, & Berry, 1991). Knowledge of both the surface features and abstract characteristics of the language are available to support test performance.² This situation has parallels to what is seen in the language acquisition of children. As discussed by Tomasello (2003), children's developing knowledge of language is a combination of both "surface" knowledge (e.g., item-based constructions, fixed linguistic routines, and so on) and more abstract knowledge of syntactic principles (e.g., knowledge of the transitive construction in English). Indeed, the interplay between such surface-based and abstract knowledge is a central topic in the study of language (e.g., Tomasello, 2003; Fillmore et al., 1988). As we unfortunately did not include a broad enough battery of tests in our experiments to develop a detailed picture of the surface-based and abstract structural knowledge that our participants acquired beyond what is revealed by the regression analyses described above, a full picture of what knowledge learners acquire from languages and training such as ours must await further exploration.

Discussion

The results of Experiment 2 generally replicate the outcome of Experiment 1. Whereas performance on the idiomatic rules improved between the *Core only* and *Core + IC* conditions, performance on the core rules did not. The modified visual reference world employed in this experiment did raise performance relative to the first study (participants in the *Core only* condition performed above chance on all core rules here, but only did so on three of the five core rules in Experiment 1), but this did not lead to a replication of Kaschak and Saffran's (2006) finding that the presence of an idiomatic construction during training can improve learning of the core

²Although the individual surface variables are generally not significant predictors of test performance, it is important to note that the variables, when considered together, do significantly predict test performance. This is shown by running regression analyses on Experiment 1 and 2 in which the surface variables are entered in the first step of the analysis, and Training, Rule type, and the Training \times Rule type interaction are entered in the second step of the analysis. For both Experiments 1 and 2, the regression model significantly predicts test performance after the first step. In both cases, the addition of Training, Rule type, and the Training \times Rule type interaction to the model produces a significant change in r^2 relative to the model with surface variables only.

rules of the language. In fact, the data suggest that, if anything, the presence of the idiomatic construction in the training set was hurting performance on the core rules, particularly Rules 4 and 5.

COMPARISON OF PRESENT RESULTS TO KASCHAK AND SAFFRAN

In an effort to get a better understanding of why the addition of a visual world to our training paradigm resulted in a failure to replicate Kaschak and Saffran’s (2006) main findings, we conducted a combined analysis of Kaschak and Saffran’s Experiments 1 and 2 and the two experiments reported here. We used the data from the *Core only* and *Idiomatic Construction + Prosody* conditions from Kaschak and Saffran’s experiments (we converted the data reported in Kaschak and Saffran to percentages for the purposes of this analysis), as these are the data that most directly match the training conditions present in the current experiments. The overall data for core rules and idiomatic rules (for Kaschak and Saffran’s data, we collapsed the idiomatic rules with ascending prosody and descending prosody into a single category), in addition to the data for each individual rule, were then analyzed using a 2 (Modality: Auditory training only versus Auditory + Visual training) × 2 (Training: *Core only* versus *Core + IC*) ANOVA with both factors being between-participants factors. Of particular interest in these analyses are cases where there is a Modality × Training interaction, suggesting that the change in performance between the *Core only* and *Core + IC* conditions is different for the Auditory training-only participants (i.e., those from Kaschak and Saffran) and the Auditory + Visual-training participants (i.e., participants from the current experiments). The relevant means for this analysis are presented in Table 4.

TABLE 4
 Mean Proportion of Correct Responses by Modality, Training Condition, and Rule Type in Kaschak and Saffran (2006) and Experiments 1 and 2 (Standard Deviations in Parentheses)

	<i>Modality and Training Condition</i>			
	<i>Auditory-Only Training</i>		<i>Audio + Visual Training</i>	
	<i>Core Only</i>	<i>Core + IC</i>	<i>Core Only</i>	<i>Core + IC</i>
Core Rules	.68 (.11)	.75 (.09)	.69 (.14)	.65 (.12)
Idiomatic rules	.56 (.14)	.65 (.15)	.49 (.12)	.61 (.13)
Rule 1	.78 (.23)	.84 (.16)	.62 (.23)	.65 (.22)
Rule 2	.64 (.21)	.65 (.22)	.65 (.22)	.59 (.20)
Rule 3	.71 (.24)	.85 (.16)	.80 (.23)	.79 (.18)
Rule 4	.65 (.18)	.62 (.23)	.81 (.23)	.71 (.23)
Rule 5	.60 (.21)	.79 (.20)	.57 (.22)	.51 (.21)
Rule 6	.59 (.19)	.66 (.21)	.46 (.15)	.57 (.19)
Rule 7	.52 (.17)	.64 (.14)	.51 (.21)	.65 (.16)

Note. Audio-only training condition data are from Kaschak and Saffran’s (2006) Experiments 1 and 2. Audio + Visual training condition data are the combined results of the present Experiments 1 and 2.

Analysis of Core and Idiomatic Rules

In the analysis of the core rules, the main effect of Training was not significant, $F < 1$, suggesting that performance in the *Core only* condition ($M = .68$) did not differ from performance in the *Core + IC* condition ($M = .70$). There was a main effect of Modality, $F(1, 162) = 5.46, p < .05$, 545 with participants in the Auditory-only training condition ($M = .71$) outperforming participants in the Auditory+Visual training condition ($M = .67$). The Modality \times Training interaction was significant, $F_{(1, 162)} = 9.40, p < .01$. Whereas participants in the Auditory-only training condition performed better in the *Core + IC* condition ($M = .75$) than in the *Core only* condition ($M = .68$), 550 $F(1, 78) = 10.85, p < .01$, participants in the Auditory + Visual training condition did not, $F(1, 84) = 1.82, p = .18$. These results confirm the overall conclusion that the learning of the core rules benefits from the presence of the idiomatic construction in the Auditory-only training condition, but not in the Auditory+Visual training condition.

Analysis of the idiomatic rules revealed a main effect of Training, $F(1, 162) = 26.60, p < .001$, with performance being better in the *Core+IC* condition ($M = .63$) than in the *Core only* condition 555 ($M = .52$). The main effect of Modality was also significant, $F(1, 162) = 6.38, p < .05$, with participants in the Auditory-only training condition performing better on the idiomatic rules ($M = .60$) than participants in the Audio+Visual training condition ($M = .55$). This main effect appears to be driven by Kaschak and Saffran's (2006) Experiment 2, where performance on the idiomatic 560 rules was much higher than in their Experiment 1 and in either of the experiments reported here. The Modality \times Training interaction was not significant, $F < 1$, showing that performance on the idiomatic rules changes in a similar way between the *Core only* and *Core + IC* condition in both modalities.

Analysis of the Individual Rules

Analysis of the Rule 1 items (Sentences must have an A-phrase) shows a main effect of Modality, 565 $F(1, 162) = 26.94, p < .001$, with participants performing better on this rule in the Auditory-only condition ($M = .81$) than in the Audio+Visual condition ($M = .64$). It has been noted that language learners acquire elements of their linguistic input that appear near the end of sentences more readily than elements of their input that appear earlier in the sentences (e.g., Echols & Newport, 1992; Echols & Marti, 2004; Slobin, 1973; but see Thompson & Newport, 2007, for a 570 counterexample), and it is possible that the presence of a visual world (and all of the additional training information that needs to be observed) increased this tendency in our participants and thereby hurt performance on this rule (see the discussion of Rule 4 below). The main effect of Training was not significant, $F(1, 162) = 2.33, p = .13$. The Modality \times Training interaction was not significant, $F < 1$, indicating that performance on Rule 1 items does not contribute to the difference in 575 performance between the *Core only* and *Core + IC* training conditions across modalities.

Analysis of the Rule 2 items (A-words precede D-words, and C-words precede D-words) revealed no significant effects, F values $< 1.29, p > .25$.

Analysis of the Rule 3 items (Sentences must contain an E-word) revealed a main effect of Training, $F(1, 162) = 4.32, p < .05$, with participants performing better in the *Core + IC* condition 580 ($M = .82$) than in the *Core only* condition ($M = .76$). There was no main effect of Modality, $F < 1$. The Modality \times Training interaction was significant, $F_{(1, 162)} = 5.45, p < .05$. Whereas participants in the Audio-only training condition performed better in the *Core + IC* condition

($M = .85$) than in the *Core only* condition ($M = .71$), $F(1, 78) = 9.69$, $p < .01$, participants in the Audio+Visual training condition showed no difference across training conditions, $F < 1$. Thus, the idiomatic construction boosted performance on this rule in the Audio-only training condition, but did not in the Audio+Visual training condition. As discussed earlier, the lack of an effect in the Audio+Visual condition may be due to the fact that participants in the *Core only* condition were already performing quite well (80% correct) on these test items. Indeed, the fact that our participants were performing well on this rule (which tests knowledge of the sentence-final element of the language) in the *Core only* condition supports the claim that the learners in these experiments were exhibiting a tendency to learn sentence-final elements of the language better than elements of the language at other sentence positions.

Analysis of the Rule 4 items (C-phrases precede E-words) showed a marginally significant effect of Training, $F(1, 162) = 3.78$, $p = .054$, with participants performing better in the *Core only* training condition ($M = .73$) than in the *Core + IC* training condition ($M = .66$). This effect suggests that reversing the order of the C-phrase and E-word in the idiomatic construction had the effect of confusing participants as to the proper order of these linguistic elements in the core language. There was also a main effect of Modality, $F(1, 162) = 12.59$, $p < .01$, with participants performing better in the Audio + Visual condition ($M = .76$) than in the Audio-only condition ($M = .63$). The fact that participants in the Audio + Visual training condition performed better on this rule than participants in the Audio-only condition lends further credence to our hypothesis that the visual world may have strengthened the “end first” trend that has been observed in language learning tasks: they are performing better on rules relevant to the end of the sentence (Rule 4), and worse on rules relevant to the beginning of the sentence (Rule 1). The Modality \times Training interaction was not significant, $F < 1$.

Analysis of the Rule 5 items (If there is a G-word, there must be a C-word) showed a marginally significant effect of Training, $F(1, 162) = 3.82$, $p = .052$, with participants in the *Core + IC* training condition ($M = .65$) outperforming participants in the *Core only* training condition ($M = .59$). The main effect of Modality was also significant, $F(1, 162) = 22.82$, $p < .001$, with participants in the Audio-only training condition ($M = .70$) outperforming participants in the Audio+Visual training condition ($M = .54$). There was also a significant Modality \times Training interaction, $F(1, 162) = 13.94$, $p < .001$. Participants in the Audio-only training condition performed better on Rule 5 in the *Core + IC* condition ($M = .79$) than in the *Core only* condition ($M = .60$), $F(1, 78) = 16.61$, $p < .001$. There was no difference across conditions for participants in the Audio+Visual training condition, $F(1, 84) = 1.55$, $p = .22$, and if anything performance was worse in the *Core + IC* condition than in the *Core only* condition. As with Rule 3, the idiomatic construction boosted performance on Rule 5 in the Audio-only training condition but did not in the Audio + Visual training condition. In addition, the overall pattern observed for Rule 5 may be a further manifestation of the tendency for participants in the current experiments to learn sentence-final elements of the language better than other elements of the language. Participants in our study performed worse on this rule (which tests sentence-medial information) in the current study than the participants tested by Kaschak and Saffran (2006), and performance on this rule was worse than performance on those rules that test sentence-final information (Rules 3 and 4).

Analysis of Rule 6 (E-words come before C-phrases in the idiomatic construction) showed a main effect of Training, $F(1, 162) = 9.05$, $p < .01$. As expected, participants performed better in the *Core + IC* condition ($M = .61$) than in the *Core only* condition ($M = .53$). There was also a main effect of Modality, $F(1, 162) = 13.58$, $p < .001$, with participants performing better in the

Audio-only condition ($M = .62$) than in the Audio+Visual condition ($M = .52$). This effect may have to do with the “end first” learning pattern noted above. The ordering of C-phrases and E-words is opposite in the core sentences (tested in Rule 4) and idiomatic sentences (tested in Rule 6). Whereas the C-phrase–E-word sequence appears at the end of the core sentences, it appears at the beginning of the idiomatic sentences. Thus, the stronger end-of-sentence learning in the Audio + Visual condition may have led participants to learn the C-phrase–E-word ordering more strongly than the opposite (idiomatic) ordering, producing superior performance on Rule 4 (core ordering), but worse performance on Rule 6 (idiomatic ordering).

Analysis of Rule 7 (Sentence-final C-words are not accompanied by a G-word) revealed the expected main effect of Training, $F(1, 162) = 22.20, p < .001$, with participants performing better in the *Core + IC* condition ($M = .64$) than in the *Core only* condition ($M = .52$). The effect of Modality and the Modality \times Training interaction were not significant, (F values < 1).

Summary and Discussion of Analyses

Several patterns emerge from these analyses. First, as discussed with the results of Experiment 1, a major difference between our results and those of Kaschak and Saffran (2006) is that whereas the presence of the idiomatic construction at training improved performance on Rules 3 and 5 in the previous experiments, they did not do so here. Performance on Rule 3 did not change much across conditions in our experiments (likely because performance was already quite good in the *Core only* condition), and, if anything, our experiments showed that performance on Rule 5 became worse when the idiomatic construction was added to the training set.

A second pattern that emerged from the cross-experiment analyses is that our participants seemed to be performing quite well on core rules testing sentence-final elements of the language (Rules 3 and 4, with performance in the *Core only* condition being around 80%), and comparatively worse on core rules testing sentence-initial elements of the language (Rule 1, with performance in the *Core only* condition at 62%). The opposite pattern was seen for Kaschak and Saffran’s data: performance was better on Rule 1 (78%) than on Rules 3 and 4 (68%). Thus, the visual reference world employed in our studies may have changed the way participants approached the learning task (compared to how participants in the Auditory-only condition approached the task), and this in turn affected the potential interplay between the participants’ knowledge of the idiomatic construction and the core sentences.

Why does the visual reference world produce an “end first” pattern of learning in our studies that was absent from Kaschak and Saffran’s (2006) experiments? At present, we do not have a good answer to this question. Serial position effects in learning have been shown to be sensitive to the modality in which the training stimuli are presented (e.g., Glenberg & Swanson, 1986). For example, Conway and Christiansen (2005) trained participants on a serial response task, and demonstrated that whereas auditory training produced a learning advantage for sequence-final elements of their input sequences, this advantage was absent from training in the visual and tactile modalities (see Saffran, 2002, for further evidence of modality differences in statistical learning). Conway and Christiansen’s (2005) finding of an enhanced recency effect in auditory training conditions is the opposite of what we are reporting here, but (a) there are important differences between the nature of the stimuli used in the two studies (e.g., an artificial language versus a simpler serial response sequence), and (b) the current studies used multimodal training (audition + vision) rather than a single modality at training. In the realm of language acquisi-

tion, some studies show learning advantages for sentence-initial or sentence-final elements of languages (e.g., Morgan, Meier, & Newport, 1987; Newport, Gleitman, & Gleitman, 1977), and other studies do not show serial position effects (e.g., Thompson & Newport, 2007). As there are many differences across these studies (e.g., the nature and complexity of the linguistic input that is used, the presence or absence of visual reference worlds, and the manner in which the visual reference world maps onto the training language), it is not always obvious how to interpret such discrepant results. Developing a principled account of how the nature of one's training in statistical learning-type tasks affects learning outcomes is clearly going to be a necessary step in determining how artificial language learning tasks such as the one used here can be employed in the service of understanding natural language acquisition. Unfortunately, the data at hand in the present studies do little to shed light on this matter. A closer examination of the relationship between input modalities and language learning, and of the ways that the mapping between visual reference worlds and linguistic input can affect learning, will be needed to resolve this important issue.³

GENERAL DISCUSSION

The goal of these experiments was to assess whether the inclusion of a special meaning for an idiomatic construction would affect learners' ability to use the information provided by that construction to aid their acquisition of the core rules of the training language (as was seen in Kaschak & Saffran, 2006). The results of this endeavor are somewhat mixed. The present experiments replicate the finding that learners are capable of acquiring an artificial language that contains both core and idiomatic sentence types—in both experiments, participants in the *Core + IC* condition performed above chance overall on both the core and idiomatic rules. However, the present experiments failed to replicate Kaschak and Saffran's finding that the presence of an idiomatic construction in one's training set can improve learning of the core rules of the language.

We have considered two reasons why participants' exposure to the idiomatic construction failed to improve their acquisition of the core rules of the language. The first reason for our failure to replicate Kaschak and Saffran (2006) may be that our participants displayed an "end first" learning pattern, and this pattern negated the value of the cues that the idiomatic construction provided to the structure of the core of the language. Whereas the data presented in Table 4 suggest that different patterns of learning were observed in our studies and in Kaschak and Saffran's studies, it remains unclear why this happened. A conservative conclusion to be drawn from the present data is that visual referent worlds can direct learner's attention to different aspects of the

³One possibility that has been suggested to us is that the "end first" pattern observed in our experiments may be a function of the strategies employed by participants at test. If participants focus on the last word of the test strings in order to make their decisions about which items are grammatical, it would lead to an overall performance advantage for rules testing sentence-final elements of the language rather than sentence-initial elements of the language. This is an intriguing possibility, but it is not clear that this alternative is currently distinguishable from the explanation that is offered here. For instance, participants may have focused on the last word of the test strings because their learning of the sentence-final elements of the language was superior to their learning of the sentence-initial elements of the language. Furthermore, since Kaschak and Saffran (2006) used the same training and test stimuli as were used in the present studies, the "last word" strategy would have been available to their participants as well. It is not clear why participants would have adopted the strategy here but not in the prior experiments.

input they receive during training, which in turn can affect the degree to which the learners will make use of different cues to linguistic structure (c.f., Valian & Levitt, 1996). This is an issue that deserves further investigation. 705

A second reason for our failure to replicate Kaschak and Saffran (2006) may be that the special meaning provided to our idiomatic construction was not “special” enough to serve as an effective learning cue. The special meaning of our idiomatic construction was a specific visual referent that was associated with the word *wug* (which itself only appeared in the idiomatic sentence type). Participants would have seen this visual referent somewhat infrequently throughout the experiment, and would have seen it just as often as they saw the visual referents for D-words and G-words in Experiment 1. Thus, the meaning of the idiomatic construction may not have been special or distinctive enough to have much of an effect on learning. 710

We undertook this exploration of the extent to which meaning affects the effectiveness of idiomatic constructions as a cue to linguistic structure in part because meaning is a central aspect of such constructions (Fillmore et al., 1988; Kay & Fillmore, 1999). Whereas it would be tempting to conclude from our results that the special meanings of idiomatic constructions do not play an important role in language learning, we believe this conclusion is premature. As discussed above, it is entirely possible that the meaning we assigned to the idiomatic construction was not special enough to affect learning. It is also possible that the meaning assigned to the idiomatic construction was not of the right sort to affect language learning. Fillmore et al. (1988), Kay and Fillmore (1999), and Lambrecht (1990) argue that the meaning of idiomatic constructions is often defined within a particular context of use. The Incredulous Response Construction is typically used to ridicule an idea that has just been presented within the current discourse: one would only say, “Tom be a doctor!?” if the notion that Tom was planning to be (or could be) a doctor had been presented in the recent past. Similarly, the *let alone* construction is used as a rejoinder to a recently proposed proposition: one would only say, “Tom didn’t make it to Chicago, let alone New York!” if it had been previously suggested that Tom had made it to New York. The meaning of the idiomatic construction used in the present studies did not bear any such relation to the sentences that directly preceded it within the training set. It is possible that modifying the training set such that the meaning of the idiomatic construction is related to the meaning of the immediately preceding sentence(s) in the training set would allow the beneficial effects of the idiomatic construction on the learning of the core rules of the language to emerge. Yoking the meaning of a core and idiomatic sentence in such a way might benefit learning of the core rules of the language by making the relationship between core and idiomatic sentence types more explicit for the learner. Thus, it may not be meaning, per se, that will function as a cue to language learning in cases such as the one studied here. Rather, it may be a combination of the variation in meaning between core and idiomatic sentence types together with the juxtaposition of these sentence types in a connected discourse that can provide the learner with a useful cue to the structure of their language. 715 720 725 730 735 740

Thus, our failure to replicate Kaschak and Saffran’s (2006) main finding is likely the result of two factors: the “end first” learning pattern of the participants in our studies, and the lack of distinctness of the special meaning assigned to the idiomatic construction. Although this conclusion is somewhat equivocal, it raises the issue of how and when different cues to linguistic structure (e.g., changes in transitional probabilities produced by syntactic movement; meaning-related changes in syntax, and so on) function during language learning, and which (if any) of these cues can boost learning when presented alone (see Thompson and Newport, 2007, for a discussion). 745

Further studies of the role of idiomatic constructions in language learning should employ a range of structural deviations from the core grammar of the language, as well as a range of special semantic and pragmatic features for the constructions, in an effort to delineate the conditions under which particular language learning cues aid the language acquisition process. 750

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APPENDIX A

The training and test items from Experiments 1 and 2 are presented below. The test items are the same for both experiments.

Training Set

- mib pell lum dupp (ADCE) 835
- hep lum vot (ACE)
- rud pell sig pilk dupp (ADCGE)

biff klor neb jux (ADCE)	
mib sig tiz vot (ACGE)	
hep pell cav pilk vot (ADCGE)	840
mib lum dupp (ACE)	
rud klor lum loke (ADCE)	
jux neb wug cav (EC WUG C)	
hep neb vot (ACE)	
mib cav dupp (ACE)	845
rud pell sig vot (ADCE)	
biff neb pilk jux (ACGE)	
rud klor cav vot (ADCE)	
jux lum tiz wug sig (ECG WUG C)	
biff klor cav tiz dupp (ADCGE)	850
mib neb loke (ACE)	
rud lum pilk neb dupp (ADCGE)	
biff pell sig vot (ADCE)	
vot neb pilk wug lum (ECG WUG C)	
biff sig vot (ACE)	855
hep cav jux (ACE)	
mib klor cav dupp (ADCE)	
hep pell sig jux (ADCE)	
hep klor neb pilk loke (ADCGE)	
loke sig wug neb (EC WUG C)	860
biff lum tiz dupp (ACGE)	
hep klor neb jux (ADCE)	
biff sig loke (ACE)	
mib pell neb loke (ADCE)	
hep cav pilk jux (ACGE)	865
mib lum tiz loke (ACGE)	
rud sig tiz loke (ACGE)	
dupp lum wug cav (EC WUG C)	
hep neb tiz dupp (ACGE)	
mib sig pilk jux (ACGE)	870
rud lum jux (ACE)	
mib sig dupp (ACE)	
loke sig pilk wug lum (ECG WUG C)	
rud cav vot (ACE)	
mib pell neb tiz jux (ADCGE)	875
hep klor lum vot (ADCE)	
biff sig tiz dupp (ACGE)	
hep sig loke (ACE)	
mib cav tiz vot (ACGE)	
biff pell sig tiz loke (ADCGE)	880
mib klor lum pilk jux (ADCGE)	
dupp cav pilk wug sig (ECG WUG C)	

rud lum loke (ACE)	
rud neb jux (ACE)	
biff lum jux (ACE)	885
hep sig dupp (ACE)	
biff pell lum vot (ADCE)	
rud neb tiz vot (ACGE)	
vot cav wug neb (EC WUG C)	
hep lum pilk loke (ACGE)	890
biff neb tiz loke (ACGE)	
rud klor sig jux (ADCE)	

Test Items

Core Rules

Rule 1: All sentences must have an A-phrase.	895
rud klor neb tiz vot (ADCGE) / neb tiz vot (CGE)	
biff cav dupp (ACE) / cav dupp (CE)	
hep sig tiz dupp (ACGE) / sig tiz dupp (CGE)	
mib pell lum pilk jux (ADCGE) / lum pilk jux (CGE)	
rud cav pilk loke (ACGE) / cav pilk loke (CGE)	900
hep klor neb vot (ADCE) / klor neb vot (DCE)	
Rule 2: In an A-phrase, A-words precede D-words; in a C-phrase, C-words precede G-words.	
biff klor lum tiz loke (ADCGE) / biff tiz lum klor loke (AGCDE)	
biff pell lum pilk vot (ADCGE) / biff pilk lum pell vot (AGCDE)	
mib klor sig tiz vot (ADCGE) / mib tiz sig klor vot (AGCDE)	905
hep pell neb pilk dupp (ADCGE) / hep pilk neb pell dupp (AGCDE)	
rud klor neb tiz jux (ADCGE) / rud tiz neb klor jux (AGCDE)	
rud pell cav tiz jux (ADCGE) / rud tiz cav pell jux (AGCDE)	
Rule 3: Sentences must have an E-word.	
mib sig tiz jux (ACGE) / mib sig tiz (ACG)	910
hep klor cav dupp (ADCE) / hep klor cav (ADC)	
biff sig pilk dupp (ACGE) / biff sig pilk (ACG)	
rud neb pilk jux (ACGE) / rud neb pilk (ACG)	
mib pell sig loke (ADCE) / mib pell sig (ADC)	
biff neb pilk vot (ACGE) / biff neb pilk (ACG)	915
Rule 4: C-phrases must precede E-words.	
rud neb vot (ACE) / rud vot neb (AEC)	
mib sig vot (ACE) / mib vot sig (AEC)	
hep neb loke (ACE) / hep loke neb (AEC)	
hep pell lum jux (ADCE) / hep pell jux lum (ADEC)	920
biff pell neb dupp (ADCE) / biff pell dupp neb (ADEC)	
rud klor sig pilk loke (ADCGE) / rud klor loke sig pilk (ADEC)	

Rule 5: If there is a G-word, there must be a C-word.

biff pell cav pilk loke (ADCGE)/ biff pell pilk loke (ADGE)
 rud pell lum tiz loke (ADCGE)/ rud pell tiz loke (ADGE) 925
 hep klor sig pilk jux (ADCGE)/ hep klor pilk jux (ADGE)
 biff klor lum tiz vot (ADCGE)/ biff klor tiz vot (ADGE)
 mib pell lum pilk dupp (ADCGE)/ mib pell pilk dupp (ADGE)
 mib klor neb tiz dupp (ADCGE)/ mib klor tiz dupp (ADGE)

Idiomatic Construction Rules 930

Rule 6: An E-word and a C-phrase (in that order) precede *wug*.

loke neb pilk wug sig (ECG WUG C)/ neb pilk loke wug sig (CGE WUG C)
 dupp neb wug cav (EC WUG C) / dupp wug cav (E WUG C)
 dupp lum tiz wug cav (ECG WUG C)/ lum tiz dupp wug cav (CGE WUG C)
 jux sig pilk wug neb (ECG WUG C)/ sig pilk jux wug neb (CGE WUG C) 935
 vot neb wug lum (EC WUG C)/ neb vot wug lum (CE WUG C)
 dupp neb wug sig (EC WUG C)/ neb dupp wug sig (CE WUG C)
 loke sig tiz wug neb (ECG WUG C)/ sig tiz like wug neb (CGE WUG C)
 vot lum pilk wug cav (ECG WUG C)/ lum pilk wug cav (CG WUG C)
 loke neb wug lum (EC WUG C)/ neb loke wug lum (CE WUG C) 940
 jux lum wug neb (EC WUG C)/ lum jux wug neb (CE WUG C)

Rule 7: The final C-phrase must be a C-word only (no G-words in sentence final position).

dupp sig pilk wug cav (ECG WUG C)/ dupp sig pilk wug loke (ECG WUG E)
 vot sig wug cav (EC WUG C)/ vot sig wug tiz (EC WUG G)
 loke neb wug cav (EC WUG C)/ loke neb wug cav vot (EC WUG CE) 945
 jux cav wug lum (EC WUG C)/ jux cav wug tiz (EC WUG G)
 jux cav pilk wug sig (ECG WUG C)/ jux cav pilk wug pilk (ECG WUG G)
 dupp neb wug neb (EC WUG C)/ dupp neb wug neb tiz (EC WUG CG)
 vot cav wug sig (EC WUG C)/ vot cav wug sig pilk (EC WUG CG)
 loke lum wug cav (EC WUG C)/ loke lum wug cav pilk (EC WUG CG) 950
 dupp cav wug lum (EC WUG C)/ dupp cav wug lum tiz (EC WUG CG)
 jux sig wug neb (EC WUG C)/ jux sig wug neb pilk (EC WUG CG)