Statistical Learning of Syntax (Among Other Higher-Order Relational Structures)

by

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Abstract

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Fluency in a language requires understanding abstract relationships between types or classes of words – the syntax of language. The learning problem has seemed so overwhelming to some that – for a long time – the dominant view was that much of this structure was not or could not, in fact, be learned (e.g. Crain, 1992; Wexler, 1991). The object of my thesis work is to examine whether and under what conditions we can learn one particular aspect of language often assumed to be innate, namely phrase structure. In three experiments, I examine acquisition of category relationships (i.e. phrases) from distributional information in the context of two miniature artificial language paradigms – one auditory and one visual. In this set of studies, I find that learners are able to generalize on the basis of strong distributional cues to phrase information with the assistance of a non-distributional cue to category membership. While it was possible to learn some aspects of phrase structure from distributional information alone, in a large language the non-distributional cue appears to enable high-order abstract generalizations that depend on category membership and category relatedness. The third experiment creates a visual analogue to the auditory phrase structure learning paradigm. Learning outcomes in the visual system were commensurate with those from the auditory artificial language, suggesting the ability to learn higher-order relationships from distributional information is largely modality independent.

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Both of those things turned out to be wrong, and I am overwhelmingly glad that they did. Carla's son, Hadrian, was born almost exactly halfway through my career at Berkeley, and he has made everyone's life that much sweeter. And, of course, I ended up completing all five years here at Berkeley, and I am glad for this as well because it has been a wonderful home.

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1. Introduction

First language learners face what has often been described as a seemingly insurmountable task. Fluency in a language requires understanding the sounds that make up that language, how the sounds get put in to words, what those words mean, as well as how words are permissibly put together. The learning problem has seemed so overwhelming to some that – for a long time – the dominant view was that much of this structure was not or could not, in fact, be learned (e.g. Crain, 1992; Wexler, 1991). The object of the present thesis is to examine whether and under what conditions we can learn one particular aspect of language often assumed to be innate, namely phrase structure.

In three experiments, I examine acquisition of category relationships (i.e. phrases) from distributional information in the context of two miniature artificial language paradigms – one auditory and one visual. In this set of studies, I find that learners are able to generalize on the basis of strong distributional cues to phrase information with the assistance of a non-distributional cue to category membership. While it was possible to learn some aspects of phrase structure from distributional information alone, in a large language the non-distributional cue appears to enable high-order abstract generalizations that depend on category membership and category relatedness. The third experiment creates a visual analogue to the auditory phrase structure learning paradigm. Learning outcomes in the visual system were commensurate with those from the auditory artificial language, suggesting the ability to learn higher-order relationships from distributional information is largely modality independent.

1.1. Syntax

Arguments for innateness have focused on abstract, higher-order relationships that occur in languages, namely the syntax of language. There are many different aspects to syntax, but at its core, syntax involves *relationships* between *types or classes* of words. To give an example from English, take the following sentence: *The cat batted the yarn.* The word 'cat' is a member of the word class or category, noun, and it has a relationship with the word 'the' in front of it, its determiner. The words 'the' and 'yarn' express a similar relationship. 'The' and 'cat' are ordered as they are because determiners precede nouns within the noun phrase, not because of anything to do with the particular words. Similarly for 'the' and 'yarn.' Moreover, the sentence as a whole is organized as it is because subject noun phrases precede verb phrases, and the verb precedes the object noun phrase within the verb phrase.

There is a great deal of evidence for these abstract constituents. For instance, constituent pairs of word classes tend to hang together and form meaningful units – like the noun phrases mentioned above – a quality that has been illustrated by replacement tests. To reuse the sentence *The cat batted the yarn,* in order to replace the entity being batted with a proform, both 'the' as well as 'yarn' are substituted (e.g. The cat batted *it.*) The same property applies to more complex constituents: *The cat that swallowed the canary batted the yarn* becomes *It batted the yarn* or *He batted the yarn.*

The ordering of these components, depending on the language, can establish roles through a canonical or basic fixed order. The above sentence, in English, establishes 'the cat' as the subject or agent of the sentence and 'the yarn' as the object acted upon because English has Subject-Verb-Object ordering. For many languages, such as the Basque language of northern Spain, both noun phrases precede the verb for a Subject-Object-Verb ergative construction. For example, *Martinek egunkariak erosten dizkit* translates to "Martin" (Subject), then, "newspapers" (Object), then, "buys them for me" (Verb + auxiliary), for the English sentence "Martin buys the newspapers for me." A smaller percentage of languages have verb initial ordering. For example, in Welsh, *Agorodd y dyn y drws* translates to "opened" (Verb), then, "the man" (Subject), then, "the door" (Object), for "The man opened the door" (King, 1993). Constituent ordering is not indicative to grammatical role in all languages, however. In some languages, ordering provides information about topic or focus, and so, while not being as a fixed indicator to role, is still important. For example, in Russian, all three of these examples are potential orderings for "The teacher reads the book": (1) Učitel'nica čitæt knigu (teacher (Subject) read (Verb) book (Object)), (2) Knigu čitæt učitel'nica (book (Object) read (Verb) teacher (Subject)), or (3) Čitæt učitel'nica knigu (read (Verb) teacher (Subject) book (Object)) (Van Valin, 2001). Most relevantly for the learning context, regardless of which construction is normative, the relationships within the meaningful units remain relatively fixed (across the categories of items contained within them) while the relationships that transition across units are relatively variable.

1.2. Implications for Learning

Two questions logically follow from this characterization of higher-order structure in language. First: where do categories come from? In terms of the learning problem, words or items must necessarily be matched in order to understand relationships across those categories. Moreover, the innateness argument only accounts for certain, particular categories (e.g. noun and verb). While my work will not address this issue directly, it is relevant to the computational problem the learner undertakes. Evidence from other studies indicates that we can use distributional information to learn grammatical categories (Mintz, 2003). Corpus analyses suggest that categories of words like nouns, adjectives, and verbs are identifiable based on frequently occurring words preceding and following the lexically variable, intervening word class (Mintz, Newport, & Bever, 2002). Additionally, behavioral studies confirm that these frequent frames can, indeed, be used to form categories by learners (Mintz, 2002). Importantly, the availability and usefulness of frequent frames as indicators of category membership is not restricted to English, but also applies to languages like French (Chemla, et al., 2009) however there may be limitations on the availability of frequent frames in other languages, like Dutch (Erkelens, 2008). Interestingly, Dutch infants appear to be able to *learn* to use frequent frames to categorize words, despite this not being a typical feature of the input in their native language (Kerkhoff, Erkelens, & deBree, in prep). Whether these analyses can and do happen simultaneously to acquiring other aspects of higher-order structure or as a precursor to phrase relationships remains unclear (cf. Thompson & Newport, 2007).

The second question for the learning problem is: can phrase structure be learned? The assumption for a long time has been that it can not. This body of work aims to demonstrate that structure of this *type* is learnable from the way categories of items are distributed in input, but with several important caveats outlined below.

Theories of Universal Grammar differ, however, almost all contemporary theories of syntax contain a hallmark set of assumptions about the nature of phrase structure. First, the proposal is that all languages contain phrases, and that those phrases consist of binary or two-element relationships – that a noun phrase consists of a determiner and a noun, for example. Second, it is also assumed that the roles of the two categories within phrases are asymmetrical – one of the categories must function as the 'head' of the phrase. For example, the verb heads a verb phrase, and correspondingly the noun heads a noun phrase (Coene & D'hulst, 2003). Additionally, head elements are distinguished from one another and are drawn from a set of specified grammatical classes that govern binding relationships within and across phrases – rules are not the same for noun heads, verb heads, and prepositions (Haiden, 2005). Lastly, the phrasal constraints present in the Universal Grammar are language-specific and do not apply to other domains of learning and knowledge (Ura, 2000). These specifications, then, can be considered necessary preconditions for the nature of the constraints on form contained in the proposed Language Acquisition Device.

Assumptions of specialized constraints on form in UG not unlike those listed above have been called in to question previously in the formal analytical literature, such as: (1) the assumption that certain context-free phrase rules cannot be learned, given a bias on the simplicity of the learned grammar (Hsu & Chater, 2010), and (2) the assumption that there are particular innate constituents (such as using the proform '*one'* to refer to a previously mentioned entity in discourse) (e.g. Regier & Gahl, 2004) – and, additionally, have discussed whether these specialized assumptions about form engage a logical fallacy on the part of UG (Regier & Gahl, 2004).

The experiments that follow test, empirically, the arguments in favor of the necessity of Universal Grammar for an abstract phrase structure by exploring whether human subjects can learn category relationships when the input deviates from the above preconditions in a number of critical ways. First, phrases in the artificial language learning paradigm are defined by adjacent co-occurrence of categories and without appealing to an abstract notion of constituency, *per se*. Secondly, categories are uniform in role, as opposed to identifying one of the elements as the head. Similarly, the languages do not distinguish between grammatical roles like noun and verb, as a result of being entirely based on form (without a semantic component). Between these three properties, then, mastery of the artificial language grammar is *phrase-like* in that pairs of categories hang together and form units, but without the potential to trigger an innate category or notion of relatedness. Finally, unlike the prediction that phrase structure is part of our domain specific knowledge, I also examine learning in the visual domain, demonstrating that learning of the (linguistically motivated) phrase relationships is not unique to language input. The goal is to investigate whether phrase structure can be induced from input given these deviations from what is supposed to be inherent to phrase structure in languages. If we find that is it, that people can still learn aspects of phrase structure, then it will demonstrate that this aspect of language need not be innate, but rather, can be learned.

1.3. Demonstrations of Learnability

Learning phrase structure without meaning, indeed, without anything resembling the classes found in natural languages has been demonstrated. In 2001, Saffran created a miniature artificial language, based on Morgan, Meier, and Newport (1987), that was defined by a grammar over classes of words. Phrase structure in this language was defined by a number of rewrite rules over a basic or canonical sentence type: S → AP + BP + (CP), where AP, BP, and CP are phrases, and CP is an optional phrase. There were also potential phrase rewrites: AP→ A + (D); BP → CP + F or BP → E; and CP → C + (G). Because of the number of optional categories of words, in the collective statistics of the exposure set, these transformations created predictive dependencies within phrases were relatively weak (between .36 and .42, none in the majority, or over .5) while the predictive dependences across phrases were highly variable (between .06 and .46 – in the instance of the C to F transition, the resulting transitional probability was higher than between the classes contained in the CP phrase that precedes it.) More recently, Thompson and Newport (2007) used an adapted version of the same language with stronger cues to phrase boundaries – in particular, phrases tended to hang together in perfectly predictive relationships, while phrase rules created dips in predictive dependencies across phrase boundaries that were relatively low.

More specifically, the Thompson and Newport (2007) language had a phrase structure where phrases were composed of pairs of categories of words. There were 6 categories (labeled here, for simplicity: A, B, C, D, E, and F) which formed three phrases: AB, CD, and EF. There were a total of 18 monosyllabic words in the language, 3 per category. Phrases could perform a variety of operations: (1) movement, (2) repetition, (3) omission, and (4) insertion, thereby creating a set of sentences where the probability of a transition between categories within phrases were high (perfect 1.0) and the probability of a transition between categories that occur across phrase boundaries was low. Importantly, the probability of a transition between individual words was also low — both within and across phrases. Therefore, the only indicator to structure were the transitional probabilities between categories of words — a higher-order relationship. At test, adult participants selected novel grammatical sentences over sentences with one word replaced from an ungrammatical category, thus demonstrating they had acquired an understanding of category-level relationships

What unites these studies is that they relied on the learners' ability to form categories distributionally while at the same time learning the relationships between the categories. Interestingly, a great deal of early work that suggested that input needs to contain cues to category relatedness – things like prosody (Gleitman & Wanner, 1982; Morgan & Newport, 1981), function words, and concord morphology (Morgan, Meier, & Newport, 1987; Braine, 1966) – that explicitly mark relatedness between the items (or types) within a phrase, if learners are to understand constituency relationships. The Saffran (2001; 2002) and Thompson and Newport (2007) results clearly demonstrate that this is not actually the case, phrase structure can in principle, be acquired from purely distributional information.

The tradition of empirical demonstrations of learnability from artificial language learning experiments has a long history, the goal of which was stated early, perhaps best by Martin Braine (1963):

> Although experiments with artificial languages provide a vehicle for studying learning and generalization processes hypothetically involved in learning the natural language, they cannot, of course, yield any direct information about how the natural language is actually learned. The adequacy of a theory which rests on findings in work with

> artificial languages will therefore be judged by its consistency with data on the structure and development of the natural language.

And so, this dissertation challenges the efficacy of a theory of language acquisition that bases its empirical evidence on learning experiments in the context of very small languages – where, correspondingly – tracking relationships between individual items is relatively easy. In order for learning accounts based on the distributional structure of the input to characterize acquisition in the context of natural language acquisition (as in the goal stated by Braine, 1963), we must also consider situations where the language's vocabulary is larger and thus, tracking and matching individual items is more difficult. In this set of studies, I examine learning in a large language where a very different type of abstract cue (i.e., a non-distributional cue) was provided that facilitates the item-matching problem, and I compare those learning outcomes with learning in the absence of these cues. Importantly, the cues to category membership were like those found in natural languages, without being anything that could conceivably trigger a potential innate category. I also examine learning of a similar system in the visual domain, both with and without a cue to category membership. I describe the particulars in the chapters that follow.

2. Cues to Category Membership

Previous work has demonstrated that learning high-order category relationships is, in principle, possible from distributional information alone (Thompson & Newport, 2007). However, as mentioned, natural languages are much larger than those used in most artificial language experiments, including those used by Saffran (2001; 2002) and Thompson and Newport (2007). This creates a possible problem: although it is clearly possible to extract categories and learn relationships between them when there are few words in the language, this same learning feat is much more difficult for a learner encountering a natural language. However, languages themselves might provide the solution to this problem. Natural languages often contain additional cues to categorical structure (Mills, 1986; Kelly & Bock, 1988). Importantly, these (often) phonological cues are of a very different type of cue from those previously explored (Morgan, Meier, & Newport, 1987) in that they are an abstract source of information that could potentially facilitate item-matching as opposed to providing more direct cues to relatedness in the input. For example, in Spanish, the final vowel sound can cue the gender class of a noun – masculine nouns tend to end in '*o*' and feminine nouns tend to end in '*a*.' To give an even more abstract example: the stress patterns of words, in English, are an aspect that can serve as an indicator to category membership – nouns tend to be stress-initial (such as *pro*-test) while verbs tend to be stress-final (such as pro-*test*).

Here, I examine whether the learning outcomes of previous work are feasible in a larger language, or whether learning is hampered when the language has a larger vocabulary, that is, if expanding the volume of vocabulary items does indeed impede the learning of higher-order structure. I go on to ask if the inclusion of abstract cues to category membership, of the kind seen in natural languages can help or even overcome the effect of the larger vocabulary. If so it would suggest that cues of this type may be necessary to learn the higher-order relationships from distributional information in natural language situations. Importantly, the cue I use provides no information about the relationships between categories. As such, it provides no information about the phrase structure – that must still be learned via the distributional information if it is to be acquired. The question then is whether phrase structure can be learned via distributional information alone even in a large language which presents a more difficult challenge to learners given informational conditions often present in natural languages.

To investigate these questions, we exposed learners to one of two versions of a miniature artificial language. Both languages had the same syntactic structure, based on the language created by Thompson and Newport (2007). However, the languages differed in that one had an abstract phonological cue perfectly correlated with category membership; in another, the same words were randomly distributed over the categories. Learners were exposed to sentences (strings of words) from one language over several sessions, and then were tested to see what they had learned about the underlying structure of the language. Performance was then compared for participants exposed to the two languages, both to each other, and to chance.

Methods

Participants

A total of 40 adults participated, 20 per condition. All participants were native speakers of English, defined as exposure to English prior to three years of age. Speakers were not required to be monolingual. Participants were recruited via flyers posted around the UC-Berkeley campus.

Stimuli

The language had a (large) vocabulary of 90 novel monosyllabic words, five times the size of the Thompson and Newport (2007) language. The words were distributed into six categories or word types: A, B, C, D, E, and F. There were 15 words in each category. Categories were then organized into phrases, and phrases into sentences.

Basic sentences were comprised of three phrases: AB-CD-EF, in that order. Phrases could 'move' to the front or back of the sentence, e.g., CD-EF-AB. Subsequently, the language had five potential sentence types: ABCDEF, CDABEF, EFABCD, CDEFAB, and ABEFCD. The transitional probabilities between categories of words in the language were perfectly predictive within the phrases, that is, the transitional probability from one category to another within the same phrase was 1.0 (e.g., between category A and category B). Transitional probabilities between categories co-occurring across phrase boundaries, by contrast, were lower (e.g. between Category D and Category A occurred with probability .14), consistent with the properties of natural languages. A summary of the transitional probabilities between the categories appears in Table 1.

Table 1. Transitional probabilities between categories of words

	A	B	C	D	E	F
A	-	1.0	-	-	-	-
B	-	-	.57	-	.28	-
C	-	-	-	1.0	-	-
D	.14	-	-	-	.57	-
E	-	-	-	-	-	1.0
F	.14	-	.14	-	-	-

In total, there are 56,953,125 possible grammatical sentences in this language. The exposure set was a subset of these, comprising 210 sentences. Ninety were of the basic sentence construction type and 120 were of the 'moved' constructions, 30 of each type. Thus, the basic sentence type is more common than any other individual type, but is not the majority type in the exposure set. The frequency of any given word in the exposure set was equated (each appeared 14 times), and the frequencies of pairs of words (within and across phrase boundaries) were low across the exposure set. Thus, as in Thompson and Newport, transitional probabilities between items were indicative of syntactic structure, but only when considered at the category level.

Cue to category membership. Both versions of the language contained the same distributional cues to category membership; word class was consistent with distribution in the sentence, both absolutely – any word was restricted to appear only in the subset of locations consistent with its category membership – and relatively – any word only occurred next to the subset of words consistent with the possible adjacent categories. However, one version of the language contained an additional, and more direct cue to category membership. Each of the 90 words in the language had one of six syllable constructions. The six constructions were: CV, CVC, CVCC, CCVC, CCV, and CCVCC, with C indicating consonant and V indicating vowel. In the cue-present version of the language, words of the same syllable type all belonged to the same category. Syllable construction, therefore, served as a potential cue to category membership. In the without-cue condition, all construction types were distributed randomly across the six syntactic categories, and so syllable type did not serve as a cue. Two example sentences from the cue-present exposure set appear below:

	CCVC	CVC	CVCC	CCV	CV	CCVCC
(1)	frim	sig	gorf	ploo	da	glert
(2)	skige	tev	werf	slah	voh	sparl

Procedure

Participants heard the exposure set a total of 7 times over the course of 5 days. On the first four days, learners heard the exposure set (comprised of the 210 sentences in a fixed, randomized order) one and a half times through, for a total of 315 sentences in a 25-minute session. On the fifth and final day, participants sat for a learning session of about 17 minutes, which was once through the 210 sentences, and also participated in a variety of two-alternative, forced-choice tests. All sentences (both exposure and test) were presented in natural speech, spoken by a female researcher in auditory form, in list intonation with no phonological cues to phrase boundaries.

Tests

The grammaticality judgment tests were designed to probe participants' knowledge of the grammatical structure of the language at increasing levels of abstraction away from the set of sentences in the exposure set. The goal was to include items that could be answered purely on the basis of memory for experienced items, as well as items that required abstract category-based knowledge in order to be answered correctly. We anticipated that learning outcomes for the cue-present and cue-absent conditions would become increasingly differentiated for tests that relied on knowledge of the relationships between word categories.

There were 7 tests total: five tested participants' knowledge at the level of sentences, and two tested participants' knowledge at the level of phrases.

Sentence Tests. The five sentence tests involved comparing two sentences, one of which was grammatical and one of which was not. The ungrammatical sentence was a version of the grammatical sentence in which one word was out of place according to its category membership. Importantly, the out-of-place word had appeared in the tested location in the exposure set. Thus, the ungrammatical sentence could not be recognized as such simply by noting that a word was in a novel location; rather, the participant had to notice that the word's relative location was ungrammatical. There were 6 trials per test, each tested one of the six possible locations (i.e. categories) in successive order.

For clarity, a schematic follows the description of each test below labeling the categories of each of the words in the sample sentence. Additionally, it indicates with a subscript 'o' following each category label (A, B, C, D, E, or F) whether that particular word had been observed in that location in the exposure sentences. By contrast, a subscript 'n' following the category label indicates a novel location for the word. In addition, two subscripted letters follow each bracketed phrase: the first 'o' or 'n' indicates whether the *combination* of words is observed or novel in that location, and the second indicates whether that particular combination was observed or novel as a pair – that is, whether those particular words had ever occurred together before in any location. Back slashes (/) indicate a non-phrasal pairing. The final subscripted letter ('o' or 'n') indicates whether the full sentence was observed or novel. All tests were based on canonical or basic sentences from the language of the form ABCDEF.

The first test compared target sentences drawn from the exposure set with an ungrammatical sentence that had one word replaced – a recognition task. In the ungrammatical sentence, the replaced word had appeared in its location in the exposure set, but in a different (grammatical) construction. In the example below, the E word, *ziye*, has been replaced with an A word, *stoom*.

(1) prov tam jusk kwoh ziye sparl (2) prov tam jusk kwoh *stoom* sparl

$[[A_oB_o]_{oo}\ [C_oD_o]_{oo}\ [E_oF_o]_{oo}]_o$ $[[A_oB_o]_{oo}\ [C_oD_o]_{oo}\ /A_oF_o/_{nn}]_n$

Test 2 required participants to generalize the phrases they had heard in the exposure set to novel sentences. In the grammatical sentences, each of the individual words had appeared in these same locations in the exposure set, as had each particular phrasal exemplar, but the combination of particular phrases that formed each sentence was novel at test. Target sentences were, again, compared against a sentence that had one word replaced, but was ungrammatical.

(1) slom rog malb prah luh swohst (2) slom rog malb prah *prov* swohst

$\mathbf{[}[A_oB_o]_{oo}\ [C_oD_o]_{oo}\ [E_oF_o]_{oo}\mathbf{]_n}$ $\mathbf{[}[A_oB_o]_{oo}\ [C_oD_o]_{oo}\ /A_oF_o/_{nn}\mathbf{]_n}$

Test 3 presented target sentences that contained one novel combination of words or bigram that comprised a grammatical phrase based on their category memberships. As in the ungrammatical sentence, both words in the novel phrase had occurred in their respective locations in the exposure set. If the learner understands that the phrases are composed of category relationships, they will understand these words are a permissible phrase, and if they have learned the relative locations of phrases, they can recognize the novel sentence as grammatical. If they do not understand the categories and how they are related to each other, they will not. In the example below, the CD combination is novel:

(1) stoom vot zirl skaye dee glert (2) stoom vot *slub* skaye dee glert

$\mathbf{[}[A_o B_o]_{oo}\ [C_o D_o]_{nn}\ [E_o F_o]_{oo}\mathbf{]_n}$ $\mathbf{[}[A_o B_o]_{oo}\ /A_o D_o/_{nn}\ [E_o F_o]_{oo}\mathbf{]_n}$

Test 4 required the participant to recognize a new location for a bigram as well as a new location for one word in that bigram. The bigram in the target phrase had appeared in the exposure, but in a different location in the sentence. The target sentence was, again, compared against a sentence with one word replaced that had appeared in that location before, but was ungrammatical. Test 4 might seem less abstract than Test 3, in particular, because the target phrase is novel in Test 3 whereas it is old in Test 4, and so out of order. However, we ordered them this way because it is the first test in which participants have to select a sentence containing a word they've never experienced in that location to get the correct answer.

(1) spag kice ralt gliye wa starp (2) *malb* kice ralt gliye wa starp

$\mathbf{[}[A_n B_o]_{on}\ [C_o D_o]_{oo}\ [E_o F_o]_{oo}\mathbf{]_n}$ $\mathbf{[}/C_o B_o/_{nn}\ [C_o D_o]_{oo}\ [E_o F_o]_{oo}\mathbf{]_n}$

Like Test 4, the fifth test also required the participant to infer the grammaticality of one novel location for one word. Additionally, however, the word was also in the context of a novel bigram. This test can be viewed as the most abstract inference because it provides the fewest item-based cues – that is, the novel bigram or phrase requires participants to understand category relationships, and, concurrently, make an inference according to the movement rules based on the novel location for one of the words.

(1) swiv bape jusk gree koh flisp (2) swiv bape *gleeb* gree koh flisp

$\mathbf{[}[A_o B_o]_{oo}\ [C_n D_o]_{nn}\ [E_o F_o]_{oo}\mathbf{]_n}$ $\mathbf{[}[A_o B_o]_{oo}\ /A_o D_o/_{nn}\ [E_o F_o]_{oo}\mathbf{]_n}$

For all sentence test items, participants were asked to indicate which of two alternatives they thought more likely came from the language they had been listening to by saying "one" or "two" for the first sentence or second sentence respectively. There was a 1s interval in between the presentation of the two test items per trial, and test trials advanced automatically at 2s intervals. Responses were recorded by the experimenter.

*Phrase Tests***.** In addition to testing whether participants understood grammatical sentences, we were also interested in whether they understood what constitutes a phrase or unit of the language. To do this, we asked participants to compare pairs of words that occurred with equal frequency over the course of the input - one pair with high between-category transitional probability and one pair with low between-category transitional probability.

The first phrase test used pairs of words that the participant had heard adjacently in the input - either within a phrase or across a phrase boundary. An example comparison is provided below, with category labels beneath, as well as the category-level transitional probabilties.

(1) voh sparl (2) sparl frim

E F (p = 1.0) F A (p = .14)

The second phrase test extends the comparison of pairs of words with high or low between category transitional probability to novel words abiding by the correlated cue (syllable construction). Importantly, this is the only test to examine whether with-cue subjects had extracted the abstract phonological cue as an indicator to category membership. Below, novel words are italicized:

(1) *flar* puv (2) puv *jiye*

A B (p = 1.0) B E (p = .28)

For these tests, participants were told that they would hear two pairs of words, and as in the sentence tests, that they should indicate which of two alternatives they thought more likely came from the language they had been listening to by saying “one” or “two” for the first pair or second pair respectively. An additional instruction was given prior to the second phrase test – that there would be some words they hadn’t ever heard before, but, like the other tests, they should indicate which pair they thought to be more likely. There was a 1s interval in between the presentation of the two test items per trial, and test trials advanced automatically at 2s intervals. Responses, again, were recorded by the experimenter.

Results

Performance on the first sentence test, a recognition test that compared a sentence from the exposure to a sentence containing one ungrammatical word, is shown in Figure 1 for participants in the two conditions. Both groups performed significantly above chance level: Without Cue Participants scored M = 60.8%, SD = 49.0% ($t(19) = 2.156$, $p = .044$), while With Cue Participants scored M = 74.2%, SD = 44.0% ($t(19) = 5.900$, $p < .001$). However, With Cue Participants performed better than Without Cue Participants, ($F(1, 39) = 4.230$, $p = .047$), suggesting that having a cue to structure facilitated even this low-level discrimination.

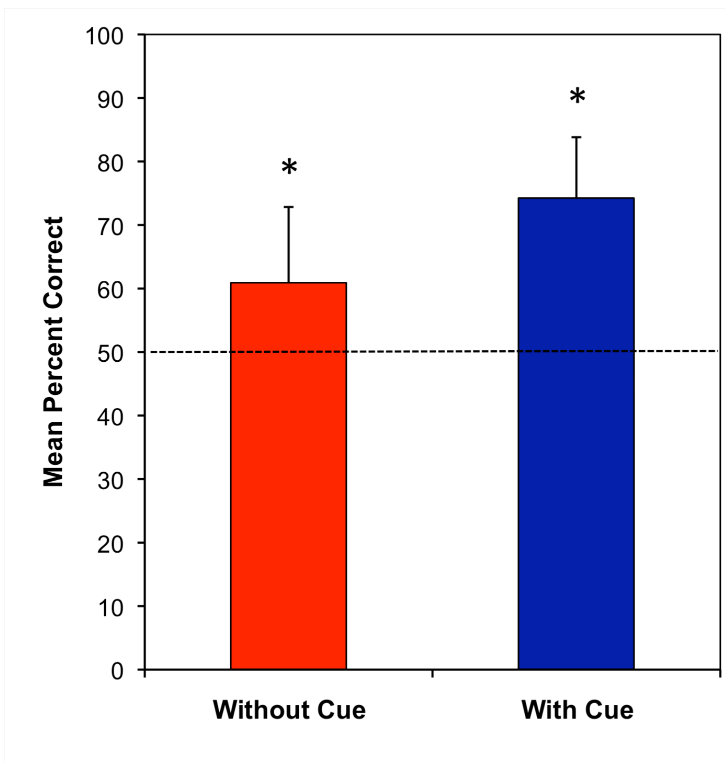

Figure 1. Without Cue and With Cue mean performance on Sentence Test 1.

Performance on the second sentence test, where target sentences were novel compositions of phrases while comparison sentences contained one ungrammatical word, is shown in Figure 2 for both conditions. The two groups did not significantly differ in their relative performance outcomes ($F(1, 39) = .253$, $p = .618$). However, both groups performed significantly above chance: Without Cue Participants scored M=61.2%, SD =48.8% ($t(19) = 2.268$, $p = .035$), and With Cue Participants scored M = 65.0%, SD = 47.9% ($t(19) = 3.596$, $p = .002$). Thus, both groups appear to have acquired some aspects of phrase structure – they understand that it is more consistent with the input to create novel combinations of phrases that conform to category membership than to created novel combinations of bigrams that violate category-level probabilistic information.

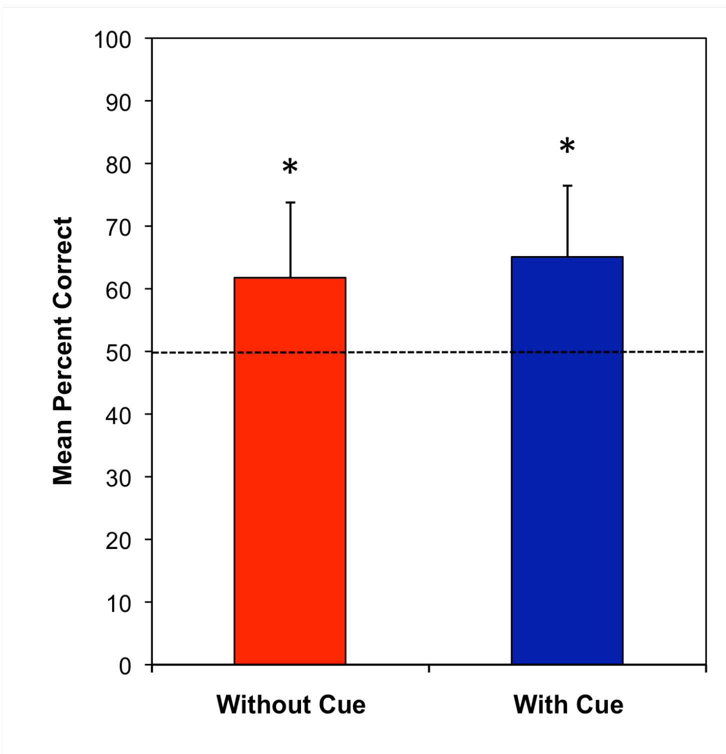

Figure 2. With Cue and Without Cue performance on Sentence Test 2.

Performance on the third sentence test, the first judgment where participants were required to infer a possible novel within-phrase bigram, is shown in Figure 3. Although the difference between the two groups is not significant (F(1,39)=.019, p=.891), only the With Cue participants performance is significantly above chance: Without Cue Participants M=57.5%, SD=49.6% (t(19) = 1.690, p = .107); With Cue Participants, M=58.3%, SD=49.5%, (t(19) = 2.032, p = .056). This suggests that, when grammaticality judgments are driven by novel word combinations that depend on category relatedness within phrases, having a cue to category membership facilitates or may enable this discrimination.

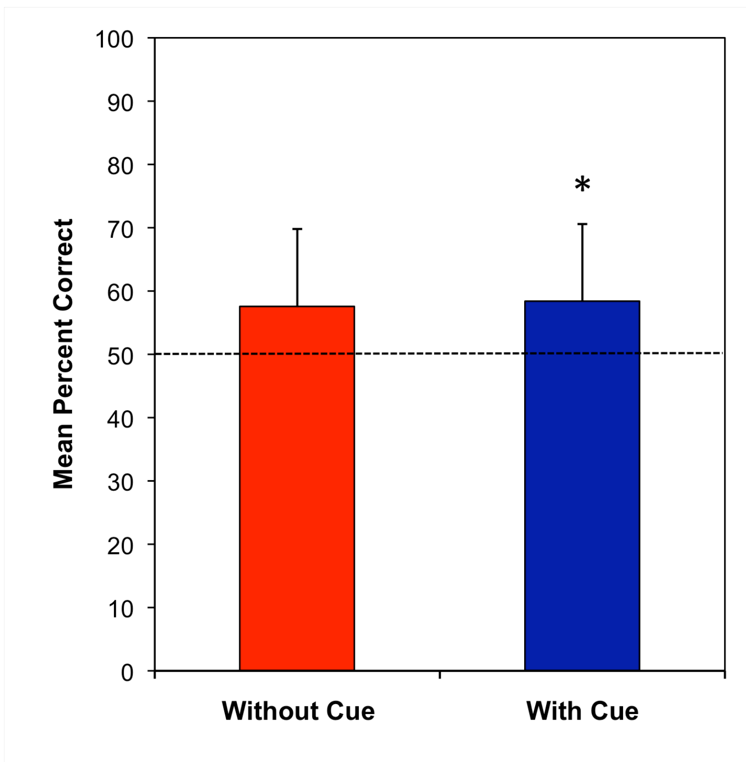

Figure 3. Without Cue and With Cue mean performance on Sentence Test 3.

Performance on the fourth sentence test, where a bigram moved to a novel location in the sentence and one of the words in the (grammatical) bigram was in a novel location, is shown in Figure 4. Performance outcomes did not significantly differ for the two groups ($F(1, 39) = 1.293$, $p = .263$). Without Cue Participants scored M=45.8%, SD=50.0% ($t(19) = -1.157$, $p = .262$), while With Cue Participants scored M=54.1%, SD=50.0% ($t(19) = .653$, $=.522$)). . Interestingly, performance on this test suggests that both conditions are paying attention to the item-level statistics: recall that the replaced, ungrammatical word had been seen in its location previously, something not true of the grammatical test item. Additionally, the bigram having appeared together, but at a different location provided another item-based distraction.

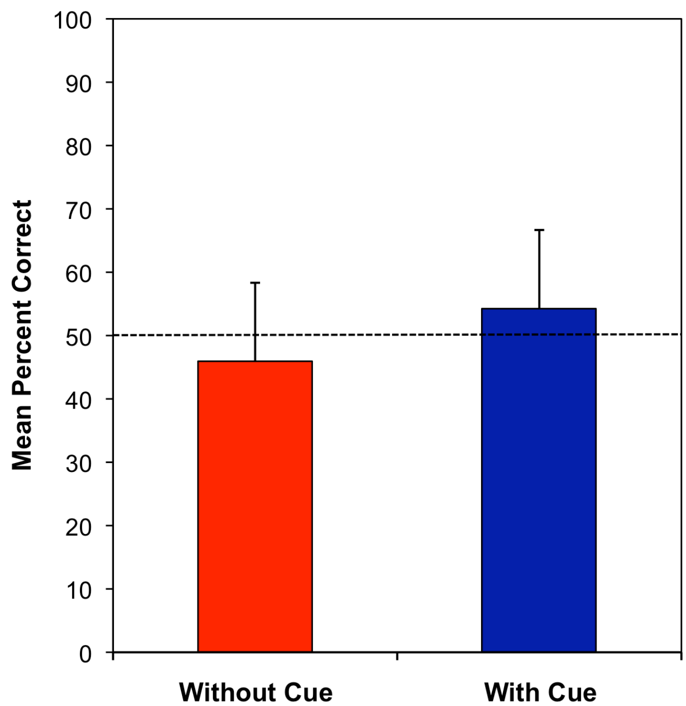

Figure 4. Without Cue and With Cue mean performance on Sentence Test 4.

Finally, performance on the fifth sentence test, where judgments were based on sentences that contained both a novel bigram or phrase and a novel location for one word, is shown in Figure 5 for both conditions. This was the most abstract sentence test in that it removed all item-based cues to grammaticality – the novel bigram was grammatical strictly based on category membership and category relatedness according to the movement rules. The two groups did not significantly differ in their performance (F(1, 39) = 1.040, p = .314). However, the groups differed in that Without Cue Participants did not show an ability to make this discrimination, performing at chance level (M=55.0%, SD=50%, t(19) = .940, p = .285), and by contrast, With Cue Participants performed significantly above chance, M=60.8%, SD=49.0% (t(19) = 3.115, p = .006). Thus, as in Sentence Test 3, when grammaticality inferences contain novel within-phrase possible bigrams, regardless of whether this bigram includes a novel location for one of the words, having a cue to category membership appears to enable selecting the grammatical target sentence over the distracter sentence.

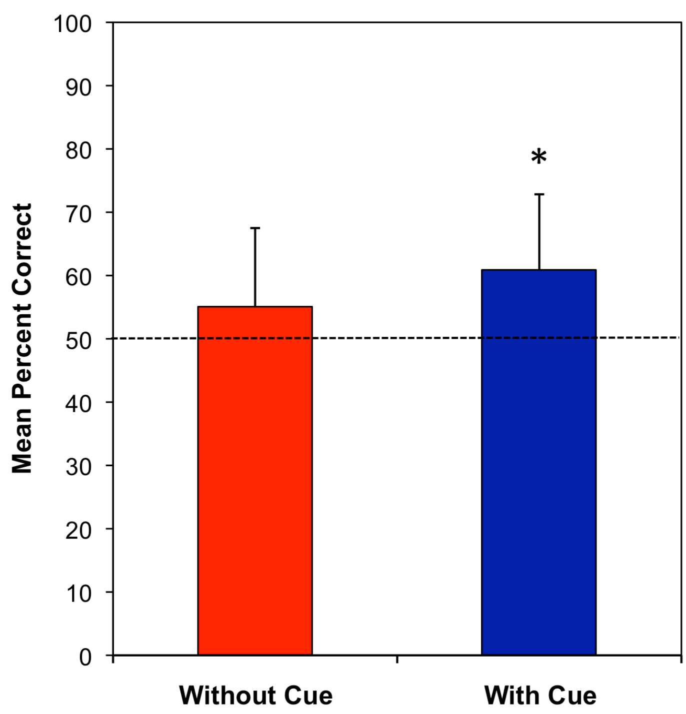

Figure 5. Without Cue and With Cue mean performance on Sentence Test 5.

The above tests all queried knowledge of the structure of the artificial language at the level of sentence. We also tested participants' knowledge of phrases – that is, based on category relatedness, do they understand that pairs of words equally frequent in the exposure are more related based on category membership than others. Performance on this test is shown in Figure 6 for both conditions. Both groups were able to make this judgment: Without Cue Participants scored M=67.5, SD= 47.0%, ($t(19) = 4.595$, $p < .001$), and With Cue Participants scored M=81.7%, SD=38.9% ($t(19) = 8.324$, $p < .001$). This learning outcome is consistent with those from the second sentence test that also depended on relative category-level probabilistic information across phrase boundaries. Additionally, for this test, With Cue participants performed significantly better than Without Cue Participants ($F(1, 39) = 8.121$, $p = .007$), suggesting that, while the absence of a cue to category membership did not prevent acquiring category relatedness, it did seem to impede it.

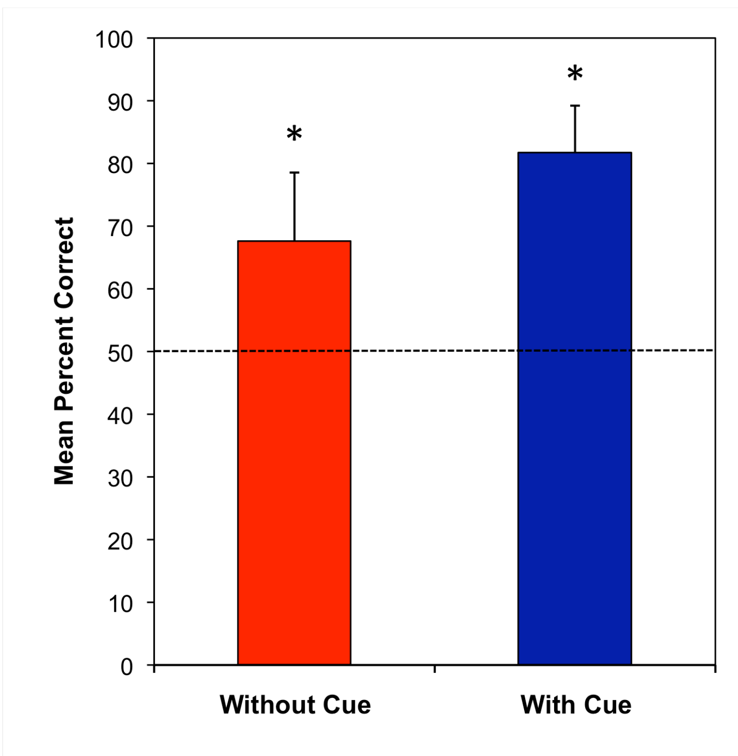

Figure 6. Without Cue and With Cue mean performance on Phrase Test 1.

Performance on the second phrase test, which extended the comparison of pairs of words with either high or low category-level transitional probability to novel words that conformed to the cue, is shown in Figure 7 for both conditions. Intuitively, this judgment was not meaningful to Without Cue Participants, who performed at chance level (M=39.1%, SD=49.1%, t(19)=-1.542, p=.143). With Cue Participants, by contrast, demonstrated they were able to extend the cue to novel words by succeeding at this task, M=60.0%, SD=49.2% (t(19)=3.284, p=.004). Importantly, this was the only judgment that tested whether participants in the With Cue condition had extracted the cue – not only did it inform grammaticality judgments at both the sentence and phrase levels, but also the cue was itself learned. Additionally, and intuitively, With Cue Participants performed significantly better than Without Cue participants (F(1,39) = 8.212, p = .007).

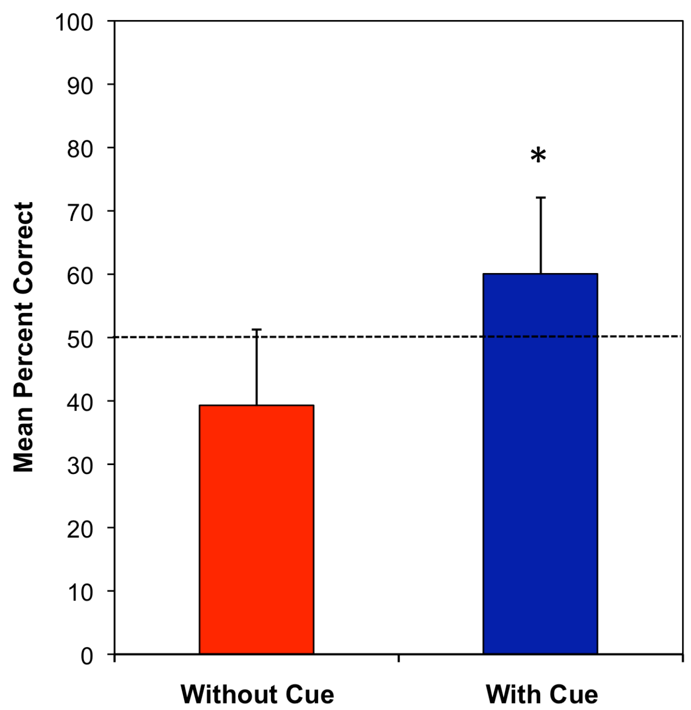

Figure 7. Without Cue and With Cue mean performance on Phrase Test 2.

Discussion

In a series of tests both at the sentence level and at the level of phrases or units of language, we have shown that cues to category membership – an abstract cue that facilitates item-matching – benefits learning of the higher-order structure of the language.

We can compare the outcomes of the two groups, With Cue and Without Cue, to the original results of Thompson and Newport (2007). By simply expanding the language, the Without Cue group presented here had relatively lower performance than the outcomes in the Thompson and Newport (2007) study – in particular, on the recognition sentence test, which was a replication of their Sentence Test. Presumably, this is strictly due to the size of the vocabulary input – since other factors like exposure duration and number of days of exposure were comparable. Providing a cue to category reconciled this detriment, however, suggesting that having a cue to category membership did, indeed facilitate the problem of matching items into categories.

We conducted a number of additional tests beyond simply recognizing sentences in order to understand whether and to what extent participants inferred the internal structure of the sentences. Without cue participants demonstrated learning of some aspects of phrase structure – as in Sentence Test 2 where they understood novel combinations of known bigrams, as well as in the first Phrase Test where they selected pairs of high-category level transitional probability over pairs of words with low category-level transitional probability. However, With Cue participants outperformed Without Cue participants in more abstract generalizations. In particular, this was the case when the tests relied on understanding possible novel bigrams based on category relations – as in Sentence Test 3 where judgments were made about a novel bigram containing words that had appeared in those locations in the exposure, and also in Sentence Test 5, where judgments were made about sentences where there was a novel location for one of the words in the context of a novel bigram. The implications for these results suggest that, despite the longtime assumption that learning a phrase structure grammar is not possible, learning high-order category relationships can, in fact, be induced in a large language. However, it may depend on facilitative, non-distributional cues to category membership.

3. Partially Predictive Cues and Noise

In the previous chapter, I suggested that having a cue to category membership, in a large language, appears to facilitate or may even enable acquisition of abstract, higher-order relationships that occur in natural languages. I also noted that cues of this type are characteristic of the structure of natural languages. Cues in language, however, are rarely perfectly predictive, instead, they are best considered tendencies. For example, in English the stress pattern of bisyllabic words is often, but not perfectly, indicative of word class. Nouns tend to have initial stress whereas verbs tend to have stress on the second syllable, exemplified by pairs such as *pro*-test (noun) and pro-*test* (verb). But there exist counter-examples, words like gui-*tar*, a noun with stress on the final syllable (Kelly & Bock, 1988). Thus, the focus of the present study is to examine the implications of partially-predictive cues to category membership.

In this experiment, I created three additional versions of the artificial language used in the previous study in which the cue to category – syllable structure – was only partially correlated with category membership; there was noise in the system. Two of these versions were created by assigning a percentage of the original vocabulary set to categories at random, and the degree to which phonological type predicted category membership was of two different levels for the two versions. That is, the words which did not match the syllable structure pattern of the distributionally defined class they were in matched the pattern of another class. What varied between the two conditions was the proportion of matching and non-matching words in each class. This configuration is very much like what happens in natural languages, as shown in the examples from English presented above. However, because it includes two factors which might interfere with learning – fewer words which exemplify the cue in each category as compared to the first experiment, and the fact that non-matching words actually match another category – I included a third condition in this experiment to disentangle the effects of these two aspects of the noise; in this third version the non-matching words were of a different type (with respect to syllable structure) from both the category in which they participated and other categories in the language.

This study is important for a variety of reasons. First, if we wish to make claims about the acquisition of real languages on the basis of studies of miniature artificial language learning, it is important that the miniature languages mirror the properties of natural languages. As mentioned, cues correlated with word classes are not deterministic in natural languages, so, if such cues are to be helpful to real learners acquiring real languages, learning must be robust to some noise in the system. At the same time, it is possible that the facilitative effect of cues to category membership demonstrated in the previous experiment might be diminished when the cue is only somewhat predictive. This second point may not be an all or nothing phenomenon, however; the degree to which noise in the system hampers learning likely depends on the nature of the noise. The three conditions in the present experiment attempt to address these points.

Methods

To test the implications of partially-predictive cues and noise in the context of learning phrase structure relationships, we constructed three additional versions of the language from Study 1. An 80% predictive condition was created by giving 20% of the words from the original vocabulary from Study 1 random category assignment – this condition will be referred to in the following sections as 80% Predictive. Another version of the language was created by scrambling 40% of the original vocabulary items using random assignment, for a 60% predictive condition. In yet another version of the language, a second 80% predictive condition was created by replacing 20% of the items, this time with words of phonological types that matched neither the majority of other category members nor the other categories in the language: VC and VCC, with C indicating consonant and V vowel. This condition will be referred to in the following section as the 80% Mismatch condition (so named because the noise words do not match either their category members or other categories). Categorized lists of the three vocabulary sets appear in Appendix A.

Phrase Structure. The grammar of the three languages was exactly the same as in Study 1.

Participants

A total of 60 adults participated, 20 per condition. As in Study 1, all participants were native speakers of English, defined as exposure to English prior to 3 years of age. Speakers were not required to be monolingual. Participants were recruited via flyers posted around the UC-Berkeley campus.

Procedure

The procedure and tests for all groups was the same as in Study 1.

Results

Performance on the first sentence test, which compared sentences from the exposure set to a sentence with one ungrammatical word, is shown in Figure 8. The previously presented data from the Without Cue and With Cue participants is also included for reference.

(Note that we are not including an overall ANOVA in any of the analyses in this experiment because the independent variable is not a single variable. Although the With Cue and Without Cue conditions are clearly points along a scale, with the 80% Predictive and 60% Predictive conditions also being intermediary points on that scale, the third new condition is different. Thus, we include only one on one comparisons (with significance thresholds adjusted for the family of comparisons), as well as comparisons to chance.)

Compared to the With Cue Condition, relative performance outcomes did not significantly differ on the recognition test for the 80% Predictive condition ($F(1, 39) = .493$, $p = .487$), the 60% Condition ($F(1, 39) = 1.267$, $p = .267$), or the 80% Mismatch condition ($F(1, 39) = 5.519$, $p = .024$) according to an adjusted p-value threshold for this family of tests, computed as .05/3 or .017. Likewise, performance outcomes did not differ from the Without Cue group for the 80% Predictive condition ($F(1, 39) = 1.924$, $p = .174$), the 60% Condition ($F(1, 39) = 1.592$, $p = .215$), or the 80% Mismatch Condition ($F(1, 39) = .015$, $p = .902$).

However, all three new conditions did demonstrate performance significantly above chance value (with a significance threshold for $p = .05$). This was true for 80% Predictive participants at M = 70.0%, SD = 46.0%, ($t(19) = 4.660$, $p<.001$), as well as 60% predictive participants, M = 68.3%, SD = 46.7%, ($t(19) = 5.772$, $p<.001$) and the participants in the 80% Mismatch condition, M = 60.0%, SD = 49.2%, ($t(19) = 2.259$, $p=.036$). Importantly, this recognition test can also be viewed as a performance threshold – since it does not test internal structure of the sentences and requires only identifying sentences from the exposure, it ensures that all groups were attending equally during listening.

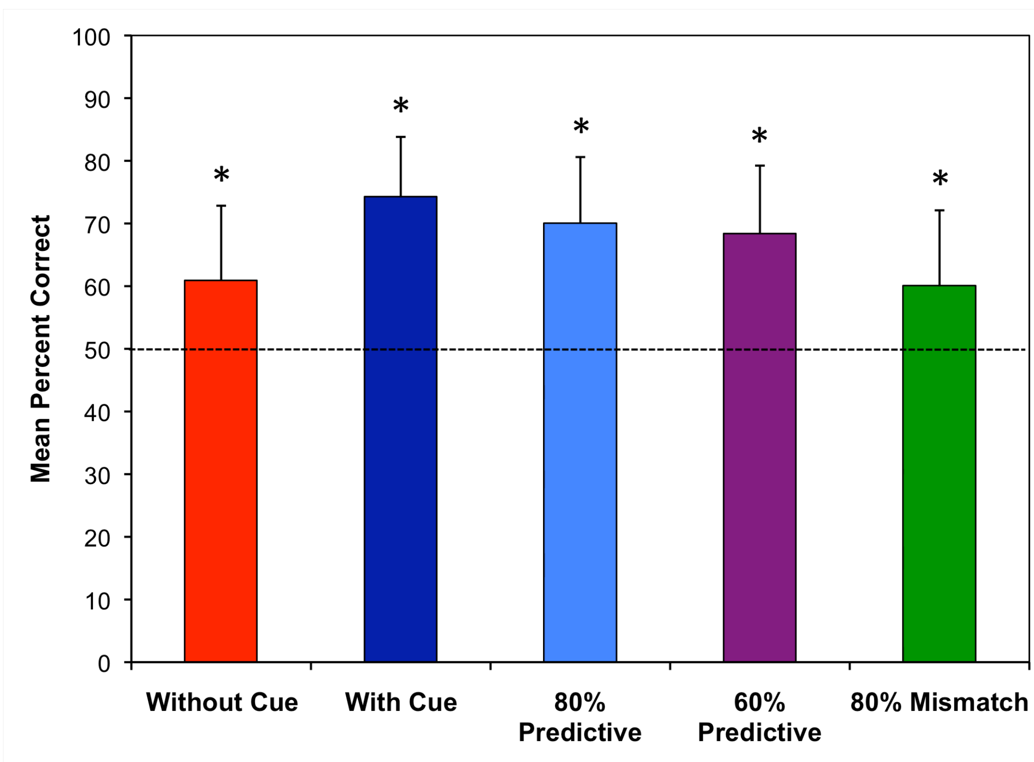

Figure 8. Mean percent correct on Sentence Test 1, all language conditions.

The second sentence test was the first test that required participants to generalize to novel sentences, comparing bigrams or phrases previously observed in their locations to a sentence that had one word replaced that had appeared in its location before, but was ungrammatical. Performance on this test for all five language groups appears in Figure 9.

Compared to the With Cue condition, relative performance outcomes did not significantly differ for the 80% Predictive condition (F(1, 39) = .264, p = .610), the 60% Predictive condition (F(1, 39) = 1.877, p = .179), or the 80% Mismatch condition (F(1, 39) = .068, p = .796), according to the adjusted p-value, .017. Nor did performance outcomes differ when compared to the Without Cue condition for the 80% Predictive condition (F(1, 39) = .869, [= .357), the 60% Predictive condition (F(1, 39) = .543, p = .466), or the 80% Mismatch condition (F(1, 39) = .501, p = .483).

When compared to chance performance, both 80% Predictive conditions, with or without noise words that match other categories, were able to make this generalization, M = 68.3%, SD = 46.7%, (t(19) = 3.688, p=.002) and M = 66.7%, SD = 47.3%, (t(19) = 3.446, p=.003), respectively. By contrast, the 60% Predictive condition did not perform above chance on this test, M = 56.7%, SD = 49.8%, (t(19) = 1.506, p=.148). This was the only group not above chance on this test, suggesting that dropping the degree of predictiveness of the cue can, in fact, affect learning outcomes, even beyond those t of participants with no cue at all.

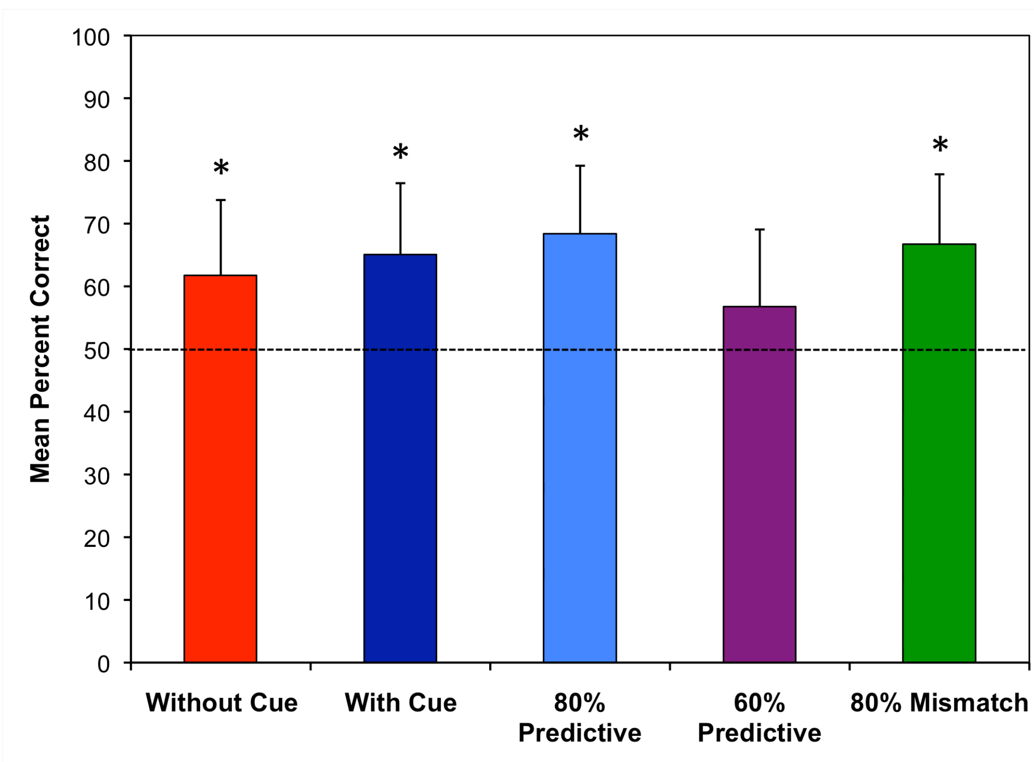

Figure 9. Mean percent correct on Sentence Test 2, all language conditions.

Performance on Sentence Test 3, which compared sentences that contained a novel within-phrase bigram to a sentence that had one word replaced that had appeared in that location before but was ungrammatical, is displayed in Figure 10. In Study 1, this was the first generalization test that showed different learning outcomes for participants with and without the cue, suggesting that the cue enables generalizations.

As in previous tests, compared to the With Cue condition, relative performance outcomes did not significantly differ for the 80% Predictive condition (F(1, 39) = .206, p = .653), the 60% Predictive condition (F(1, 39) = 1.120, p = .297), or the 80% Mismatch condition (F(1, 39) = 2.397, p = .130) according to the adjusted p-value, .017. Likewise, performance outcomes did not significantly differ on this test from the Without Cue condition for 80% Predictive (F(1, 39) = .334, p = .567), the 60% Predictive condition (F(1, 39) = 1.336, p = .255), or the 80% Mismatch condition (F(1, 39) = 1.830, p = .184).

Interestingly, some but not all partially predictive conditions made this generalization above chance level. The 80% Predictive condition performed above chance M = 60.8%, SD = %, (t(19)=2.942, p=.008) as did the 60% Predictive condition, M = 64.2%, SD = % (t(19)=3.847, p=.001). The 80% Predictive Condition with mismatched noise words did not M = 49.2%, SD = % (t(19)=-.195, p=.847).

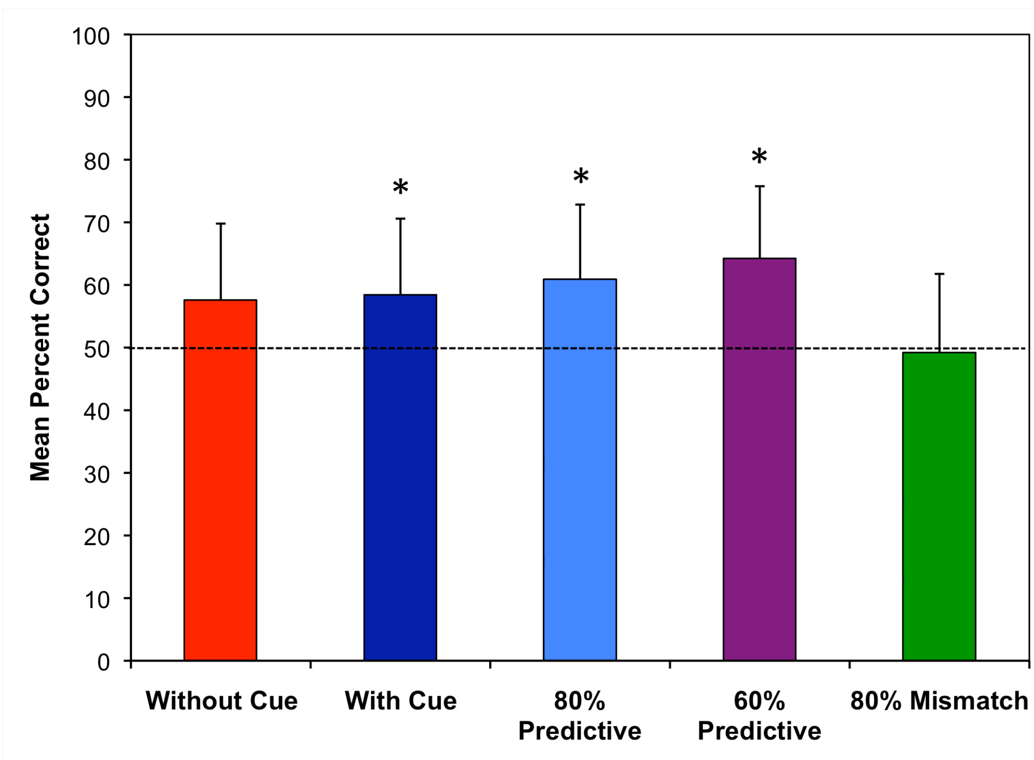

Figure 10. Mean percent correct on Sentence Test 3, all language conditions.

In Sentence Test 4, participants compared target sentences that contained an old bigram appearing in a novel location for that bigram, and in which one of the words in the bigram was in a novel location. Importantly, this sentence was compared to a sentence with one word replaced that *had* appeared in that location before. As it turns out, performance on this test was robustly bad, as shown in Figure 11.

Compared to the With Cue condition, relative performance outcomes were not significantly different for the 80% Predictive condition ($F(1, 39) = .000$, $p = 1.000$), the 60% Predictive condition ($F(1, 39) = .012$, $p = .914$), or the 80% Mismatch condition ($F(1, 39) = .049$, $p = .827$). Performance outcomes were also not significantly different from the Without Cue condition for the 80% Predictive condition ($F(1, 39) = 2.184$, $p = .148$), the 60% Predictive condition ($F(1, 39) = 1.792$, $p = .189$), or the 80% Mismatch condition ($F(1, 39) = 1.509$, $p = .227$).

Additionally, none of the groups performed above chance. 80% Predictive participants scored M = 54.2%, SD = 50.0%, ($t(19) = .960$, $p=.349$), 60% Predictive scored M = 53.3%, SD = 50.1%, ($t(19) = .777$, $p=.447$), and 80% Predictive with mismatched noise words scored M = 54.2%, SD = 50.1%, ($t(19) =.616$, $p=.545$), all of which were at chance level.

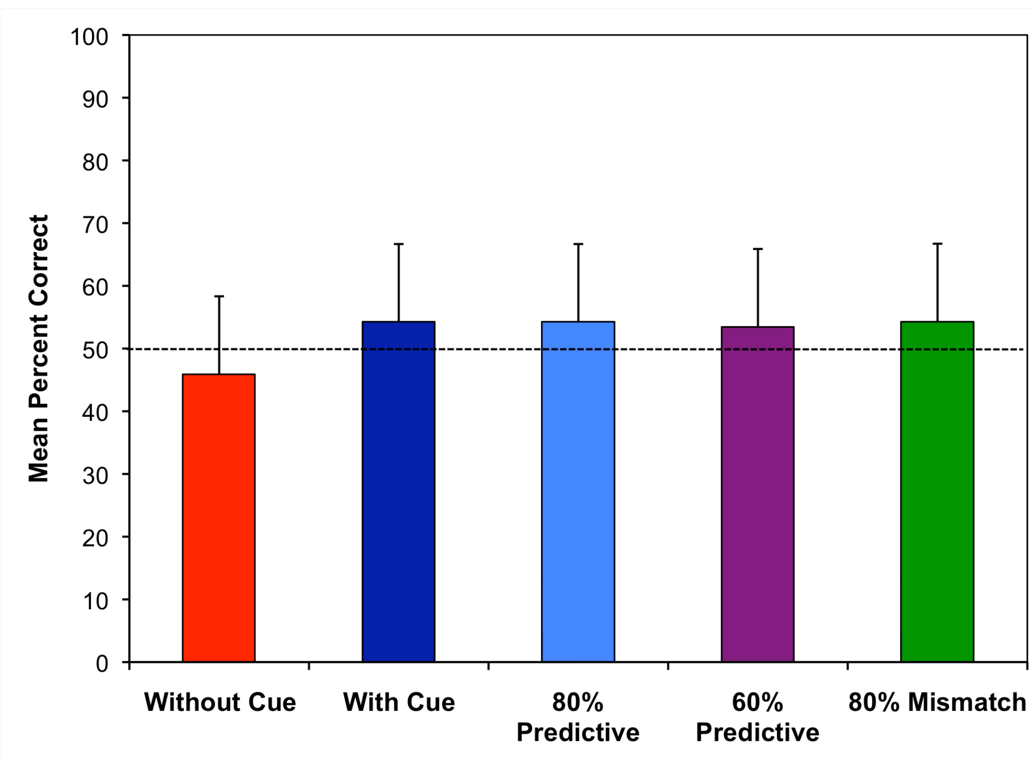

Figure 11. Mean percent correct on Sentence Test 4, all language conditions.

Sentence Test 5 was of critical interest because it removed all item-based judgments – target sentences contained a novel location for one word contained within a novel, but grammatical, bigram. This test can also be considered the most abstract generalization. In Study 1, Without Cue and With Cue participants had different learning outcomes for this test – Without Cue participants performed at chance level while With Cue participants were able to make this generalization. Performance on this test for all groups appears in Figure 12.

According to the adjusted p-value (.017) for the family of comparisons, relative performance outcomes did not significantly differ from the the With Cue condition for the 80% Predictive condition ($F(1, 39) = 2.007$, $p = .165$), the 60% Predictive condition ($F(1, 39) = 3.240$, $p = .080$), or the 80% Mismatch condition ($F(1, 39) = .000$, $p = 1.000$). These groups also did not differ from the Without Cue Condition – for the 80% Predictive condition ($F(1, 39) = 4.864$, $p = .034$), the 60% Predictive condition ($F(1, 39) = .107$, $p = .745$), or the 80% Mismatch condition ($F(1, 39) = .882$, $p = .353$).

When compared to chance level performance, like Sentence Test 3 for the Partially Predictive groups, both 80% Predictive conditions (with and without noise words that matched other categories) performed above chance level on this test, M = 68.3%, SD = 46.7%, ($t(19) = 4.593$, $p<.001$) and M = 60.8%, SD = 49.0%, ($t(19) = 2.557$, $p=.019$) respectively. By contrast, the 60% Predictive condition performed at chance level, M = 53.3%, SD = 50.1%, ($t(19) = 1.453$, $p=.163$).

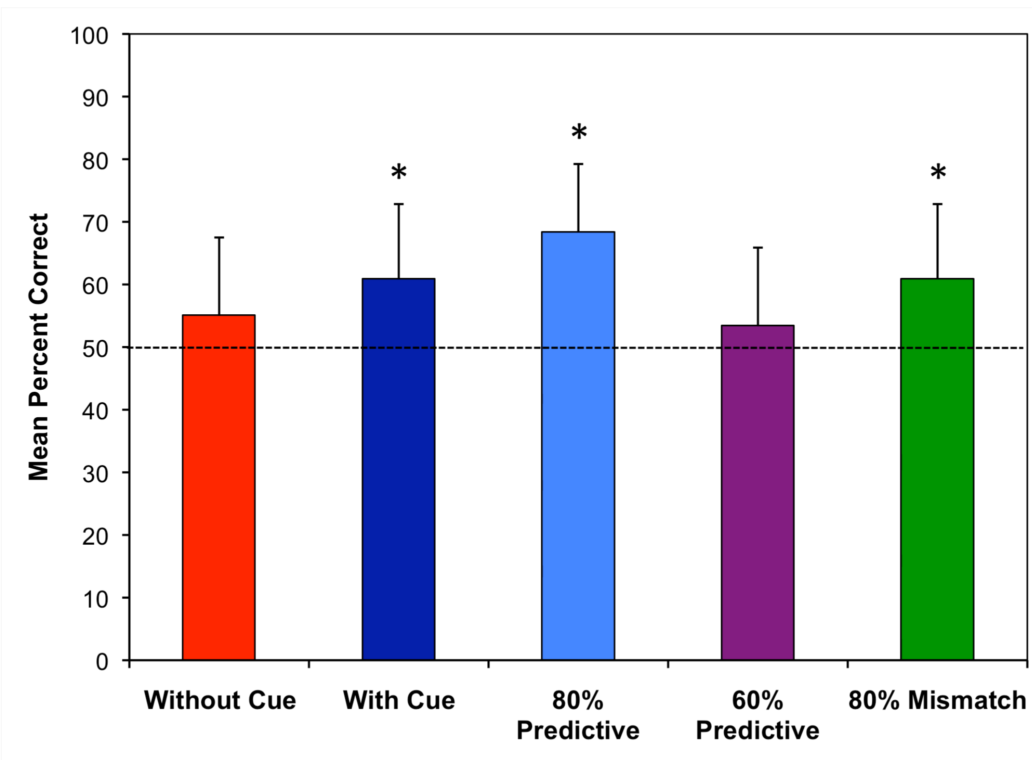

Figure 12. Mean percent correct on Sentence Test 5, all language conditions.

While the previous tests probed participants' knowledge of the structure of the language at the level of sentence, the phrase tests looked at knowledge of the components units or phrases in the language. The first phrase test compared pairs of words equally frequent in the exposure, but differed in that one pair had a high category-level transitional probability (within a phrase) and one pair had a low category-level transitional probability (across a phrase boundary). Both the With Cue and Without Cue groups in the previous study were able to make this judgment.

Compared to the With Cue condition, relative performance outcomes were not significantly different for the 80% Predictive condition ($F(1, 39) = 2.533$, $p = .120$) or the 80% Mismatch condition ($F(1, 39) = 1.142$, $p = .292$). However, they were significantly lower for the 60% Predictive condition ($F(1, 39) = 37.426$, $p = .000$), according to the adjusted p-value (.017). Compared to the Without Cue Condition, relative performance outcomes were not significantly different for the 80% Predictive condition ($F(1, 39) = .655$, $p = .423$) or the 80% Mismatch condition ($F(1, 39) = 2.951$, $p = .094$). But, the 60% Predictive condition performed significantly lower than this group as well ($F(1, 39) = 10.408$, $p = .003$).

When compared to chance level performance, both 80% Predictive groups, with and without noise words that matched other categories, performed above chance (M = 71.7%, SD = 45.3%, ($t(19) = 4.333$, $p<.001$) and M = 75.8%, SD = 43.0%, ($t(19) = 6.601$, $p<.001$) respectively). By contrast, the 60% Predictive condition performed at chance level, M = 50.8%, SD = 50.2%, ($t(19) =.252$, $p=.804$) indicating that dropping to degree to which the cue predicts category membership can impede learning outcomes beyond having no cue at all.

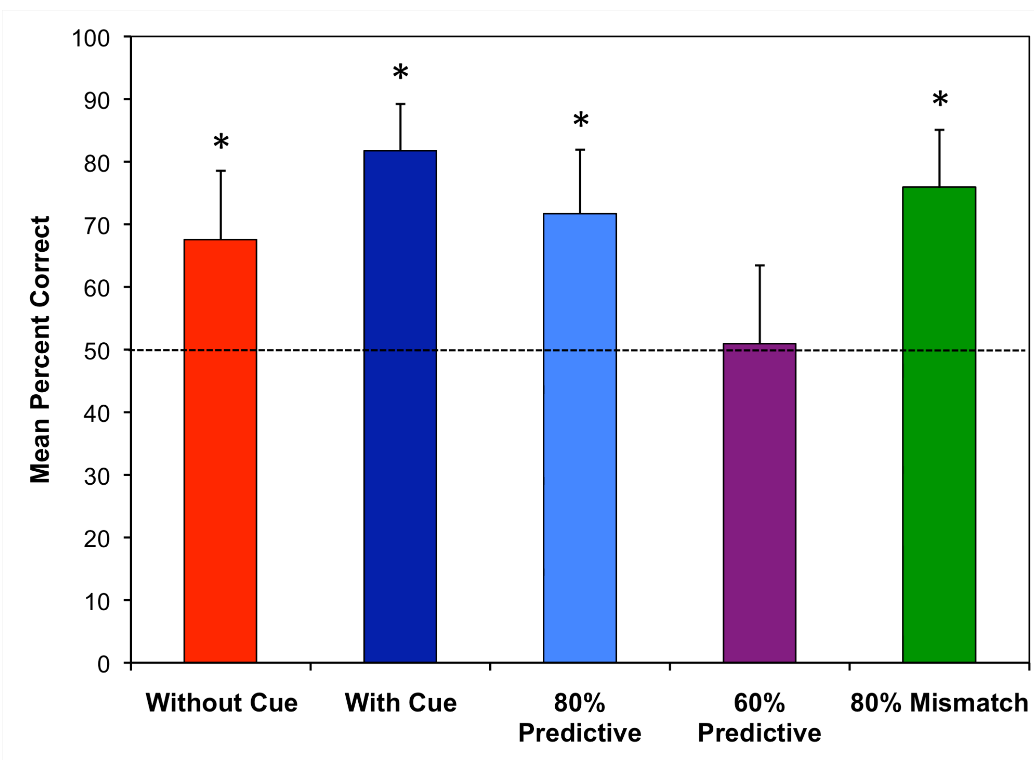

Figure 13. Mean percent correct on Phrase Test 1, all language conditions.

The final phrase test extended the comparison of pairs of words with either a high or a low category-level transitional probability to include novel words that conformed to the category cue (syllable structure). This was the only test that provided evidence for whether participants learned the cue itself, as opposed to simply using this property of the words to inform judgments about category relatedness. From Study 1, only the With Cue participants made this generalization.

Compared to the With Cue condition, relative performance outcomes were not significantly different for the 80% Predictive condition ($F(1, 39) = 1.072$, $p = .307$), the 60% Predictive condition ($F(1, 39) = 2.684$, $p = .110$), or the 80% Mismatch condition ($F(1, 39) = .974$, $p = .330$). Both the 80% Predictive condition ($F(1, 38) = 3.515$, $p = .069$) and the 60% Predictive condition ($F(1, 38) = 2.088$, $p = .157$) performed comparably to the Without Cue condition as well. The 80% Mismatch condition, where noise words did not match either the category or other categories in the language, performed significantly better than the Without Cue condition ($F(1, 39) = 11.187$, $p = .002$).

Interestingly, for the two partially predictive conditions that contained noise words that were indicative of other categories, was also not significantly different from chance with 80% Predictive scoring M = 54.2%, SD = 50.0%, ($t(19) = .960$, $p = .349$) and 60% Predictive scoring M = 50.8%, SD = 50.2%, ($t(19) = .188$, $p = .853$). However, when the noise words were of a different type from both the category members and other categories, performance was above the chance level, M = 64.2%, SD = 48.2%, ($t(19) = 4.073$, $p = .001$).

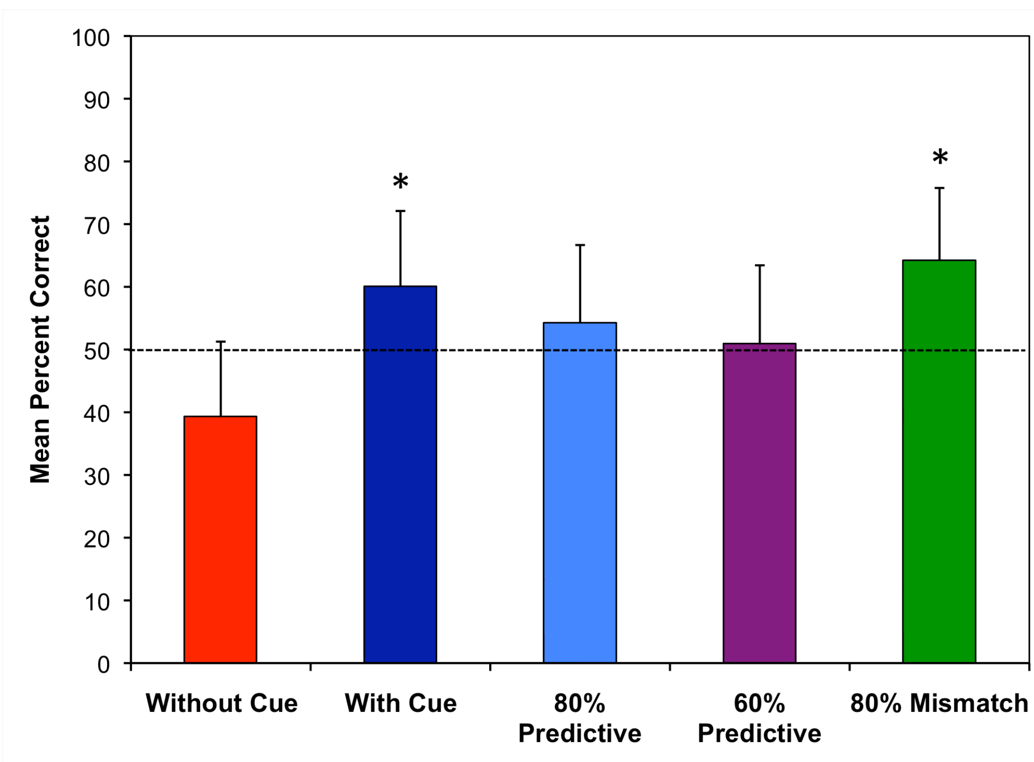

Figure 14. Mean percent correct on Phrase Test 2, all language conditions.

Discussion

Between Studies 1 and 2, we examined the learning of the distribution of pairs of categories of words in the context of five versions of a miniature artificial language. While previous work has demonstrated that learning phrase structure from distributional information alone is indeed possible (Thompson & Newport, 2007), we hypothesized that, as the scope of the computational problem is expanded with a larger vocabulary, the problem of tracking this information would become increasingly difficult. We also hypothesized that properties of natural languages, namely, the existence of non-distributional cues to category membership, would help solve the learning problem, by providing learners with a way into the system. As such, we included an abstract phonological cue to facilitate the problem of matching items into categories in an expanded language, both in a version that perfectly correlated the cue to category membership, as well as in situations where the cue partially correlated to category membership at two different levels of predictiveness and where the noise words were of two types.

We found that the cue to category membership did, indeed, facilitate acquiring the higher-order structure of the language, in particular when the novel grammatical sentence included a novel phrase. The usefulness of the cue was shown to be conditional, however, in that it did not facilitate this ability in the version of the language where the cue was 60% predictive of category membership. Interestingly, in the only test that examined whether the cue itself was learned, only participants in the versions where the cue perfectly correlated with category membership or was 80% Predictive but did not contain words that matched other categories were able to make this generalization.

We suggest that, in a large language, providing a cue to category membership provides the right conditions for learning higher-order relationships characteristic of natural languages.

4. A Visual Analogue

This body of work was motivated by noting a set of assumptions central to theories of Universal Grammar of phrase structure. Specifically, these theories place a number of constraints on the nature of phrases, such as headedness and category type and argue that these structures are unique to language. The goal is to test these assumptions of UG as they relate to acquisition and to investigate whether or not they hold. The final study in this dissertation is designed to test whether phrase structure is specific to language, by investigating whether it can also be learned in a different domain – in this case, a visual system.

In this experiment I exposed participants to visual stimuli constructed to have the same properties as the auditory languages used in the previous experiments. Simple two-dimensional objects were organized into categories which sometimes correlated with non-obvious visual cues. These objects were then arranged into visual arrays according to a phrase-structure grammar based on the categories. After exposure, I tested the participants to see if they had learned the category-based grammar governing the combination of the items in the array and assessed whether and how learning was affected by the presence and reliability of the cues to category membership.

The visual array paradigm used was based on that originally developed by Fiser and Aslin (2001). Making sense of the visual domain, like learning a language, is a complex problem that requires understanding higher-order relationships that could potentially be defined by relative statistics between items. As such, Fiser and Aslin created a series of experiments examining rapid and automatic acquisition of the several different higher-order aspects of the statistical structure of the displays, including absolute shape positions, shape-pair arrangements independent of position, and conditional probabilities of shape co-occurrences. Their third and final experiment, where relationships occurred irrespective of absolute spatial location in 5x5 grid, was modified here to examine the learnability of phrase relationships.

In their study, Fiser and Aslin created a set of visual arrays in which the adjacent relationships appeared according to a specific statistical structure. There were 12 uniquely-shaped black objects. Pairs of objects formed base pairs that always appeared together. These base pairs had one of three possible alignment types: (1) vertical, (2) horizontal, or (3) oblique (diagonal). There were two base pairs with each type of alignment. Additionally, the base frequencies of some base pairs and cross-pair, non-base pairs were equated. Therefore, the lower order, joint probability of these base pairs and cross pairs were equal (i.e., P(object1,object2) = P(object2, object3)), but the higher-order relative statistic, their conditional probabilities, differed (i.e., P(object2|object1) = 1.0 vs. P(object2|object3) ~ low). At test, adult participants reliably chose base pairs over cross pairs, suggesting they had learned the higher order conditional probability relationship. (See Figure 15 for a sample exposure scene.)

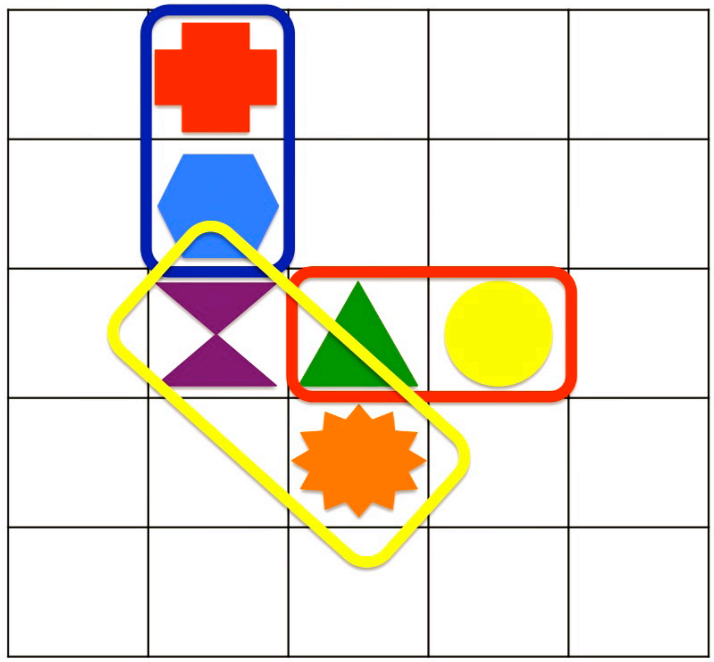

Figure 15. Schematic of example scene from Fiser and Aslin (2001), composed of three base pairs (one vertical, one horizontal, one oblique)

Their paradigm was modified here to investigate the acquisition of a phrase structure, where statistical relationships occur across pairs of categories, as opposed to pairs of individual items. To implement these ideas in the visual array paradigm, I expanded base pair relationships to include categories of objects adjacently in relevant configurations, while equating the co-occurrence of individual items within and across phrase boundaries.

Methods

Participants

A total of 60 adults participated in this study (20 per condition) for course credit in Psychology courses at the University of California – Berkeley.

Stimuli

Twenty-four unique objects were used, each with a unique color (properties of the color to be discussed later). Objects were assigned to one of eight categories (A, B, C, D, E, F, G, and H), with three objects per category. Pairs of categories were then grouped into phrases (much like the previous experiments), in one of two forms: vertical or horizontal. Phrases were then arranged into one of 16 distinct arrays in a five by five grid, with each array containing one example of each phrase. The 16 arrays, or category constructions, are much like the 5 distinct sentence types used in Studies 1 and 2. As such, the arrays, shown in Figure 16, constitute the 'grammar' of the visual system.

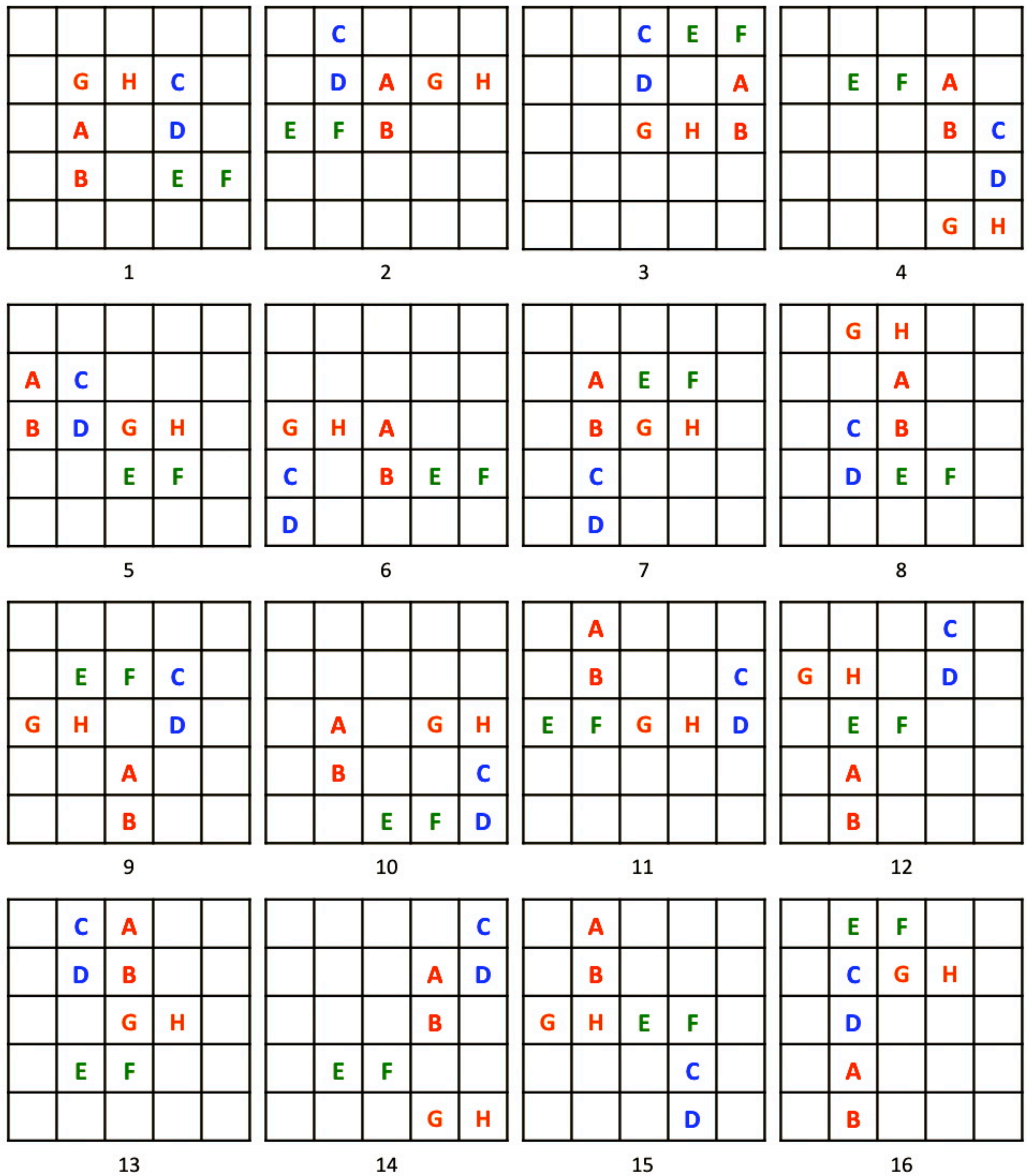

Figure 16. The sixteen possible construction types, labeled with category arrangements.

This design resulted in conditional probabilities of adjacent co-occurrence of categories within phrases being perfect (1.0). Adjacent co-occurrence of pairs of categories that were possible but not necessary – and crossed a phrase boundary - had a much lower conditional probability: each occurred exactly once over the exposure set, and therefore have the probability *p* =.0625. The complete set of adjacent co-occurrence relationships, for both the vertical and horizontal dimensions appear below in Tables 2 and 3.

Table 2. Adjacent co-occurrence conditional probabilities, vertical from top category to bottom category (phrase transitions in **bold**)

	A	B	C	D	E	F	G	H
A	-	**1.0**	-	-	-	-	-	-
B	-	-	.06	-	.06	.06	.06	.06
C	-	-	-	**1.0**	-	-	-	-
D	.06	-	-	-	.06	.06	.06	.06
E	.06	-	.06	-	-	-	.06	.06
F	.06	-	.06	-	-	-	.06	.06
G	.06	-	.06	-	.06	.06	-	-
H	.06	-	.06	-	.06	.06	-	-

Table 3. Adjacent co-occurrence conditional probabilities, horizontal from left category to right category (transitions in **bold**)

	A	B	C	D	E	F	G	H
A	-	-	.06	.06	.06	-	.06	-
B	-	-	.06	.06	.06	-	.06	-
C	.06	.06	-	-	.06	-	.06	-
D	.06	.06	-	-	.06	-	.06	-
E	-	-	-	-	-	**1.0**	-	-
F	.06	.06	.06	.06	-	-	.06	-
G	-	-	-	-	-	-	-	**1.0**
H	.06	.06	.06	.06	.06	-	-	-

The exposure set contained 96 unique scenes total, 6 of each type. A sample scene is shown in Figure 17.

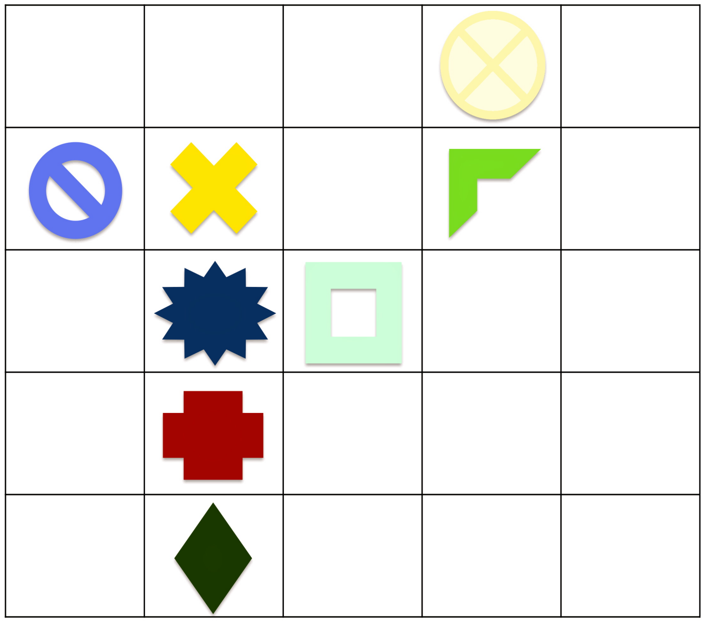

Figure 17. Example visual array of construction type 12.

The adjacent co-occurrence frequencies (or joint probabilities) of some within-phrase pairs of objects and pairs of objects that crossed phrase boundaries were equated. In order to accomplish this, some pairs of objects were highly frequent (occurring 26 times) and some were less frequent (occurring 6 times). In this way, the less frequent pairs of objects had equal joint probability with the pair of objects that crossed the phrase boundary in the 6 examples of any given scene and serve as test items. Additionally, some pairs of objects, both within phrase and across phrase boundaries, were reserved from the exposure set also for test purposes.

Experimental Manipulation

This study also addressed the contribution of a lower-order cue to category membership in acquisition of the phrase structure. In order to mimic the abstract nature of the phonological cue from the language work, the visual cue to category is an aspect of the color of the objects irrespective of hue. Colors for objects were selected from levels of brightness and saturation available in Microsoft Powerpoint — three hues from each level. In the cue-present version of the visual arrays, objects from the same category are of different hues from the same brightness and saturation level. In the without cue condition, objects are randomly assigned to categories, and color cannot serve as a cue. A third version of the arrays contains a partially predictive cue to category membership, where two of the objects match the category and one object has random assignment.

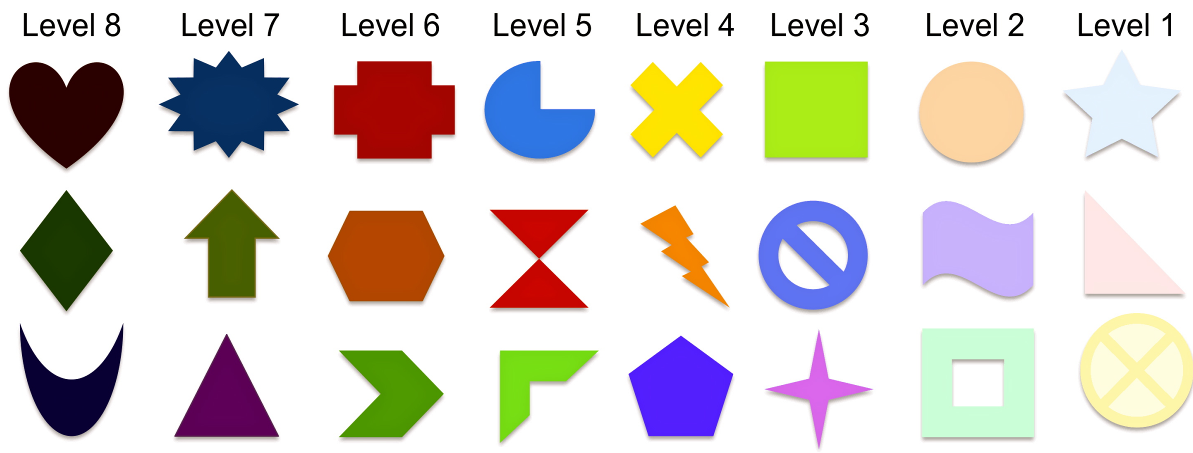

Figure 18. All 24 objects, shown in respective color assignment, organized into 8 levels of lightness and saturation.

Although lightness and saturation may not be perceived categorically, it is an aspect of color that is perceived (Palmer, 1999) and so available for use in organizing categories. However, to ensure that people are indeed able to perceive the (somewhat subtle) lightness and saturation distinctions we used, we conducted a separate pilot study. Participants were asked to match one of two uniformly shaped color blocks to a target: one block of the same lightness and saturation level as target, the other block being either one or two levels away from the target. Both color match choices were of differing hues from the target color. Participants identified the block of the same lightness and saturation level as being more similar to the target than the color block from a different brightness and saturation level both when the comparison color was one level away from the target color: M = 63%, SD = 48.2% ($t(1319) = 210.172$, $p < .001$), as well as when the comparison color was two levels away M = 69%, SD = 46.2% ($t(1319) = 15.004$, $p < .001$). Additionally, participants were significantly more likely to choose the color of the same lightness and saturation level when the comparison was two levels away than when the comparison color was just one level away, suggesting the discrimination got easier the further it was away on our scale ($F(1, 2638) = 9.308$, $p = .002$). We suggest that this demonstrates the lightness and saturation cue is, indeed, perceptually available as a grouping aid.

Tests

There were two types of tests in this experiment designed to test whether participants understood the phrases or units of the visual grammar – very much like the phrase tests from the language work. Both tests required participants to compare two pairs of objects: one with a high category-level conditional probability and one with a low category-level conditional probability. The two comparison pairs were displayed to the left and to the right of the center square of the 5 x 5 grid, as shown in Figure 19.

Phrase Test. Some pairs of objects in the exposure set were matched for frequency – that is, had the same joint probabilities of appearing together – either within or across a phrase boundary. However, the pairs differed in that some had high category-level conditional probability (i.e., there were within a phrase) while others had a category-level conditional probability that was low (i.e, they were not within a phrase). The first test compared these two types of pairs. There were 12 such items total, six on the first day and six on the second day.

*Generalization Test***.** The second test was a generalization test, in which participants were tested using pairs of objects that had been reserved from the exposure set. One test pair was a novel phrase with high category conditional probability. The comparison pair of objects was also novel, but which had a low category transitional probability (but not zero or absent). There were 12 of these items, six on the first day and six on the second day.

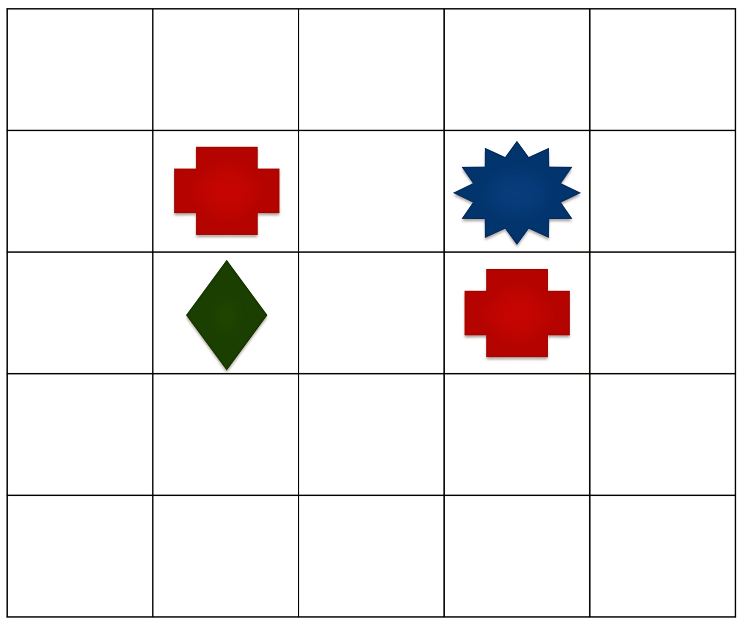

Figure 19. Sample test item, within-phrase object versus frequency matched objects crossing a phrase boundary (vertical phrase).

Procedure

Participation in this study spanned two days, with each day involving an exposure session and a test session. While the earlier experiments tested strictly end-state performance outcomes, we were interested in the trajectory of learning – whether we could capture an intermediary stage of having learned some aspects, but not all, of the grammr.

On each day, participants saw the exposure set a total of eight times: four times through, followed by a two-minute break, then another four times through, for a total exposure session of about 25 minutes. Across both days, participants saw the exposure set 16 times. Participants then sat for the two-alternative, forced choice tests at the end of both days.

The phrase test was always given first, followed by the generalization test. Prior to test, participants were shown a practice comparison that contained objects that had not appeared in the scenes, first in the vertical then the horizontal orientation. Participants were instructed that they were going to indicate which of the pairs of objects they thought more likely came from the scenes they had been learning about. Responses were recorded by the experimenter, who was also advancing the test-item slides. Participants were given as much time as they needed to make a response.

Results

Performance on the phrase test, in which participants chose between one high category-level conditional probability pair and one low category-level conditional probability pair, is shown in Figure 20. On the first day, relative performance of the three groups was not in fact significantly different ($F(2, 59)=1.640$, $p=.203$). Additionally, relative performance of the three groups on the second day was also not significantly different, $F(2, 59)=1.936$, $p=.154$). However, when compared to chance, on the first day, Without Cue participants performed significantly above, M = 63.3%, SD = 48.4% ($t(19) = 2.707$, $p = .014$), while With Cue participants performed at chance level, M = 52.5%, SD = 50.1% ($t(19) = .529$, $p = .603$) as did Partially Predictive Cue participants, M = 53.3%, SD = 50.1% ($t(19) = .748$, $p = .464$).

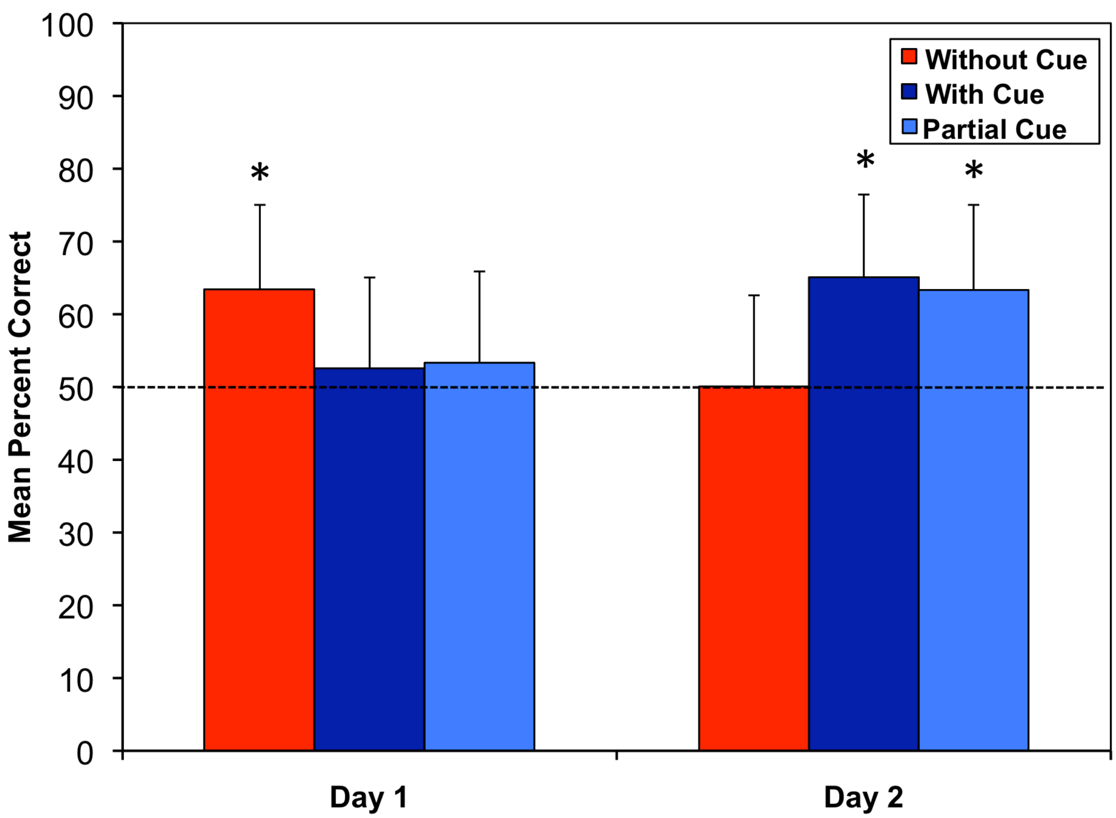

Figure 20. Mean percent correct on Phrase Test 1, by condition by day.

On the second day, the relative performance outcomes of the three groups flipped when compared to chance. Without cue participants performed at chance level, M = 50.0%, SD = 50.2% (t(19) = .000, p = 1.000), while With Cue participants performed above chance, M = 65.0%, SD = 47.9% (t(19) = 2.932, p = .009) as did Partially Predictive Cue participants, M = 63.3%, SD = 48.4% (t(19) = 2.320, p = .032).

Because this set of tests queried the same participants on two separate occasions, we also considered it appropriate to conduct a paired-samples t-test for whether the groups improved significantly from one day to the next. This was true for With Cue participants (t(19)=2.263, p=.036), but not true for Without Cue participants (t(19)=-1.962, p=.065) or Partially Predictive Cue participants (t(19)=1.837, p=.083).

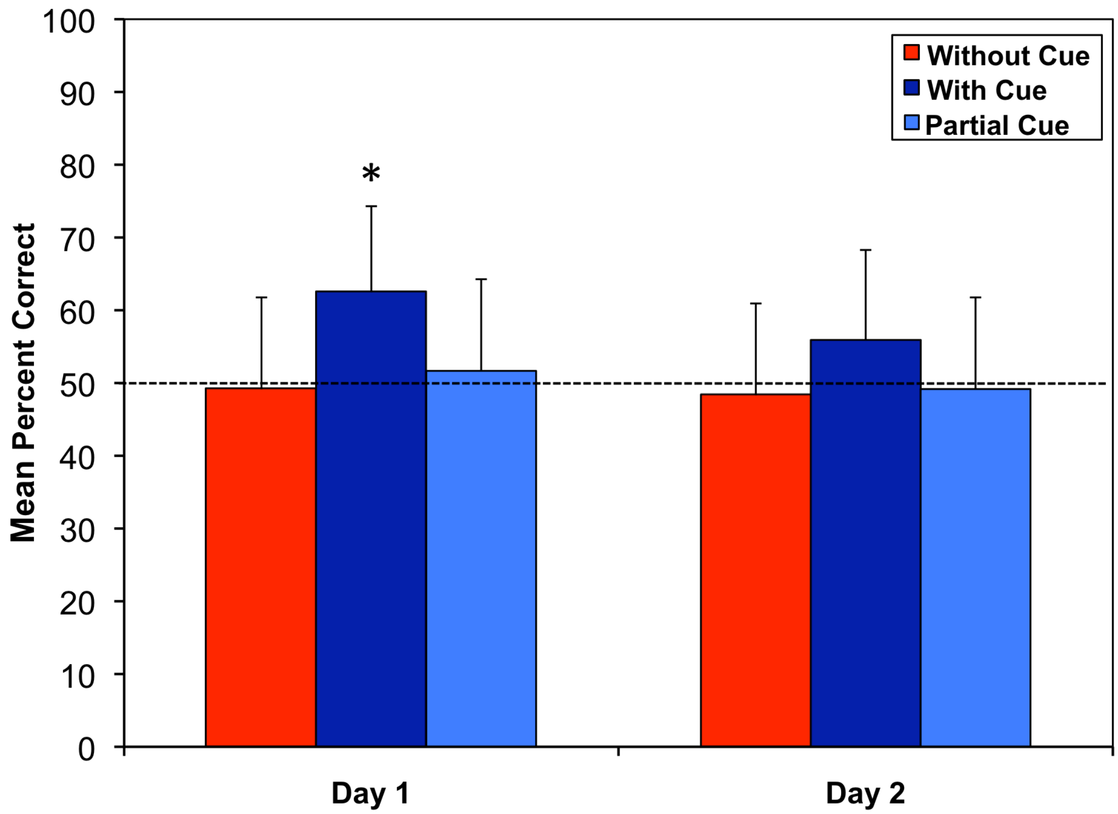

Figure 21. Mean percent correct on Phrase Test 2, by condition by day.

Figure 21 shows mean performance on the generalization test, again by condition and test day. This test asked participants to compare novel pairs that had been reserved from the exposure set, but which again differed in that one had a high category-level conditional probability and one had a low category-level conditional probability. On the first day, the relative performance of the three groups approached significance (F(2, 59)=1.862, p=.165) with the With Cue participants outperforming the other two groups. On the second day, there was no significant difference in performance outcomes (F(2, 59)=.646, p=.528), however, the same pattern was still apparent, the with-cue participants performed better than the other two conditions.

Without cue participants performed at chance level both on the first day, M = 49.2%, SD = 50.2% (t(19) = -.188, p = .853) as well as the second day, M = 48.3%, SD = 50.2% (t(19) = -.302, p = .766).

Despite performing at chance on the less abstract item-based test, on the first day With Cue participants performed significantly above chance, M = 62.5%, SD = 48.6% (t(19) = 2.380, p = .028) and then dropped on Day 2 for this test to chance level, M = 55.8%, SD = 49.9% (t(19) = 1.234, p = .232).

Partially predictive cue participants, like the Without Cue participants, performed at chance level both on the first day M = 51.7%, SD = 50.2% (t(19) = .302, p = .766) as well as the second day, M = 49.2%, SD = 50.2% (t(19) = -.165, p = .871).

Discussion

This experiment was designed to assess whether category relatedness or phrases can be inferred in a nonlinguistic system, or is instead a property only of linguistic systems. In addition, we asked whether cues to category membership would function similarly in the auditory and visual domains. Participants were exposed to visual arrays comprised of phrases defined over categories, arranged so that the within-phrase category-level conditional probabilities were higher than those of categories that co-occurred but did not form phrases. Participants were then tested to see if they had acquired the phrases or units of the visual grammar. The hypothesis was that general purpose learning processes would enable acquiring phrase structure in the visual system as in the auditory language, and that these learning processes would be improved by cues that facilitated the matching items in categories. If this is the case, the relative statistics in the input should inform judgments about category relatedness that contrast pairs of objects that are a phrase-relevant pair to pairs that cross phrase boundaries. Indeed this was the case. Based on the frequency-matched pairs of objects drawn from the exposure set, learning appeared early in Without Cue group and late in the With Cue group, and this could have potentially been a result of the small number of items being learned from. Additionally, despite not identifying the phrase relevant pairs from the input over non-phrase pairs, with cue participants are able to generalize the structure to novel phrases on day one, suggesting that the higher-order structure was, in fact, acquired in these participants in the visual grammar, making this the first time this ability has ever been shown.

5. Concluding Remarks

For many years it has been assumed that many aspects of human language are innate, that is, that they reflect particular knowledge about language built into each and every human being. Recently, this view has been challenged by experiments demonstrating that humans and other animals are very sophisticated learners, capable of extracting a great deal of information about the patterns present in their environments (e.g. Saffran, Aslin, & Newport, 1996; Finn & Hudson Kam, 2008; Gómez, 2002; Feldman, et al., 2011; Fiser & Aslin, 2001; Conway & Christiansen, 2005; Toro & Trobalón, 2005; Hauser, Newport, & Aslin, 2001). Much of this work has been conducted within the tradition of Statistical Learning, asking about the information present in the environment, particularly the linguistic environment, and whether learners can perform the necessary computations to make use of the information.

The initial study in this line of work looked at the problem of word segmentation. Segmenting words from fluent speech is a non-intuitive problem because the speech signal doesn't contain consistent acoustic cues to where word boundaries fall (i.e. a pause or other property of the speech signal). It does, however, contain a different kind of cue: its statistical structure. In particular, the sounds that happen within words co-occur more regularly than the sounds that happen together but across word boundaries. For example, if you think about the phrase "pretty baby" you are more likely to hear the syllables "pre-tty" adjacently, than you are to hear "ty-ba." To test whether infants could use the transitional probabilities between syllables as a cue to units like words, Saffran, Aslin, & Newport (1996) created a miniature artificial language that contained 6 trisyllabic words, where the within word transitional probabilities were relatively high (between .31 and 1) and syllables across word boundaries had transitional probabilities that were relatively low (between .1 and .2). At test, in a head-turn preference procedure, infants showed a familiarity bias, looking longer towards properly segmented words over mis-segmented words, suggesting they understood those words to be more likely.

Since that groundbreaking work, this same ability has been demonstrated in other domains such as visual sequences (Fiser & Aslin, 2002; Kirkham, Slemmer, & Johnson, 2002) and non-speech tones (Saffran, Johnson, Aslin, & Newport, 1999), as well as in other species, including rats (Toro & Trobalón, 2005) and monkeys (Hauser, Newport, & Aslin, 2001). Taken together, these studies suggest that language acquisition may involve more learning than has been long assumed.

However, the original statistical learning study, and much of what followed, involved learning relationships between specific items (in the case of Saffran, Aslin, and Newport (1996) – syllables). And the outcome of the learning was similarly specific - words. Arguments for innateness have focused on other, higher-order aspects of language, namely the syntax of language. There is much less extant evidence for the involvement of statistical learning in more abstract domains. Saffran (2001) demonstrated learning of some aspects of predictive dependencies between classes of words, and Thompson and Newport (2007) demonstrated robust learning of category relationships in a small language. Other work has also shown that statistics across classes may be acquirable over classes that are semantically defined (Hudson Kam, 2009).

However, because the scope of these languages was small, these demonstrations could be posited as simply existence proofs for learnability – far from what can and does happen the broader language learning context, leaving open the question of how this could be realized in larger languages. Thus, the goal was to examine learning of phrase relationships in a large language and the conditions under which this learning is feasible.

Study 1 created two versions of an auditory miniature artificial language based on the grammar of Thompson and Newport (2007) with a large vocabulary (five times the size). In one version, there was associated an abstract phonological cue (syllable structure) to category membership – not unlike cues found in natural languages (Mills, 1986; Kelly & Bock, 1988). In another version, words were randomly assigned to categories, and therefore syllable structure did not serve as a cue to category. Interestingly, participants in the Without Cue version of the language demonstrated having learned some aspects of phrase structure, in that they were able to generalize what they had heard to novel sentences composed of observed bigrams or phrases. They also distinguished between pairs of words that had a high category-level transitional probability and pairs of words with low category-level transitional probability that had appeared with equal frequency in the input. However, With Cue participants outperformed this group on tests at the level of sentence that involved novel combinations of words – both when the words had appeared in those locations before and when the sentence contained a novel location for one word. Additionally, With Cue participants distinguished between pairs of words that contained novel words conforming to the syllable-structure cue to category membership – demonstrating that the cue was itself learned. We concluded that, in the most abstract generalizations based on input, having a cue to category membership appeared to enable learning.

Study 2 created three additional versions of the auditory miniature artificial language from Study 1. We were interested in whether learning phrase structure from distributional information in the presence of an abstract phonological cue was robust to the presence of noise in the cue – in particular because cues to category in natural language are rarely perfectly predictive. It was found that, in the presence of a small percentage of noise in the cue (80% Predictive) learning outcomes were much like that of the With Cue condition from Study 1 – these participants generalized the grammar to novel sentences, including those that contained novel combinations of words that had or had not been observed in the test locations. However, dropping the degree to which the cue predicted category membership (60% Predictive) changed these outcomes – in some cases below that of the Without Cue condition. This was true of the sentence test that required participants to generalize to novel sentences that contained observed bigrams from the exposure, as well as the phrase test that compared pairs of words equally frequent in the exposure that had high category-level transitional probability or low category-level transitional probability. Learning outcomes for yet another version of the language that contained noise words that were not like any of the other categories were similar to both the With Cue and the original 80% Predictive condition, with one important difference – in judgments over pairs of words that contained novel words conforming to the cue, participants were able to discriminate between high category-level transitional probability words and low category-level transitional probability words, as had the With Cue participants, suggesting that they had extracted the cue and changing the nature of the noise words enabled this discrimination.

Study 3 expanded learning of phrase structure to a nonlinguistic system, in this instance a visual system. Phrase relationships were created in the distribution of categories of objects in the context of three set of visual arrays: one with a cue to category membership, one with an abstract aspect of color as a cue to category membership, and one with a partially predictive cue. All three groups demonstrated learning of phrase relationships. The Without Cue group demonstrated learning early – on the first day – on the test that compared pairs of objects from the exposure set with either a high or low between category conditional probability. The With Cue and Partially Predictive Cue conditions also demonstrated learning on this test on the second day. Additionally, on novel combinations of objects that were phrase relevant or crossed a phrase boundary, With Cue participants reliably selected the phrase relevant pairs on the first day, suggesting they had extracted the high-order category relationships.

One could argue that we have simple managed to trigger the Language Acquisition Device, and thus, that we have not actually demonstrated *learning* of aspects of syntax. However, the language was designed in such a way as to minimize this possibility. Words in natural languages belong to one of a set of possible word classes: noun, verb, and determiner, for instance. And, these classes are determined by their grammatical and or semantic features – something presumably only recoverable via meaning. Moreover, the phrases in which these categories are asymmetrical: that is, phrases contain a head element that determines relationships within and across phrases. The miniature artificial languages we used had no meaning, and the categories were equal within a phrase. Thus, we suggest that our grammar does not easily map on to innate expectations for phrase structure. Moreover, we exposed learners to visual input with similar organizational properties, suggesting that the phrase structure that was learned was not restricted to linguistic input.

It is also important to note that, while we provided a grammar presented in the visual domain, the arrays of objects did not contain characteristics that easily map onto natural signed languages, or anything that could trigger an innate expectation for that type of visual system. That is, it is true that natural sign languages typically make use of spatial location relationally (Senghas & Coppola, 2001) and that the use of this space is arbitrary and conventionalized, and thus, grammatical (Hudson Kam & Goodrich Smith, 2011). However, the relational aspects of space invoked in referring back to entities (Senghas, 2011) and conveying locations of and actions upon referents (Senghas, 2011) in these languages rely on a semantic component, which our visual grammar lacks.

It is, in some ways, seemingly easy to dismiss experimental artificial language work that appears, on the surface, to be very different from long-held beliefs about the structure of language. However, we consider the key components of linguistic structure in the abstract – importantly, deviating from any particular conception of the syntactic structure of language in ways that demonstrate it is learnable without them. The object of a theory of Universal Grammar is to outline a set of constraints that will identify all the grammatical sentences in a language and none of the ungrammatical ones. It is impossible to do this in the absence of specifications on the nature of phrases, and this work demonstrates that phrase relationships are learnable in the absence of triggers for these aspects of the Language Acquisition Device.

In sum, we would like to suggest that, unlike the proposition that phrase structure must be an innately determined component of the Language Acquisition Device, that phrase relationships are indeed accessible to learners. Importantly, in this particular examination of learnability, we consider that, rather than it being that the null hypothesis in poor learning situations be that language is simply 'unlearnable,' instead that there are malleable parameters to learning (like presence of a cue) that facilitate or expedite core learning processes.

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Appendix A. Complete Vocabulary Lists, All Language Conditions

Without Cue Condition

A	B	C	D	E	F
drisk	blee	brole	bleef	bape	fiye
plohnt	da	clab	swiv	flerb	gop
gee	drame	dee	dut	hift	skige
flisp	droh	klor	gorf	gurk	klee
kerm	klard	gleeb	sleft	filk	luh
foo	glert	gliye	kice	pralk	nort
kwoh	koh	wa	kiye	puv	frim
lerd	kwim	lum	na	skaye	poh
vray	prov	prah	malb	slom	werf
sah	briye	neek	swohst	snoo	sig
ralt	scoo	pralb	jusk	sparl	gree
rog	stoom	slah	rilm	spee	sool
trosk	trelt	slub	skuln	spag	tasp
vot	zirl	tay	voh	tam	ziye
mib	starp	tev	rud	jarb	ploo

Contains 15 words per category, with category labels. Words 'reserved' from their location in the canonical sentence type are highlighted in grey.

With Cue Condition (100% Predictive)

A	B	C	D	E	F
bleef	bape	filk	blee	da	drisk
brole	dut	gorf	briye	dee	flisp
clab	gop	gurk	gliye	foo	glert
drame	kice	hift	klee	gee	klard
frim	lum	jarb	kwoh	kiye	plohnt
gleeb	mib	jusk	ploo	koh	pralb
kwim	puv	kerm	prah	luh	pralk
prov	rog	lerd	scoo	na	skuln
skige	sig	malb	skaye	poh	sleft
slom	sool	ralt	slah	tay	sparl
slub	tam	rilm	snoo	voh	starp
stoom	tev	werf	spee	wa	swohst
swiv	vot	zirl	vray	ziye	trelt
klor	neek	nort	droh	fiye	trosk
spag	rud	tasp	gree	sah	flirb
CCVC	CVC	CVCC	CCV	CV	CCVCC

Shows 15 words per category, sorted by syllable-type, with category labels. Words 'reserved' from the location for test are highlighted in grey. Syllable construction appears below.

80% Predictive Condition

A	B	C	D	E	F
brole	dut	filk	blee	dee	drisk
clab	gop	gurk	briye	fiye	glert
drame	kice	hift	gliye	foo	klard
frim	lum	jarb	gree	gee	plohnt
kwim	mib	kerm	klee	kiye	pralk
prov	neek	lerd	kwoh	luh	skuln
skige	puv	malb	prah	na	sleft
slub	rog	nort	scoo	poh	sparl
spag	sig	ralt	skaye	tay	starp
stoom	sool	rilm	slah	voh	trelt
swiv	tev	werf	snoo	wa	trosk
droh	gleeb	klor	tasp	slom	vray
swohst	jusk	pralb	bape	gorf	tam
bleef	vot	koh	sah	flirb	flisp
rud	ploo	zirl	spee	ziye	da

A	B	C	D	E	F
CCVC	CVC	CVCC	CCV	CV	CCVCC
ccv	ccvc	ccvc	cvcc	ccvc	ccv
ccvcc	cvcc	ccvcc	cvc	cvcc	cvc
cvc	ccv	cv	cv	ccvcc	cv

Shows 15 words per category: cue-match words color-coded and appear first, randomized noise words are a different shade and appear after. Reserved words are highlighted in grey. Syllable construction for 80% of words appears in all capital letters below each set, syllable constructions for randomized noise words also in category appear in normal type below.

60% Predictive Condition

A	B	C	D	E	F
skige	lum	gorf	ploo	da	glert
bleef	puv	gurk	slah	voh	flisp
kwim	vot	jarb	gliye	wa	pralk
clab	tev	werf	blee	luh	skuln
prov	sool	hift	snoo	tay	sparl
frim	rog	kerm	briye	ziye	drisk
slub	kice	malb	skaye	gee	starp
stoom	sig	filk	spee	foo	trosk
spag	neek	tasp	droh	sah	klard
tam	brole	plohnt	drame	gleeb	klor
jusk	slom	mib	gop	pralb	bape
kwoh	zirl	rud	swohst	lerd	ralt
dee	vray	klee	nort	scoo	na
flirb	sleft	koh	fiye	gree	kiye
trelt	poh	swiv	rilm	dut	prah

CCVC	CVC	CVCC	CCV	CV	CCVCC
cvc	ccvc (2)	ccvcc	ccvcc	ccvc	ccvc
cvcc	cvcc	cvc (2)	cvc	ccvcc	cvc
ccv	ccv	ccv	ccvcc	cvcc	cvcc
cv	ccvcc	cvc	cvcc (2)	ccv (2)	cv (2)
ccvcc (2)	cv	ccvc	cv	cvc	ccv

Shows 15 words per category: cue-match words color-coded and appear first, randomized noise words are a different shade and appear after. Reserved words are highlighted in grey. Syllable construction for 60% of words appears in all capital letters below each set, syllable constructions for randomized noise words also in category appear in normal type below.

80% Predictive with Mismatched Noise Words

A	B	C	D	E	F
brole	dut	filk	blee	dee	drisk
clab	gop	gurk	briye	fiye	glert
drame	kice	hift	gliye	foo	klard
frim	lum	jarb	gree	gee	plohnt
kwim	mib	kerm	klee	kiye	pralk
prov	neek	lerd	kwoh	luh	skuln
skige	puv	malb	prah	na	sleft
slub	rog	nort	scoo	poh	sparl
spag	sig	ralt	skaye	tay	starp
stoom	sool	rilm	slah	voh	trelt
swiv	tev	werf	snoo	wa	trosk
alb	ohl	een	et	ip	os
ub	elt	aff	eesk	urp	ohst
bleef	vot	zirl	spee	ziye	flisp
ust	oov	ard	ild	ent	ayn

CCVC	CVC	CVCC	CCV	CV	CCVCC
vc	vc (2)	vc (2)	vc	vc	vc (2)
vcc (2)	vcc	vcc	vcc (2)	vcc (2)	vcc

Shows 15 words per category: cue-match words color-coded and appear first, words of different phonological type are a different shade and appear after. Reserved words are highlighted in grey. Syllable construction for 80% of words appears in all capital letters below each set, syllable constructions for noise words also in category appear in normal type below.

Appendix B. Complete Input Sets, All Language Conditions

Without Cue Exposure Set, Sorted by Sentence Type
Note: Each word occurs exactly 14 times across the exposure set – this is true of all languages.

	ABCDEF					
1	drisk	blee	brole	gorf	bape	fiye
2	drisk	da	clab	malb	hift	nort
3	drisk	drame	klor	swiv	pralk	sig
4	drisk	droh	gliye	swohst	skaye	skige
5	drisk	klard	lum	dut	snoo	frim
6	drisk	glert	prah	malb	bape	gop
7	drisk	koh	slah	dut	hift	frim
8	drisk	kwim	slub	malb	pralk	plohst
9	plohnt	prov	brole	swiv	skaye	klee
10	plohnt	briye	dee	swiv	gurk	tasp
11	plohnt	scoo	klor	dut	bape	skige
12	plohnt	trelt	gliye	jusk	sparl	poh
13	plohnt	stoom	lum	gorf	pralk	sool
14	plohnt	blee	neek	swohst	sparl	werf
15	plohnt	da	slah	gorf	skaye	luh
16	plohnt	drame	slub	swohst	pralk	fiye
17	gee	droh	brole	dut	gurk	poh
18	gee	klard	dee	dut	bape	klee
19	gee	glert	klor	gorf	skaye	nort
20	gee	koh	gliye	rilm	sparl	sig
21	gee	kwim	lum	sleft	bape	luh
22	gee	prov	neek	jusk	pralk	gop
23	flisp	briye	brole	gorf	gurk	werf
24	flisp	scoo	klor	sleft	sparl	gree
25	flisp	trelt	dee	gorf	bape	nort
26	flisp	stoom	gliye	skuln	skaye	frim
27	flisp	blee	lum	kice	pralk	skige
28	flisp	da	neek	rilm	skaye	tasp
29	flisp	drame	slah	sleft	pralk	klee
30	flisp	droh	slub	jusk	sparl	sool
31	kerm	klard	brole	sleft	flerb	frim
32	kerm	glert	dee	sleft	gurk	gree
33	kerm	koh	gleeb	dut	gurk	sig

34	kerm	kwim	gliye	gorf	slom	poh
35	kerm	prov	lum	kiye	sparl	fiye
36	kerm	briye	neek	skuln	gurk	sool
37	kerm	scoo	slah	kice	flerb	tasp
38	kerm	trelt	slub	rilm	pralk	luh
39	foo	stoom	brole	kice	slom	werf
40	foo	blee	dee	kice	spee	gop
41	foo	da	gleeb	gorf	gurk	fiye
42	foo	drame	wa	jusk	flerb	poh
43	foo	droh	lum	na	puv	nort
44	foo	klard	neek	gorf	spee	klee
45	vray	glert	brole	kiye	spag	nort
46	vray	koh	dee	kiye	flerb	werf
47	vray	kwim	gleeb	sleft	gurk	gop
48	vray	prov	wa	rilm	puv	frim
49	vray	briye	prah	swohst	slom	sig
50	vray	scoo	neek	swiv	spee	luh
51	lerd	trelt	brole	na	flerb	sig
52	lerd	stoom	dee	na	filk	skige
53	lerd	blee	gleeb	kice	puv	tasp
54	lerd	da	wa	skuln	slom	gree
55	lerd	drame	prah	dut	spee	frim
56	lerd	droh	pralb	gorf	flerb	gree
57	kwoh	klard	clab	swohst	filk	klee
58	kwoh	glert	dee	malb	puv	poh
59	kwoh	koh	gleeb	kiye	slom	sool
60	kwoh	kwim	wa	gorf	spee	poh
61	kwoh	prov	prah	jusk	hift	sool
62	kwoh	briye	pralb	malb	filk	luh
63	ralt	scoo	clab	jusk	puv	werf
64	ralt	trelt	klor	kice	slom	fiye
65	ralt	stoom	gleeb	spe	spee	fiye
66	ralt	blee	wa	swiv	hift	fiye
67	ralt	da	prah	rilm	filk	nort
68	ralt	drame	pralb	swohst	puv	sig
69	ralt	scoo	slah	kiye	snoo	gop
70	ralt	stoom	slub	skuln	spag	gop
71	sah	kwim	clab	rilm	hift	gop
72	sah	trelt	klor	kiye	filk	frim
73	sah	blee	gleeb	malb	snoo	skige

74	sah	da	wa	dut	puv	gree
75	sah	drame	prah	skuln	spag	klee
76	sah	droh	pralb	swohst	hift	skige
77	rog	klard	clab	skuln	filk	tasp
78	rog	glert	gleeb	swohst	puv	sool
79	rog	koh	klor	na	snoo	klee
80	rog	kwim	wa	kiye	spag	luh
81	rog	stoom	prah	gorf	hift	klee
82	rog	scoo	pralb	jusk	filk	poh
83	trosk	blee	clab	gorf	skaye	fiye
84	trosk	da	klor	malb	snoo	luh
85	trosk	drame	gliye	swiv	hift	luh
86	trosk	droh	wa	malb	spag	frim
87	trosk	kwim	prah	swiv	filk	werf
88	trosk	scoo	pralb	rilm	skaye	gop
89	trosk	stoom	slah	na	snoo	tasp
90	trosk	briye	slub	gorf	spag	poh

	ABEFCD					
91	drisk	prov	pralk	tasp	lum	gorf
92	drisk	briye	filk	gree	pralb	na
93	plohnt	droh	slom	ziye	neek	kice
94	plohnt	glert	snoo	ziye	lum	swiv
95	gee	briye	jarb	ploo	pralb	swiv
96	gee	trelt	pralk	sig	neek	rud
97	gee	stoom	filk	sig	brole	rud
98	gee	blee	slom	gree	wa	voh
99	foo	glert	snoo	skige	tay	na
100	foo	koh	jarb	frim	brole	malb
101	foo	kwim	hift	sool	wa	rud
102	foo	prov	tam	ziye	tay	swohst
103	kerm	stoom	gurk	ziye	clab	sleft
104	kerm	da	skaye	ziye	tev	swohst
105	kwoh	scoo	sparl	ploo	tay	jusk
106	kwoh	trelt	hift	werf	clab	kice
107	sah	klard	tam	fiye	tev	skuln
108	sah	koh	gurk	sool	tay	skuln
109	lerd	klard	skaye	nort	slub	voh
110	lerd	briye	sparl	poh	tev	jusk

111	ralt	kwim	flerb	poh	klor	voh
112	ralt	trelt	spee	ploo	slub	gorf
113	rog	blee	spag	ziye	tev	voh
114	rog	da	jarb	tasp	klor	rud
115	trosk	scoo	bape	ploo	gliye	sleft
116	trosk	trelt	flerb	skige	slah	gorf
117	trosk	prov	spee	frim	prah	kiye
118	trosk	briye	spag	nort	gliye	kiye
119	vray	scoo	jarb	werf	slah	malb
120	vray	droh	bape	fiye	prah	gorf

CDABEF

121	tay	kiye	kerm	droh	bape	werf
122	tev	sleft	vot	drame	bape	sig
123	gliye	na	vot	da	sparl	gop
124	gleeb	gorf	foo	zirl	sparl	klee
125	lum	voh	drisk	stoom	sparl	luh
126	tay	malb	vray	da	sparl	nort
127	tev	skuln	kwoh	zirl	skaye	gree
128	gliye	ble	flisp	glert	skaye	sool
129	gleeb	swiv	mib	kwim	skaye	tasp
130	lum	rud	mib	koh	skaye	poh
131	klor	gorf	sah	stoom	puv	fiye
132	slah	rud	plohnt	koh	puv	gop
133	pralb	kice	lerd	kwim	snoo	poh
134	dee	skuln	mib	drame	snoo	fiye
135	brole	voh	ralt	klard	spag	skige
136	klor	swohst	ralt	prov	spag	werf
137	slah	rilm	plohnt	starp	gurk	frim
138	pralb	voh	lerd	prov	gurk	nort
139	dee	swohst	sah	zirl	slom	skige
140	brole	rilm	mib	glert	slom	klee
141	prah	sleft	flisp	starp	spee	sig
142	neek	dut	rog	trelt	spee	sool
143	tev	kiye	kwoh	drame	filk	gree
144	slub	kice	drisk	scoo	filk	klee
145	clab	gorf	vray	trelt	flerb	luh
146	prah	na	rog	zirl	flerb	nort
147	neek	malb	foo	scoo	hift	tasp

148	tev	swiv	vot	starp	hift	klee
149	slub	dut	vot	klard	pralk	frim
150	clab	voh	kerm	starp	pralk	nort

EFABCD

151	bape	nort	drisk	drame	dee	voh
152	bape	ziye	sah	scoo	gleeb	voh
153	sparl	ziye	vray	stoom	pralb	rud
154	sparl	tasp	mib	droh	neek	voh
155	jarb	werf	drisk	droh	prah	na
156	jarb	ziye	sah	starp	brole	skuln
157	jarb	gop	vray	koh	dee	rud
158	jarb	fiye	lerd	starp	wa	gorf
159	puv	ziye	gee	drame	neek	jusk
160	puv	gop	flisp	klard	lum	jusk
161	snoo	ploo	kwoh	blee	wa	kice
162	snoo	sool	lerd	kwim	slub	kiye
163	spag	gree	gee	zirl	klor	rud
164	spag	ploo	flisp	starp	lum	rilm
165	gurk	ploo	kwoh	glert	slub	swiv
166	gurk	luh	ralt	prov	tev	gorf
167	slom	ziye	vot	zirl	tay	sleft
168	slom	ploo	rog	briye	brole	jusk
169	spee	ziye	mib	klard	gliye	kice
170	spee	werf	ralt	kwim	tev	kice
171	tam	nort	vot	blee	tay	rud
172	tam	ziye	rog	starp	clab	dut
173	tam	gop	mib	zirl	gliye	voh
174	tam	gop	vot	koh	slah	voh
175	tam	fiye	vot	starp	tay	rilm
176	tam	poh	trosk	glert	clab	rud
177	filk	ploo	mib	briye	pralb	gorf
178	filk	sool	vot	zirl	slah	gorf
179	flerb	ploo	vot	stoom	tay	swiv
180	flerb	luh	trosk	starp	gleeb	rud

CDEFAB

181	lum	swohst	tam	sig	plohnt	zirl

182	lum	skuln	slom	werf	rog	droh
183	clab	kiye	jarb	poh	kwoh	starp
184	clab	na	pralk	ploo	gee	starp
185	gleeb	rilm	tam	klee	mib	koh
186	gleeb	jusk	slom	luh	plohnt	klard
187	dee	rilm	jarb	sool	foo	briye
188	dee	jusk	pralk	ziye	gee	da
189	slub	sleft	tam	skige	mib	blee
190	slub	na	spag	sig	sah	briye
191	gliye	dut	jarb	luh	foo	starp
192	gliye	rud	hift	frim	kerm	blee
193	pralb	sleft	tam	tasp	mib	da
194	pralb	gorf	spag	sool	sah	glert
195	wa	swohst	jarb	sig	vot	trelt
196	wa	sleft	hift	skige	kerm	zirl
197	tev	dut	tam	gree	mib	glert
198	tev	rud	snoo	sig	flisp	prov
199	tev	malb	jarb	klee	vot	koh
200	tev	rilm	flerb	skige	vray	zirl
201	slah	swiv	spee	werf	mib	zirl
202	slah	skuln	snoo	gree	flisp	zirl
203	neek	kiye	jarb	gree	vot	droh
204	neek	na	flerb	frim	vray	starp
205	tay	kice	tam	ploo	lerd	zirl
206	tay	gorf	spee	skige	kwoh	drame
207	tay	dut	puv	tasp	vot	prov
208	tay	voh	puv	ploo	rog	prov
209	klor	malb	bape	ploo	mib	klard
210	prah	skuln	bape	tasp	lerd	trelt

With Cue Condition Exposure Set, Sorted by Sentence Type

	ABCDEF					
1	skige	lum	gorf	ploo	da	glert
2	skige	puv	gurk	klee	wa	drisk
3	skige	vot	werf	slah	ziye	sleft
4	skige	tev	kerm	scoo	foo	pralk
5	skige	sool	filk	gliye	kiye	starp
6	skige	rog	zirl	klee	da	flisp
7	skige	kice	ralt	gliye	wa	starp

8	skige	sig	jusk	klee	ziye	plohst
9	bleef	dut	gorf	slah	foo	skuln
10	bleef	mib	jarb	slah	luh	pralb
11	bleef	gop	werf	gliye	da	pralk
12	bleef	tam	kerm	prah	dee	klard
13	bleef	bape	filk	blee	ziye	swohst
14	bleef	lum	rilm	scoo	dee	trelt
15	bleef	puv	ralt	blee	foo	sparl
16	bleef	vot	jusk	scoo	ziye	glert
17	kwim	tev	gorf	gliye	luh	klard
18	kwim	sool	jarb	gliye	da	skuln
19	kwim	rog	werf	blee	foo	drisk
20	kwim	kice	kerm	kwoh	dee	sleft
21	kwim	sig	filk	snoo	da	sparl
22	kwim	dut	rilm	prah	ziye	flisp
23	clab	mib	gorf	blee	luh	trelt
24	clab	gop	werf	snoo	dee	plohnt
25	clab	tam	jarb	blee	da	drisk
26	clab	bape	kerm	vray	foo	starp
27	clab	lum	filk	briye	ziye	pralk
28	clab	puv	rilm	kwoh	foo	pralb
29	clab	vot	ralt	snoo	ziye	skuln
30	clab	tev	jusk	prah	dee	swohst
31	prov	sool	gorf	snoo	voh	starp
32	prov	rog	jarb	snoo	luh	plohnt
33	prov	kice	hift	gliye	luh	sleft
34	prov	sig	kerm	ploo	na	klard
35	prov	dut	filk	skaye	dee	glert
36	prov	mib	rilm	vray	luh	swohst
37	prov	gop	ralt	briye	voh	pralb
38	prov	tam	jusk	kwoh	ziye	sparl
39	frim	bape	gorf	briye	na	trelt
40	frim	lum	jarb	briye	poh	flisp
41	frim	puv	hift	blee	luh	glert
42	frim	vot	malb	prah	voh	klard
43	frim	tev	filk	spee	gee	drisk
44	frim	sool	rilm	ploo	poh	skuln
45	slom	rog	gorf	skaye	koh	drisk
46	slom	kice	jarb	skaye	voh	trelt
47	slom	sig	hift	snoo	luh	flisp

48	slom	dut	malb	kwoh	gee	starp
49	slom	mib	zirl	scoo	na	sleft
50	slom	gop	rilm	slah	poh	sparl
51	stoom	tam	gorf	spee	voh	sleft
52	stoom	bape	jarb	spee	tay	pralk
53	stoom	lum	hift	briye	gee	pralb
54	stoom	puv	malb	vray	na	plohnt
55	stoom	vot	zirl	gliye	poh	starp
56	stoom	tev	lerd	ploo	voh	plohnt
57	slub	sool	gurk	scoo	tay	skuln
58	slub	rog	jarb	klee	gee	klard
59	slub	kice	hift	skaye	na	swohst
60	slub	sig	malb	ploo	poh	klard
61	slub	dut	zirl	prah	wa	swohst
62	slub	mib	lerd	klee	tay	sparl
63	swiv	gop	gurk	prah	gee	trelt
64	swiv	tam	werf	briye	na	glert
65	swiv	bape	hift	spe	poh	glert
66	swiv	lum	malb	slah	wa	glert
67	swiv	puv	zirl	kwoh	tay	drisk
68	swiv	vot	lerd	scoo	gee	sleft
69	swiv	gop	ralt	skaye	kiye	flisp
70	swiv	bape	jusk	vray	koh	flisp
71	brole	sig	gurk	kwoh	wa	flisp
72	brole	tam	werf	skaye	tay	starp
73	brole	lum	hift	klee	kiye	pralk
74	brole	puv	malb	gliye	gee	plohnt
75	brole	vot	zirl	vray	koh	skuln
76	brole	tev	lerd	scoo	wa	pralk
77	drame	sool	gurk	vray	tay	pralb
78	drame	rog	hift	scoo	gee	swohst
79	drame	kice	werf	spee	kiye	skuln
80	drame	sig	malb	skaye	koh	sparl
81	drame	bape	zirl	ploo	wa	skuln
82	drame	gop	lerd	prah	tay	klard
83	gleeb	lum	gurk	ploo	foo	glert
84	gleeb	puv	werf	klee	kiye	sparl
85	gleeb	vot	kerm	slah	wa	sparl
86	gleeb	tev	malb	klee	koh	starp
87	gleeb	sig	zirl	slah	tay	trelt

88	gleeb	gop	lerd	kwoh	foo	flisp
89	gleeb	bape	ralt	spee	kiye	pralb
90	gleeb	mib	jusk	ploo	koh	klard

ABEFCD

91	skige	dut	ziye	pralb	filk	ploo
92	skige	mib	tay	plohnt	lerd	spee
93	bleef	tev	na	flirb	rilm	briye
94	bleef	rog	kiye	flirb	filk	slah
95	kwim	mib	fiye	trosk	lerd	slah
96	kwim	tam	ziye	sleft	rilm	gree
97	kwim	bape	tay	sleft	gorf	gree
98	kwim	lum	na	plohnt	malb	droh
99	frim	rog	kiye	pralk	tasp	spee
100	frim	kice	fiye	starp	gorf	klee
101	frim	sig	wa	swohst	malb	gree
102	frim	dut	sah	flirb	tasp	scoo
103	prov	bape	luh	flirb	gurk	snoo
104	prov	puv	foo	flirb	nort	scoo
105	slub	gop	dee	trosk	tasp	prah
106	slub	tam	wa	trelt	gurk	briye
107	brole	sool	sah	glert	nort	vray
108	brole	kice	luh	swohst	tasp	vray
109	stoom	sool	foo	drisk	jusk	droh
110	stoom	mib	dee	klard	nort	prah
111	swiv	sig	voh	klard	werf	droh
112	swiv	tam	poh	trosk	jusk	blee
113	drame	lum	koh	flirb	nort	droh
114	drame	puv	fiye	pralb	werf	gree
115	gleeb	gop	da	trosk	kerm	snoo
116	gleeb	tam	voh	pralk	ralt	ploo
117	gleeb	dut	poh	starp	zirl	skaye
118	gleeb	mib	koh	drisk	kerm	skaye
119	slom	gop	fiye	trelt	ralt	klee
120	slom	tev	da	glert	zirl	blee

CDABEF

121	tasp	skaye	prov	tev	da	trelt

122	nort	snoo	klor	vot	da	sleft
123	kerm	spee	klor	puv	dee	flisp
124	hift	ploo	frim	rud	dee	skuln
125	filk	droh	skige	bape	dee	sparl
126	tasp	klee	slom	puv	dee	drisk
127	nort	vray	slub	rud	foo	plohnt
128	kerm	ble	clab	rog	foo	swohst
129	hift	slah	spag	sig	foo	pralb
130	filk	gree	spag	kice	foo	klard
131	werf	ploo	brole	bape	gee	glert
132	ralt	gree	bleef	kice	gee	flisp
133	lerd	briye	stoom	sig	kiye	klard
134	jarb	vray	spag	vot	kiye	glert
135	gorf	droh	swiv	sool	koh	pralk
136	werf	scoo	swiv	dut	koh	trelt
137	ralt	kwoh	bleef	neek	luh	starp
138	lerd	droh	stoom	dut	luh	drisk
139	jarb	scoo	brole	rud	na	pralk
140	gorf	kwoh	spag	rog	na	skuln
141	zirl	snoo	clab	neek	poh	sleft
142	rilm	gliye	drame	tam	poh	swohst
143	nort	skaye	slub	vot	tay	plohnt
144	jusk	briye	skige	gop	tay	skuln
145	gurk	blee	slom	tam	voh	sparl
146	zirl	spee	drame	rud	voh	drisk
147	rilm	klee	frim	gop	wa	pralb
148	nort	slah	klor	neek	wa	skuln
149	jusk	gliye	klor	sool	ziye	starp
150	gurk	droh	prov	neek	ziye	drisk

	EFABCD					
151	da	drisk	skige	vot	jarb	droh
152	da	flirb	brole	gop	hift	droh
153	dee	flirb	slom	bape	lerd	gree
154	dee	pralb	spag	tev	rilm	droh
155	fiye	trelt	skige	tev	zirl	spee
156	fiye	flirb	brole	neek	gorf	vray
157	fiye	flisp	slom	kice	jarb	gree
158	fiye	glert	stoom	neek	malb	blee

159	gee	flirb	kwim	vot	rilm	prah
160	gee	flisp	clab	sool	filk	prah
161	kiye	trosk	slub	lum	malb	briye
162	kiye	swohst	stoom	sig	jusk	skaye
163	koh	plohnt	kwim	rud	werf	gree
164	koh	trosk	clab	neek	filk	kwoh
165	luh	trosk	slub	rog	jusk	slah
166	luh	sparl	swiv	dut	nort	blee
167	na	flirb	klor	rud	tasp	snoo
168	na	trosk	drame	mib	gorf	prah
169	poh	flirb	spag	sool	kerm	briye
170	poh	trelt	swiv	sig	nort	briye
171	sah	drisk	klor	lum	tasp	gree
172	sah	flirb	drame	neek	gurk	gliye
173	sah	flisp	spag	rud	kerm	droh
174	sah	flisp	klor	kice	ralt	droh
175	sah	glert	klor	neek	tasp	kwoh
176	sah	klard	gleeb	rog	gurk	gree
177	tay	trosk	spag	mib	lerd	blee
178	tay	swohst	klor	rud	ralt	ploo
179	voh	trosk	klor	bape	tasp	slah
180	voh	sparl	gleeb	neek	hift	gree

CDEFAB

181	filk	scoo	sah	sleft	bleef	rud
182	filk	vray	na	trelt	drame	tev
183	gurk	skaye	fiye	klard	slub	neek
184	gurk	spee	ziye	trosk	kwim	neek
185	hift	kwoh	sah	skuln	spag	kice
186	hift	prah	na	sparl	bleef	sool
187	jarb	kwoh	fiye	swohst	frim	mib
188	jarb	prah	ziye	flirb	kwim	puv
189	jusk	snoo	sah	pralk	spag	lum
190	jusk	spee	koh	sleft	brole	mib
191	kerm	gliye	fiye	sparl	frim	neek
192	kerm	gree	wa	starp	prov	lum
193	lerd	snoo	sah	pralb	spag	puv
194	lerd	ploo	koh	swohst	brole	rog
195	malb	scoo	fiye	sleft	klor	tam

196	malb	snoo	wa	pralk	prov	rud
197	nort	gliye	sah	plohnt	spag	rog
198	nort	gree	kiye	sleft	clab	dut
199	nort	klee	fiye	skuln	klor	kice
200	nort	kwoh	voh	pralk	slom	rud
201	ralt	slah	poh	trelt	spag	rud
202	ralt	vray	kiye	plohnt	clab	rud
203	rilm	skaye	fiye	plohnt	klor	tev
204	rilm	spee	voh	starp	slom	neek
205	tasp	briye	sah	trosk	stoom	rud
206	tasp	blee	poh	pralk	slub	vot
207	tasp	gliye	gee	pralb	klor	dut
208	tasp	droh	gee	trosk	drame	dut
209	werf	klee	da	trosk	spag	sool
210	zirl	vray	da	pralb	stoom	tam

80% Predictive Condition Exposure Set, Sorted by Sentence Type

	ABCDEF					
1	kwim	dut	rilm	prah	ziye	trosk
2	prov	dut	filk	skaye	dee	glert
3	slub	dut	zirl	prah	wa	tam
4	spag	dut	nort	slah	luh	vray
5	swohst	dut	malb	kwoh	gee	starp
6	clab	gleeb	kerm	sah	foo	starp
7	drame	gleeb	zirl	gree	wa	skuln
8	droh	gleeb	ralt	spee	kiye	vray
9	frim	gleeb	nort	briye	nah	trelt
10	spag	gleeb	filk	blee	ziye	tam
11	stoom	gleeb	jarb	spee	tay	pralk
12	swiv	gleeb	hift	spee	poh	glert
13	swiv	gleeb	klor	sah	flirb	trosk
14	clab	gop	werf	snoo	dee	plohnt
15	drame	gop	lerd	prah	tay	klard
16	droh	gop	lerd	kwoh	foo	trosk
17	prov	gop	ralt	briye	voh	vray

18	spag	gop	werf	gliye	fiye	pralk
19	swiv	gop	gurk	prah	gee	trelt
20	swiv	gop	ralt	skaye	kiye	trosk
21	swohst	gop	rilm	slah	poh	sparl
22	brole	jusk	werf	skaye	tay	starp
23	clab	jusk	jarb	blee	fiye	drisk
24	prov	jusk	klor	kwoh	ziye	sparl
25	spag	jusk	kerm	prah	dee	klard
26	stoom	jusk	nort	spee	voh	sleft
27	swiv	jusk	werf	briye	na	glert
28	drame	kice	werf	spee	kiye	skuln
29	kwim	kice	kerm	kwoh	dee	sleft
30	prov	kice	hift	gliye	luh	sleft
31	skige	kice	ralt	gliye	wa	starp
32	slub	kice	hift	skaye	na	tam
33	swohst	kice	jarb	skaye	voh	trelt
34	brole	lum	hift	klee	kiye	pralk
35	clab	lum	filk	briye	ziye	pralk
36	droh	lum	gurk	gree	foo	glert
37	frim	lum	jarb	briye	poh	trosk
38	skige	lum	nort	gree	fiye	glert
39	spag	lum	rilm	scoo	dee	trelt
40	stoom	lum	hift	briye	gee	vray
41	swiv	lum	malb	slah	wa	glert
42	clab	mib	nort	blee	luh	trelt
43	droh	mib	klor	gree	flirb	klard
44	prov	mib	rilm	sah	luh	tam
45	slub	mib	lerd	klee	tay	sparl
46	spag	mib	jarb	slah	luh	vray
47	swohst	mib	zirl	scoo	na	sleft
48	brole	neek	zirl	sah	flirb	skuln
49	clab	neek	ralt	snoo	ziye	skuln
50	droh	neek	kerm	slah	wa	sparl
51	frim	neek	malb	prah	voh	klard
52	skige	neek	werf	slah	ziye	sleft
53	spag	neek	klor	scoo	ziye	glert
54	stoom	neek	zirl	gliye	poh	starp
55	swiv	neek	lerd	scoo	gee	sleft
56	brole	puv	malb	gliye	gee	plohnt
57	clab	puv	rilm	kwoh	foo	vray

58	droh	puv	werf	klee	kiye	sparl
59	frim	puv	hift	blee	luh	glert
60	skige	puv	gurk	klee	wa	drisk
61	spag	puv	ralt	blee	foo	sparl
62	stoom	puv	malb	sah	na	plohnt
63	swiv	puv	zirl	kwoh	tay	drisk
64	drame	rog	hift	scoo	gee	tam
65	kwim	rog	werf	blee	foo	drisk
66	prov	rog	jarb	snoo	luh	plohnt
67	skige	rog	zirl	klee	fiye	trosk
68	slub	rog	jarb	klee	gee	klard
69	swohst	rog	nort	skaye	flirb	drisk
70	brole	sig	gurk	kwoh	wa	trosk
71	drame	sig	malb	skaye	flirb	sparl
72	droh	sig	zirl	slah	tay	trelt
73	kwim	sig	filk	snoo	fiye	sparl
74	prov	sig	kerm	gree	na	klard
75	skige	sig	klor	klee	ziye	plohnt
76	slub	sig	malb	gree	poh	klard
77	swohst	sig	hift	snoo	luh	trosk
78	drame	sool	gurk	sah	tay	vray
79	frim	sool	rilm	gree	poh	skuln
80	kwim	sool	jarb	gliye	fiye	skuln
81	prov	sool	nort	snoo	voh	starp
82	skige	sool	filk	gliye	kiye	starp
83	slub	sool	gurk	scoo	tay	skuln
84	brole	tev	lerd	scoo	wa	pralk
85	clab	tev	klor	prah	dee	tam
86	droh	tev	malb	klee	flirb	starp
87	frim	tev	filk	spee	gee	drisk
88	kwim	tev	nort	gliye	luh	klard
89	skige	tev	kerm	scoo	foo	pralk
90	stoom	tev	lerd	gree	voh	plohnt

ABEFCD

91	droh	dut	poh	starp	zirl	skaye
92	skige	dut	ziye	vray	filk	gree
93	frim	dut	slom	da	pralb	scoo
94	kwim	gleeb	tay	sleft	nort	tasp

95	prov	gleeb	luh	da	gurk	snoo
96	droh	gop	fiye	flisp	kerm	snoo
97	slub	gop	dee	flisp	pralb	prah
98	swohst	gop	gorf	trelt	ralt	klee
99	droh	jusk	voh	pralk	ralt	gree
100	kwim	jusk	ziye	sleft	rilm	tasp
101	slub	jusk	wa	trelt	gurk	briye
102	swiv	jusk	poh	flisp	klor	blee
103	brole	kice	luh	tam	pralb	sah
104	frim	kice	gorf	starp	nort	klee
105	drame	lum	flirb	da	koh	bape
106	kwim	lum	na	plohnt	malb	bape
107	droh	mib	flirb	drisk	kerm	skaye
108	kwim	mib	gorf	flisp	lerd	slah
109	skige	mib	tay	plohnt	lerd	spee
110	stoom	mib	dee	klard	koh	prah
111	drame	puv	gorf	vray	werf	tasp
112	prov	puv	foo	da	koh	scoo
113	frim	rog	kiye	pralk	pralb	spee
114	spag	rog	kiye	da	filk	slah
115	frim	sig	wa	tam	malb	tasp
116	swiv	sig	voh	klard	werf	bape
117	brole	sool	slom	glert	koh	sah
118	stoom	sool	foo	drisk	klor	bape
119	spag	tev	na	da	rilm	briye
120	swohst	tev	fiye	glert	zirl	blee

	CDABEF					
121	filk	bape	skige	gleeb	dee	sparl
122	gurk	bape	prov	vot	ziye	drisk
123	lerd	bape	stoom	dut	luh	drisk
124	nort	bape	swiv	sool	flirb	pralk
125	gurk	blee	swohst	jusk	voh	sparl
126	kerm	blee	clab	rog	foo	tam
127	klor	briye	skige	gop	tay	skuln
128	lerd	briye	stoom	sig	kiye	klard
129	klor	gliye	rud	sool	ziye	starp
130	rilm	gliye	drame	jusk	poh	tam
131	hift	gree	frim	ploo	dee	skuln

132	werf	gree	brole	gleeb	gee	glert
133	pralb	klee	swohst	puv	dee	drisk
134	rilm	klee	frim	gop	wa	vray
135	nort	kwoh	bleef	rog	nah	skuln
136	ralt	kwoh	spag	vot	luh	starp
137	jarb	sah	bleef	neek	kiye	glert
138	koh	sah	slub	ploo	foo	plohnt
139	jarb	scoo	brole	ploo	na	pralk
140	werf	scoo	swiv	dut	flirb	trelt
141	koh	skaye	slub	neek	tay	plohnt
142	pralb	skaye	prov	tev	fiye	trelt
143	hift	slah	bleef	sig	foo	vray
144	koh	slah	rud	vot	wa	skuln
145	koh	snoo	rud	neek	fiye	sleft
146	zirl	snoo	clab	vot	poh	sleft
147	kerm	spee	rud	puv	dee	trosk
148	zirl	spee	drame	ploo	voh	drisk
149	filk	tasp	bleef	kice	foo	klard
150	ralt	tasp	spag	kice	gee	trosk

EFABCD

151	dee	da	swohst	gleeb	lerd	tasp
152	fiye	da	brole	gop	hift	bape
153	gee	da	kwim	neek	rilm	prah
154	gorf	da	brole	vot	nort	sah
155	na	da	rud	ploo	pralb	snoo
156	poh	da	bleef	sool	kerm	briye
157	slom	da	drame	vot	gurk	gliye
158	fiye	drisk	skige	neek	jarb	bape
159	slom	drisk	rud	lum	pralb	tasp
160	flirb	flisp	clab	vot	filk	kwoh
161	kiye	flisp	slub	lum	malb	briye
162	luh	flisp	slub	rog	klor	slah
163	na	flisp	drame	mib	nort	prah
164	tay	flisp	bleef	mib	lerd	blee
165	voh	flisp	rud	gleeb	pralb	slah
166	gorf	glert	stoom	vot	malb	blee
167	slom	glert	rud	vot	pralb	kwoh
168	slom	klard	droh	rog	gurk	tasp

169	flirb	plohnt	kwim	ploo	werf	tasp
170	luh	sparl	swiv	dut	koh	blee
171	voh	sparl	droh	vot	hift	tasp
172	kiye	tam	stoom	sig	klor	skaye
173	tay	tam	rud	ploo	ralt	gree
174	gorf	trelt	skige	tev	zirl	spee
175	poh	trelt	swiv	sig	koh	briye
176	gee	trosk	clab	sool	filk	prah
177	gorf	trosk	swohst	kice	jarb	tasp
178	slom	trosk	rud	kice	ralt	bape
179	slom	trosk	bleef	ploo	kerm	bape
180	dee	vray	bleef	tev	rilm	bape

	CDEFAB					
181	koh	tasp	kiye	sleft	clab	dut
182	pralb	bape	gee	flisp	drame	dut
183	pralb	gliye	gee	vray	rud	dut
184	malb	scoo	gorf	sleft	rud	jusk
185	zirl	sah	fiye	vray	stoom	jusk
186	hift	kwoh	slom	skuln	bleef	kice
187	koh	klee	gorf	skuln	rud	kice
188	klor	snoo	slom	pralk	bleef	lum
189	kerm	tasp	wa	starp	prov	lum
190	klor	spee	flirb	sleft	brole	mib
191	jarb	kwoh	gorf	tam	frim	mib
192	pralb	blee	poh	pralk	slub	neek
193	ralt	slah	poh	trelt	bleef	ploo
194	ralt	sah	kiye	plohnt	clab	ploo
195	malb	snoo	wa	pralk	prov	ploo
196	filk	scoo	slom	sleft	spag	ploo
197	pralb	briye	slom	flisp	stoom	ploo
198	koh	kwoh	voh	pralk	swohst	ploo
199	lerd	snoo	slom	vray	bleef	puv
200	jarb	prah	ziye	da	kwim	puv
201	kerm	gliye	slom	plohnt	bleef	rog
202	lerd	gree	flirb	tam	brole	rog
203	werf	klee	fiye	flisp	bleef	sool
204	hift	prah	na	sparl	spag	sool
205	filk	sah	na	trelt	drame	tev

206	rilm	skaye	gorf	plohnt	rud	tev
207	kerm	gliye	gorf	sparl	frim	vot
208	gurk	spee	ziye	flisp	kwim	vot
209	gurk	skaye	gorf	klard	slub	vot
210	rilm	spee	voh	starp	swohst	vot

60% Predictive Condition Exposure Set, Sorted by Sentence Type

	ABCDEF					
1	skige	lum	gorf	ploo	da	glert
2	skige	puv	gurk	fiye	wa	drisk
3	skige	vot	werf	slah	ziye	bape
4	skige	tev	kerm	drame	foo	pralk
5	skige	sool	filk	gliye	gleeb	starp
6	skige	rog	koh	fiye	da	flisp
7	skige	kice	rud	gliye	wa	starp
8	skige	sig	klee	fiye	ziye	plohst
9	bleef	zirl	gorf	slah	foo	skuln
10	bleef	brole	jarb	slah	luh	kiye
11	bleef	slom	werf	gliye	da	pralk
12	bleef	sleft	kerm	gop	pralb	klard
13	bleef	vray	filk	blee	ziye	na
14	bleef	lum	plohnt	drame	pralb	klor
15	bleef	puv	rud	blee	foo	sparl
16	bleef	vot	klee	drame	ziye	glert
17	kwim	tev	gorf	gliye	luh	klard
18	kwim	sool	jarb	gliye	da	skuln
19	kwim	rog	werf	blee	foo	drisk
20	kwim	kice	kerm	swohst	pralb	bape
21	kwim	sig	filk	snoo	da	sparl
22	kwim	zirl	plohnt	gop	ziye	flisp
23	clab	brole	gorf	blee	luh	klor
24	clab	slom	werf	snoo	pralb	ralt
25	clab	sleft	jarb	blee	da	drisk
26	clab	vray	kerm	nort	foo	starp
27	clab	lum	filk	briye	ziye	pralk
28	clab	puv	plohnt	swohst	foo	kiye
29	clab	vot	rud	snoo	ziye	skuln

30	clab	tev	klee	gop	pralb	na
31	prov	sool	gorf	snoo	voh	starp
32	prov	rog	jarb	snoo	luh	ralt
33	prov	kice	hift	gliye	luh	bape
34	prov	sig	kerm	ploo	gree	klard
35	prov	zirl	filk	skaye	pralb	glert
36	prov	brole	plohnt	nort	luh	na
37	prov	slom	rud	briye	voh	kiye
38	prov	sleft	klee	swohst	ziye	sparl
39	frim	vray	gorf	briye	gree	klor
40	frim	lum	jarb	briye	lerd	flisp
41	frim	puv	hift	blee	luh	glert
42	frim	vot	malb	gop	voh	klard
43	frim	tev	filk	spee	gee	drisk
44	frim	sool	plohnt	ploo	lerd	skuln
45	trelt	rog	gorf	skaye	scoo	drisk
46	trelt	kice	jarb	skaye	voh	klor
47	trelt	sig	hift	snoo	luh	flisp
48	trelt	zirl	malb	swohst	gee	starp
49	trelt	brole	koh	drame	gree	bape
50	trelt	slom	plohnt	slah	lerd	sparl
51	stoom	sleft	gorf	spee	voh	bape
52	stoom	vray	jarb	spee	tay	pralk
53	stoom	lum	hift	briye	gee	kiye
54	stoom	puv	malb	nort	gree	ralt
55	stoom	vot	koh	gliye	lerd	starp
56	stoom	tev	mib	ploo	voh	ralt
57	slub	sool	gurk	drame	tay	skuln
58	slub	rog	jarb	fiye	gee	klard
59	slub	kice	hift	skaye	gree	na
60	slub	sig	malb	ploo	lerd	klard
61	slub	zirl	koh	gop	wa	na
62	slub	brole	mib	fiye	tay	sparl
63	jusk	slom	gurk	gop	gee	klor
64	jusk	sleft	werf	briye	gree	glert
65	jusk	vray	hift	spe	lerd	glert
66	jusk	lum	malb	slah	wa	glert
67	jusk	puv	koh	swohst	tay	drisk
68	jusk	vot	mib	drame	gee	bape
69	jusk	slom	rud	skaye	gleeb	flisp

70	jusk	vray	klee	nort	scoo	flisp
71	tam	sig	gurk	swohst	wa	flisp
72	tam	sleft	werf	skaye	tay	starp
73	tam	lum	hift	fiye	gleeb	pralk
74	tam	puv	malb	gliye	gee	ralt
75	tam	vot	koh	nort	scoo	skuln
76	tam	tev	mib	drame	wa	pralk
77	kwoh	sool	gurk	nort	tay	kiye
78	kwoh	rog	hift	drame	gee	na
79	kwoh	kice	werf	spee	gleeb	skuln
80	kwoh	sig	malb	skaye	scoo	sparl
81	kwoh	vray	koh	ploo	wa	skuln
82	kwoh	slom	mib	gop	tay	klard
83	dee	lum	gurk	ploo	foo	glert
84	dee	puv	werf	fiye	gleeb	sparl
85	dee	vot	kerm	slah	wa	sparl
86	dee	tev	malb	fiye	scoo	starp
87	dee	sig	koh	slah	tay	klor
88	dee	slom	mib	swohst	foo	flisp
89	dee	vray	rud	spee	gleeb	kiye
90	dee	brole	klee	ploo	scoo	klard

	ABEFCD					
91	skige	zirl	ziye	kiye	filk	ploo
92	skige	brole	tay	ralt	mib	spee
93	bleef	tev	gree	prah	plohnt	briye
94	bleef	rog	gleeb	prah	filk	slah
95	kwim	brole	dut	trosk	mib	slah
96	kwim	sleft	ziye	bape	plohnt	rilm
97	kwim	vray	tay	bape	gorf	rilm
98	kwim	lum	gree	ralt	malb	droh
99	frim	rog	gleeb	pralk	tasp	spee
100	frim	kice	dut	starp	gorf	fiye
101	frim	sig	wa	na	malb	rilm
102	frim	zirl	sah	prah	tasp	drame
103	prov	vray	luh	prah	gurk	snoo
104	prov	puv	foo	prah	swiv	drame
105	slub	slom	pralb	trosk	tasp	gop
106	slub	sleft	wa	klor	gurk	briye

107	tam	sool	sah	glert	swiv	nort
108	tam	kice	luh	na	tasp	nort
109	stoom	sool	foo	drisk	klee	droh
110	stoom	brole	pralb	klard	swiv	gop
111	jusk	sig	voh	klard	werf	droh
112	jusk	sleft	lerd	trosk	klee	blee
113	kwoh	lum	scoo	prah	swiv	droh
114	kwoh	puv	dut	kiye	werf	rilm
115	dee	slom	da	trosk	kerm	snoo
116	dee	sleft	voh	pralk	rud	ploo
117	dee	zirl	lerd	starp	koh	skaye
118	dee	brole	scoo	drisk	kerm	skaye
119	trelt	slom	dut	klor	rud	fiye
120	trelt	tev	da	glert	koh	blee

	CDABEF					
121	tasp	skaye	prov	tev	da	klor
122	swiv	snoo	flirb	vot	da	bape
123	kerm	spee	flirb	puv	pralb	flisp
124	hift	ploo	frim	poh	pralb	skuln
125	filk	droh	skige	vray	pralb	sparl
126	tasp	fiye	trelt	puv	pralb	drisk
127	swiv	nort	slub	poh	foo	ralt
128	kerm	ble	clab	rog	foo	na
129	hift	slah	spag	sig	foo	kiye
130	filk	rilm	spag	kice	foo	klard
131	werf	ploo	tam	vray	gee	glert
132	rud	rilm	bleef	kice	gee	flisp
133	mib	briye	stoom	sig	gleeb	klard
134	jarb	nort	spag	vot	gleeb	glert
135	gorf	droh	jusk	sool	scoo	pralk
136	werf	drame	jusk	zirl	scoo	klor
137	rud	swohst	bleef	neek	luh	starp
138	mib	droh	stoom	zirl	luh	drisk
139	jarb	drame	tam	poh	gree	pralk
140	gorf	swohst	spag	rog	gree	skuln
141	koh	snoo	clab	neek	lerd	bape
142	plohnt	gliye	kwoh	sleft	lerd	na
143	swiv	skaye	slub	vot	tay	ralt

144	klee	briye	skige	slom	tay	skuln
145	gurk	blee	trelt	sleft	voh	sparl
146	koh	spee	kwoh	poh	voh	drisk
147	plohnt	fiye	frim	slom	wa	kiye
148	swiv	slah	flirb	neek	wa	skuln
149	klee	gliye	flirb	sool	ziye	starp
150	gurk	droh	prov	neek	ziye	drisk

	EFABCD					
151	da	drisk	skige	vot	jarb	droh
152	da	prah	tam	slom	hift	droh
153	pralb	prah	trelt	vray	mib	rilm
154	pralb	kiye	spag	tev	plohnt	droh
155	dut	klor	skige	tev	koh	spee
156	dut	prah	tam	neek	gorf	nort
157	dut	flisp	trelt	kice	jarb	rilm
158	dut	glert	stoom	neek	malb	blee
159	gee	prah	kwim	vot	plohnt	gop
160	gee	flisp	clab	sool	filk	gop
161	gleeb	trosk	slub	lum	malb	briye
162	gleeb	na	stoom	sig	klee	skaye
163	scoo	ralt	kwim	poh	werf	rilm
164	scoo	trosk	clab	neek	filk	swohst
165	luh	trosk	slub	rog	klee	slah
166	luh	sparl	jusk	zirl	swiv	blee
167	gree	prah	flirb	poh	tasp	snoo
168	gree	trosk	kwoh	brole	gorf	gop
169	lerd	prah	spag	sool	kerm	briye
170	lerd	klor	jusk	sig	swiv	briye
171	sah	drisk	flirb	lum	tasp	rilm
172	sah	prah	kwoh	neek	gurk	gliye
173	sah	flisp	spag	poh	kerm	droh
174	sah	flisp	flirb	kice	rud	droh
175	sah	glert	flirb	neek	tasp	swohst
176	sah	klard	dee	rog	gurk	rilm
177	tay	trosk	spag	brole	mib	blee
178	tay	na	flirb	poh	rud	ploo
179	voh	trosk	flirb	vray	tasp	slah
180	voh	sparl	dee	neek	hift	rilm

	CDEFAB					
181	filk	drame	sah	bape	bleef	poh
182	filk	nort	gree	klor	kwoh	tev
183	gurk	skaye	dut	klard	slub	neek
184	gurk	spee	ziye	trosk	kwim	neek
185	hift	swohst	sah	skuln	spag	kice
186	hift	gop	gree	sparl	bleef	sool
187	jarb	swohst	dut	na	frim	brole
188	jarb	gop	ziye	prah	kwim	puv
189	klee	snoo	sah	pralk	spag	lum
190	klee	spee	scoo	bape	tam	brole
191	kerm	gliye	dut	sparl	frim	neek
192	kerm	rilm	wa	starp	prov	lum
193	mib	snoo	sah	kiye	spag	puv
194	mib	ploo	scoo	na	tam	rog
195	malb	drame	dut	bape	flirb	sleft
196	malb	snoo	wa	pralk	prov	poh
197	swiv	gliye	sah	ralt	spag	rog
198	swiv	rilm	gleeb	bape	clab	zirl
199	swiv	fiye	dut	skuln	flirb	kice
200	swiv	swohst	voh	pralk	trelt	poh
201	rud	slah	lerd	klor	spag	poh
202	rud	nort	gleeb	ralt	clab	poh
203	plohnt	skaye	dut	ralt	flirb	tev
204	plohnt	spee	voh	starp	trelt	neek
205	tasp	briye	sah	trosk	stoom	poh
206	tasp	blee	lerd	pralk	slub	vot
207	tasp	gliye	gee	kiye	flirb	zirl
208	tasp	droh	gee	trosk	kwoh	zirl
209	werf	fiye	da	trosk	spag	sool
210	koh	nort	da	kiye	stoom	sleft

80% Mismatch Noise Words Exposure Set, Sorted by Sentence Type

	ABCDEF					
1	kwim	dut	rilm	prah	ip	trosk

2	prov	dut	filk	skaye	dee	glert
3	slub	dut	een	prah	wa	ohst
4	spag	dut	nort	slah	luh	os
5	ub	dut	malb	kwoh	gee	starp
6	clab	ohl	kerm	eesk	foo	starp
7	drame	ohl	een	gree	wa	skuln
8	alb	ohl	ralt	et	kiye	os
9	frim	ohl	nort	briye	nah	trelt
10	spag	ohl	filk	blee	ip	ohst
11	stoom	ohl	jarb	et	tay	pralk
12	swiv	ohl	hift	et	poh	glert
13	swiv	ohl	aff	eesk	urp	trosk
14	clab	gop	werf	snoo	dee	plohnt
15	drame	gop	lerd	prah	tay	klard
16	alb	gop	lerd	kwoh	foo	trosk
17	prov	gop	ralt	briye	voh	os
18	spag	gop	werf	gliye	fiye	pralk
19	swiv	gop	gurk	prah	gee	trelt
20	swiv	gop	ralt	skaye	kiye	trosk
21	ub	gop	rilm	slah	poh	sparl
22	brole	elt	werf	skaye	tay	starp
23	clab	elt	jarb	blee	fiye	drisk
24	prov	elt	aff	kwoh	ip	sparl
25	spag	elt	kerm	prah	dee	klard
26	stoom	elt	nort	et	voh	sleft
27	swiv	elt	werf	briye	na	glert
28	drame	kice	werf	et	kiye	skuln
29	kwim	kice	kerm	kwoh	dee	sleft
30	prov	kice	hift	gliye	luh	sleft
31	skige	kice	ralt	gliye	wa	starp
32	slub	kice	hift	skaye	na	ohst
33	ub	kice	jarb	skaye	voh	trelt
34	brole	lum	hift	klee	kiye	pralk
35	clab	lum	filk	briye	ip	pralk
36	alb	lum	gurk	gree	foo	glert
37	frim	lum	jarb	briye	poh	trosk
38	skige	lum	nort	gree	fiye	glert
39	spag	lum	rilm	scoo	dee	trelt
40	stoom	lum	hift	briye	gee	os
41	swiv	lum	malb	slah	wa	glert

42	clab	mib	nort	blee	luh	trelt
43	alb	mib	aff	gree	urp	klard
44	prov	mib	rilm	eesk	luh	ohst
45	slub	mib	lerd	klee	tay	sparl
46	spag	mib	jarb	slah	luh	os
47	ub	mib	een	scoo	na	sleft
48	brole	neek	een	eesk	urp	skuln
49	clab	neek	ralt	snoo	ip	skuln
50	alb	neek	kerm	slah	wa	sparl
51	frim	neek	malb	prah	voh	klard
52	skige	neek	werf	slah	ip	sleft
53	spag	neek	aff	scoo	ip	glert
54	stoom	neek	een	gliye	poh	starp
55	swiv	neek	lerd	scoo	gee	sleft
56	brole	puv	malb	gliye	gee	plohnt
57	clab	puv	rilm	kwoh	foo	sleft
58	alb	puv	werf	klee	kiye	sparl
59	frim	puv	hift	blee	luh	glert
60	skige	puv	gurk	klee	wa	drisk
61	spag	puv	ralt	blee	foo	sparl
62	stoom	puv	malb	eesk	na	plohnt
63	swiv	puv	een	kwoh	tay	drisk
64	drame	rog	hift	scoo	gee	ohst
65	kwim	rog	werf	blee	foo	drisk
66	prov	rog	jarb	snoo	luh	plohnt
67	skige	rog	een	klee	fiye	trosk
68	slub	rog	jarb	klee	gee	klard
69	ub	rog	nort	skaye	urp	drisk
70	brole	sig	gurk	kwoh	wa	trosk
71	drame	sig	malb	skaye	urp	sparl
72	alb	sig	een	slah	tay	trelt
73	kwim	sig	filk	snoo	fiye	sparl
74	prov	sig	kerm	gree	na	klard
75	skige	sig	aff	klee	ip	plohnt
76	slub	sig	malb	gree	poh	klard
77	ub	sig	hift	snoo	luh	trosk
78	drame	sool	gurk	eesk	tay	os
79	frim	sool	rilm	gree	poh	skuln
80	kwim	sool	jarb	gliye	fiye	skuln
81	prov	sool	nort	snoo	voh	starp

82	skige	sool	filk	gliye	kiye	starp
83	slub	sool	gurk	scoo	tay	skuln
84	brole	tev	lerd	scoo	wa	pralk
85	clab	tev	aff	prah	dee	ohst
86	alb	tev	malb	klee	urp	starp
87	frim	tev	filk	et	gee	drisk
88	kwim	tev	nort	gliye	luh	klard
89	skige	tev	kerm	scoo	foo	pralk
90	stoom	tev	lerd	gree	voh	plohnt

ABEFCD

91	alb	dut	poh	starp	een	skaye
92	skige	dut	ip	os	filk	gree
93	frim	dut	ziye	ayn	zirl	scoo
94	kwim	ohl	tay	sleft	nort	spee
95	prov	ohl	luh	ayn	gurk	snoo
96	alb	gop	fiye	flisp	kerm	snoo
97	slub	gop	dee	flisp	zirl	prah
98	ub	gop	ent	trelt	ralt	klee
99	alb	elt	voh	pralk	ralt	gree
100	kwim	elt	ip	sleft	rilm	spee
101	slub	elt	wa	trelt	gurk	briye
102	swiv	elt	poh	flisp	aff	blee
103	brole	kice	luh	ohst	zirl	eesk
104	frim	kice	ent	starp	nort	klee
105	drame	lum	urp	ayn	ard	ild
106	kwim	lum	na	plohnt	malb	ild
107	alb	mib	urp	drisk	kerm	skaye
108	kwim	mib	ent	flisp	lerd	slah
109	skige	mib	tay	plohnt	lerd	et
110	stoom	mib	dee	klard	ard	prah
111	drame	puv	ent	os	werf	spee
112	prov	puv	foo	ayn	ard	scoo
113	frim	rog	kiye	pralk	zirl	et
114	spag	rog	kiye	ayn	filk	slah
115	frim	sig	wa	ohst	malb	spee
116	swiv	sig	voh	klard	werf	ild
117	brole	sool	ziye	glert	ard	eesk
118	stoom	sool	foo	drisk	aff	ild

119	spag	tev	na	ayn	rilm	briye
120	ub	tev	fiye	glert	een	blee

	CDABEF					
121	filk	ild	skige	ohl	dee	sparl
122	gurk	ild	prov	vot	ip	drisk
123	lerd	ild	stoom	dut	luh	drisk
124	nort	ild	swiv	sool	urp	pralk
125	gurk	blee	ub	elt	voh	sparl
126	ard	blee	clab	rog	foo	ohst
127	aff	briye	skige	gop	tay	skuln
128	lerd	briye	stoom	sig	kiye	klard
129	aff	gliye	ust	sool	ip	starp
130	rilm	gliye	drame	elt	poh	ohst
131	hift	gree	frim	oov	dee	skuln
132	werf	gree	brole	ohl	gee	glert
133	zirl	klee	ub	puv	dee	drisk
134	rilm	klee	frim	gop	wa	os
135	nort	kwoh	bleef	rog	nah	skuln
136	ralt	kwoh	spag	vot	luh	starp
137	jarb	eesk	bleef	neek	kiye	glert
138	ard	eesk	slub	oov	foo	plohnt
139	jarb	scoo	brole	oov	na	pralk
140	werf	scoo	swiv	dut	urp	trelt
141	ard	skaye	slub	neek	tay	plohnt
142	zirl	skaye	prov	tev	fiye	trelt
143	hift	slah	bleef	sig	foo	os
144	ard	slah	ust	vot	wa	skuln
145	ard	snoo	ust	neek	fiye	sleft
146	een	snoo	clab	vot	poh	sleft
147	kerm	et	ust	puv	dee	trosk
148	een	et	drame	oov	voh	drisk
149	filk	spee	bleef	kice	foo	klard
150	ralt	spee	spag	kice	gee	trosk

	EFABCD					
151	dee	ayn	ub	ohl	lerd	spee
152	fiye	ayn	brole	gop	hift	ild

153	gee	ayn	kwim	neek	rilm	prah
154	ent	ayn	brole	vot	nort	eesk
155	na	ayn	ust	oov	zirl	snoo
156	poh	ayn	bleef	sool	kerm	briye
157	ziye	ayn	drame	vot	gurk	gliye
158	fiye	drisk	skige	neek	jarb	ild
159	ziye	drisk	ust	lum	zirl	spee
160	urp	flisp	clab	vot	filk	kwoh
161	kiye	flisp	slub	lum	malb	briye
162	luh	flisp	slub	rog	aff	slah
163	na	flisp	drame	mib	nort	prah
164	tay	flisp	bleef	mib	lerd	blee
165	voh	flisp	ust	ohl	zirl	slah
166	ent	glert	stoom	vot	malb	blee
167	ziye	glert	ust	vot	zirl	kwoh
168	ziye	klard	alb	rog	gurk	spee
169	urp	plohnt	kwim	oov	werf	spee
170	luh	sparl	swiv	dut	ard	blee
171	voh	sparl	alb	vot	hift	spee
172	kiye	ohst	stoom	sig	aff	skaye
173	tay	ohst	ust	oov	ralt	gree
174	ent	trelt	skige	tev	een	et
175	poh	trelt	swiv	sig	ard	briye
176	gee	trosk	clab	sool	filk	prah
177	ent	trosk	ub	kice	jarb	spee
178	ziye	trosk	ust	kice	ralt	ild
179	ziye	trosk	bleef	oov	kerm	ild
180	dee	os	bleef	tev	rilm	ild

	CDEFAB					
181	ard	spee	kiye	sleft	clab	dut
182	zirl	ild	gee	flisp	drame	dut
183	zirl	gliye	gee	os	ust	dut
184	malb	scoo	ent	sleft	ust	elt
185	een	eesk	fiye	os	stoom	elt
186	hift	kwoh	ziye	skuln	bleef	kice
187	ard	klee	ent	skuln	ust	kice
188	aff	snoo	ziye	pralk	bleef	lum
189	kerm	spee	wa	starp	prov	lum

190	aff	et	urp	sleft	brole	mib
191	jarb	kwoh	ent	ohst	frim	mib
192	zirl	blee	poh	pralk	slub	neek
193	ralt	slah	poh	trelt	bleef	oov
194	ralt	eesk	kiye	plohnt	clab	oov
195	malb	snoo	wa	pralk	prov	oov
196	filk	scoo	ziye	sleft	spag	oov
197	zirl	briye	ziye	flisp	stoom	oov
198	ard	kwoh	voh	pralk	ub	oov
199	lerd	snoo	ziye	os	bleef	puv
200	jarb	prah	ip	ayn	kwim	puv
201	kerm	gliye	ziye	plohnt	bleef	rog
202	lerd	gree	urp	ohst	brole	rog
203	werf	klee	fiye	flisp	bleef	sool
204	hift	prah	na	sparl	spag	sool
205	filk	eesk	na	trelt	drame	tev
206	rilm	skaye	ent	plohnt	ust	tev
207	kerm	gliye	ent	sparl	frim	vot
208	gurk	et	ip	flisp	kwim	vot
209	gurk	skaye	ent	klard	slub	vot
210	rilm	et	voh	starp	ub	vot

Appendix C. Frequencies of Bigram Within and Across Phrases (With Cue)

A words to B words, Within-Phrase Frequencies

bleef	bape	1
bleef	dut	1
bleef	gop	1
bleef	kice	1
bleef	lum	1
bleef	mib	1
bleef	neek	1
bleef	puv	1
bleef	rog	1
bleef	rud	1
bleef	sool	1
bleef	tam	1
bleef	tev	1
bleef	vot	1
brole	bape	1
brole	gop	1
brole	kice	1
brole	lum	1
brole	mib	1
brole	neek	1
brole	puv	1
brole	rog	1
brole	rud	1
brole	sig	1
brole	sool	1
brole	tam	1
brole	tev	1
brole	vot	1
clab	bape	1
clab	dut	1
clab	gop	1
clab	lum	1
clab	mib	1
clab	neek	2
clab	puv	1
clab	rog	1
clab	rud	1
clab	sool	1
clab	tam	1
clab	tev	1
clab	vot	1
drame	bape	1
drame	dut	1
drame	gop	1
drame	kice	1
drame	lum	1
drame	mib	1
drame	neek	1
drame	puv	1
drame	rog	1
drame	rud	1
drame	sig	1
drame	sool	1
drame	tam	1
drame	tev	1
frim	bape	1
frim	dut	1
frim	gop	1
frim	kice	1
frim	lum	1
frim	mib	1
frim	neek	1
frim	puv	1
frim	rog	1
frim	rud	1
frim	sig	1
frim	sool	1
frim	tev	1
frim	vot	1
gleeb	bape	1
gleeb	dut	1
gleeb	gop	1
gleeb	gop	1
gleeb	lum	1
gleeb	mib	2
gleeb	neek	1
gleeb	puv	1
gleeb	rog	1
gleeb	sig	1
gleeb	tam	1
gleeb	tev	1
gleeb	vot	1
klor	bape	1
klor	dut	1
klor	kice	2
klor	lum	1
klor	neek	2
klor	puv	1
klor	rud	2
klor	sool	1
klor	tam	1
klor	tev	1
klor	vot	1
kwim	bape	1
kwim	dut	1
kwim	kice	1

Frequencies of A Words to B Words, Continued

kwim	lum	1	skige	rog	1	spag	puv	1
kwim	mib	1	skige	sig	1	spag	rog	2
kwim	neek	1	skige	sool	1	spag	rud	2
kwim	puv	1	skige	tev	2	spag	sig	1
kwim	rog	1	skige	vot	2	spag	sool	2
kwim	rud	1	slom	bape	1	spag	tev	1
kwim	sig	1	slom	dut	1	spag	vot	1
kwim	sool	1	slom	gop	2	stoom	bape	1
kwim	tam	1	slom	kice	2	stoom	dut	1
kwim	tev	1	slom	mib	1	stoom	lum	1
kwim	vot	1	slom	neek	1	stoom	mib	1
prov	bape	1	slom	puv	1	stoom	neek	1
prov	dut	1	slom	rog	1	stoom	puv	1
prov	gop	1	slom	rud	1	stoom	rud	1
prov	kice	1	slom	sig	1	stoom	sig	2
prov	lum	1	slom	tam	1	stoom	sool	1
prov	mib	1	slom	tev	1	stoom	tam	2
prov	neek	1	slub	dut	1	stoom	tev	1
prov	puv	1	slub	gop	1	stoom	vot	1
prov	rog	1	slub	kice	1	swiv	bape	1
prov	rud	1	slub	lum	1	swiv	bape	1
prov	sig	1	slub	mib	1	swiv	dut	2
prov	sool	1	slub	neek	1	swiv	gop	2
prov	tam	1	slub	rog	2	swiv	lum	1
prov	tev	1	slub	rud	1	swiv	puv	1
skige	bape	1	slub	sig	1	swiv	sig	2
skige	dut	1	slub	sool	1	swiv	sool	1
skige	gop	1	slub	tam	1	swiv	tam	2
skige	kice	1	slub	vot	2	swiv	vot	1
skige	lum	1	spag	kice	2			
skige	mib	1	spag	lum	1			
skige	puv	1	spag	mib	1			

Frequencies of B Words to C or E Words, Across a Phrase Boundary

bape	dee	1	gop	rilm	1	mib	zirl	1
bape	filk	1	gop	tay	1	neek	filk	1
bape	gee	1	gop	wa	1	neek	gorf	1
bape	gorf	1	gop	werf	2	neek	gurk	1
bape	hift	1	kice	fiye	1	neek	hift	1
bape	jarb	1	kice	foo	1	neek	luh	1
bape	jusk	1	kice	gee	1	neek	malb	1
bape	kerm	1	kice	hift	2	neek	poh	1
bape	lerd	1	kice	jarb	2	neek	tasp	1
bape	luh	1	kice	kerm	1	neek	wa	1
bape	ralt	1	kice	luh	1	neek	ziye	1
bape	tasp	1	kice	ralt	2	puv	dee	2
bape	tay	1	kice	werf	2	puv	fiye	1
bape	zirl	1	lum	filk	1	puv	foo	1
dut	filk	1	lum	gorf	1	puv	gurk	1
dut	gorf	1	lum	gurk	1	puv	hift	1
dut	koh	1	lum	hift	2	puv	malb	2
dut	luh	1	lum	jarb	1	puv	ralt	1
dut	malb	1	lum	koh	1	puv	rilm	1
dut	nort	1	lum	malb	2	puv	werf	1
dut	poh	1	lum	na	1	puv	zirl	1
dut	rilm	1	lum	rilm	1	rog	foo	1
dut	sah	1	lum	tasp	1	rog	gorf	1
dut	zirl	1	mib	dee	1	rog	gurk	1
dut	ziye	1	mib	fiye	1	rog	hift	1
gop	da	1	mib	gorf	2	rog	jarb	2
gop	dee	1	mib	jarb	1	rog	jusk	1
gop	fiye	1	mib	jusk	1	rog	kiye	2
gop	gurk	1	mib	koh	1	rog	na	1
gop	hift	1	mib	lerd	2	rog	werf	1
gop	lerd	2	mib	rilm	1	rog	zirl	1
gop	ralt	2	mib	tay	1	rud	dee	1

Frequencies of B Words to C or E Words, Continued

rud	foo	1	tam	jarb	1
rud	kerm	1	tam	jusk	1
rud	na	1	tam	kerm	1
rud	ralt	1	tam	poh	2
rud	tasp	1	tam	voh	2
rud	voh	1	tam	wa	1
rud	werf	1	tam	werf	2
sig	filk	1	tam	ziye	1
sig	foo	1	tev	da	2
sig	gurk	1	tev	filk	1
sig	hift	1	tev	gorf	1
sig	jusk	2	tev	jusk	1
sig	kerm	1	tev	kerm	1
sig	kiye	1	tev	lerd	2
sig	malb	2	tev	malb	1
sig	nort	1	tev	na	1
sig	voh	1	tev	rilm	1
sig	wa	1	tev	zirl	1
sig	zirl	1	vot	da	1
sool	filk	2	vot	jarb	1
sool	foo	1	vot	jusk	1
sool	gorf	1	vot	kerm	1
sool	gurk	2	vot	kiye	1
sool	jarb	1	vot	lerd	1
sool	kerm	1	vot	malb	1
sool	koh	1	vot	ralt	1
sool	rilm	1	vot	rilm	1
sool	sah	1	vot	tay	1
sool	ziye	1	vot	werf	1
tam	gorf	1	vot	zirl	2

Frequencies of C Words to D Words, Within Phrase

filk	blee	1	gurk	kwoh	1	jarb	spee	1
filk	briye	1	gurk	ploo	1	jarb	vray	1
filk	droh	1	gurk	prah	1	jusk	blee	1
filk	gliye	1	gurk	scoo	1	jusk	briye	1
filk	gree	1	gurk	skaye	1	jusk	droh	1
filk	kwoh	1	gurk	snoo	1	jusk	gliye	1
filk	ploo	1	gurk	spee	1	jusk	klee	1
filk	prah	1	gurk	vray	1	jusk	kwoh	1
filk	scoo	1	hift	blee	1	jusk	ploo	1
filk	skaye	1	hift	briye	1	jusk	prah	1
filk	slah	1	hift	droh	1	jusk	scoo	1
filk	snoo	1	hift	gliye	1	jusk	skaye	1
filk	spee	1	hift	gree	1	jusk	slah	1
filk	vray	1	hift	klee	1	jusk	snoo	1
gorf	blee	1	hift	kwoh	1	jusk	spee	1
gorf	briye	1	hift	ploo	1	jusk	vray	1
gorf	droh	1	hift	prah	1	kerm	blee	1
gorf	gliye	1	hift	scoo	1	kerm	briye	1
gorf	gree	1	hift	skaye	1	kerm	droh	1
gorf	klee	1	hift	slah	1	kerm	gliye	1
gorf	kwoh	1	hift	snoo	1	kerm	gree	1
gorf	ploo	1	hift	spee	1	kerm	kwoh	1
gorf	prah	1	jarb	blee	1	kerm	ploo	1
gorf	skaye	1	jarb	briye	1	kerm	prah	1
gorf	slah	1	jarb	droh	1	kerm	scoo	1
gorf	snoo	1	jarb	gliye	1	kerm	skaye	1
gorf	spee	1	jarb	gree	1	kerm	slah	1
gorf	vray	1	jarb	klee	1	kerm	snoo	1
gurk	blee	1	jarb	kwoh	1	kerm	spee	1
gurk	briye	1	jarb	prah	1	kerm	vray	1
gurk	droh	1	jarb	scoo	1	lerd	blee	1
gurk	gliye	1	jarb	skaye	1	lerd	briye	1
gurk	gree	1	jarb	slah	1	lerd	droh	1
gurk	klee	1	jarb	snoo	1	lerd	gree	1

Frequencies of C Words to D Words, Continued

lerd	klee	1
lerd	kwoh	1
lerd	ploo	2
lerd	prah	1
lerd	scoo	2
lerd	slah	1
lerd	snoo	1
lerd	spee	1
malb	blee	1
malb	briye	1
malb	droh	1
malb	gliye	1
malb	gree	1
malb	klee	1
malb	kwoh	1
malb	ploo	1
malb	prah	1
malb	scoo	1
malb	skaye	1
malb	slah	1
malb	snoo	1
malb	vray	1
nort	blee	1
nort	briye	1
nort	droh	1
nort	gliye	1
nort	gree	1
nort	klee	1
nort	kwoh	1
nort	prah	1
nort	scoo	1
nort	skaye	1
nort	slah	1
nort	snoo	1
nort	vray	2
ralt	blee	1
ralt	briye	1
ralt	droh	1
ralt	gliye	1
ralt	gree	1
ralt	klee	1
ralt	kwoh	1
ralt	ploo	2
ralt	skaye	1
ralt	slah	1
ralt	snoo	1
ralt	spee	1
ralt	vray	1
rilm	briye	1
rilm	droh	1
rilm	gliye	1
rilm	gree	1
rilm	klee	1
rilm	kwoh	1
rilm	ploo	1
rilm	prah	2
rilm	scoo	1
rilm	skaye	1
rilm	slah	1
rilm	spee	1
rilm	vray	1
tasp	blee	1
tasp	briye	1
tasp	droh	1
tasp	gliye	1
tasp	gree	1
tasp	klee	1
tasp	kwoh	1
tasp	prah	1
tasp	scoo	1
tasp	skaye	1
tasp	slah	1
tasp	snoo	1
tasp	spee	1
tasp	vray	1
werf	blee	1
werf	briye	1
werf	droh	1
werf	gliye	1
werf	gree	2
werf	klee	2
werf	ploo	1
werf	scoo	1
werf	skaye	1
werf	slah	1
werf	snoo	1
werf	spee	1
zirl	blee	1
zirl	gliye	1
zirl	klee	1
zirl	kwoh	1
zirl	ploo	1
zirl	prah	1
zirl	scoo	1
zirl	skaye	1
zirl	slah	1
zirl	snoo	1
zirl	spee	2
zirl	vray	2

Frequencies of D Words to A or E Words, Across Phrase Boundaries

blee	clab	1	gree	spag	1	prah	dee	2
blee	da	1	gree	wa	1	prah	gee	1
blee	foo	2	klee	da	2	prah	na	1
blee	luh	2	klee	fiye	1	prah	tay	1
blee	poh	1	klee	frim	1	prah	voh	1
blee	slom	1	klee	gee	1	prah	wa	1
blee	ziye	1	klee	kiye	2	prah	ziye	2
briye	gee	1	klee	koh	1	scoo	brole	1
briye	na	2	klee	slom	1	scoo	dee	1
briye	poh	1	klee	tay	1	scoo	fiye	1
briye	sah	1	klee	wa	1	scoo	foo	1
briye	skige	1	klee	ziye	1	scoo	gee	2
briye	stoom	1	kwoh	bleef	1	scoo	na	1
briye	voh	1	kwoh	dee	1	scoo	sah	1
briye	ziye	1	kwoh	fiye	1	scoo	swiv	1
droh	gee	1	kwoh	foo	2	scoo	tay	1
droh	prov	1	kwoh	gee	1	scoo	wa	1
droh	skige	1	kwoh	sah	1	scoo	ziye	1
droh	stoom	1	kwoh	spag	1	skaye	dee	1
droh	swiv	1	kwoh	tay	1	skaye	fiye	2
gliye	da	2	kwoh	voh	1	skaye	kiye	1
gliye	drame	1	kwoh	wa	1	skaye	koh	2
gliye	fiye	1	kwoh	ziye	1	skaye	na	1
gliye	gee	2	ploo	brole	1	skaye	prov	1
gliye	kiye	1	ploo	da	1	skaye	slub	1
gliye	klor	1	ploo	foo	1	skaye	tay	1
gliye	luh	2	ploo	frim	1	skaye	voh	1
gliye	poh	1	ploo	koh	2	slah	foo	1
gliye	sah	1	ploo	na	1	slah	klor	1
gliye	wa	1	ploo	poh	2	slah	luh	1
gree	bleef	1	ploo	voh	1	slah	poh	2
gree	kiye	1	ploo	wa	1	slah	spag	1

Frequencies of D Words to A or E Words, Continued

slah	tay	1
slah	wa	2
slah	ziye	1
snoo	clab	1
snoo	da	1
snoo	dee	1
snoo	klor	1
snoo	luh	2
snoo	sah	2
snoo	voh	1
snoo	wa	1
snoo	ziye	1
spe	poh	1
spee	drame	1
spee	gee	1
spee	kiye	2
spee	klor	1
spee	koh	1
spee	tay	1
spee	voh	2
spee	ziye	1
vray	da	1
vray	foo	1
vray	kiye	1
vray	koh	2
vray	luh	1
vray	na	2
vray	slub	1
vray	spag	1
vray	tay	1

Frequencies of E Words to F Words, Within Phrase

da	drisk	2	fiye	skuln	1	gee	trosk	1
da	flirb	1	fiye	sleft	1	kiye	flirb	1
da	flisp	1	fiye	sparl	1	kiye	flisp	1
da	glert	2	fiye	starp	1	kiye	glert	1
da	pralb	1	fiye	swohst	1	kiye	klard	1
da	pralk	1	fiye	trelt	2	kiye	plohnt	1
da	skuln	1	fiye	trosk	1	kiye	pralb	1
da	sleft	1	foo	drisk	2	kiye	pralk	2
da	sparl	1	foo	flirb	1	kiye	skuln	1
da	trelt	1	foo	flisp	1	kiye	sleft	1
da	trosk	2	foo	glert	1	kiye	sparl	1
dee	drisk	1	foo	klard	1	kiye	starp	1
dee	flirb	1	foo	plohnt	1	kiye	swohst	1
dee	flisp	1	foo	pralb	2	kiye	trosk	1
dee	glert	1	foo	pralk	1	koh	drisk	2
dee	klard	2	foo	skuln	1	koh	flirb	1
dee	plohnt	1	foo	sparl	1	koh	flisp	1
dee	pralb	1	foo	starp	1	koh	klard	1
dee	skuln	1	foo	swohst	1	koh	plohnt	1
dee	sleft	1	gee	drisk	1	koh	pralk	1
dee	sparl	1	gee	flirb	1	koh	skuln	1
dee	swohst	1	gee	flisp	2	koh	sleft	1
dee	trelt	1	gee	glert	1	koh	sparl	1
dee	trosk	1	gee	klard	1	koh	starp	1
fiye	flirb	1	gee	plohnt	1	koh	swohst	1
fiye	flisp	1	gee	pralb	2	koh	trelt	1
fiye	glert	1	gee	sleft	1	koh	trosk	1
fiye	klard	1	gee	starp	1	luh	drisk	1
fiye	plohnt	1	gee	swohst	1	luh	flirb	1
fiye	pralb	1	gee	trelt	1	luh	flisp	1

Frequencies of E Words to F Words, Continued

luh	glert	1	poh	swohst	1	voh	pralk	2
luh	klard	1	poh	trelt	2	voh	sleft	1
luh	plohnt	1	poh	trosk	1	voh	sparl	2
luh	pralb	1	sah	drisk	1	voh	starp	2
luh	sleft	1	sah	flirb	2	voh	trelt	1
luh	sparl	1	sah	flisp	2	voh	trosk	1
luh	starp	1	sah	glert	2	wa	drisk	1
luh	swohst	2	sah	klard	1	wa	flisp	1
luh	trelt	1	sah	plohnt	1	wa	glert	1
luh	trosk	1	sah	pralb	1	wa	pralb	1
na	flirb	2	sah	pralk	1	wa	pralk	2
na	glert	1	sah	skuln	1	wa	skuln	2
na	klard	1	sah	sleft	1	wa	sparl	1
na	plohnt	2	sah	trosk	1	wa	starp	2
na	pralk	1	tay	drisk	1	wa	swohst	2
na	skuln	1	tay	klard	1	wa	trelt	1
na	sleft	1	tay	plohnt	2	ziye	drisk	1
na	sparl	1	tay	pralb	1	ziye	flirb	1
na	swohst	1	tay	pralk	1	ziye	flisp	1
na	trelt	2	tay	skuln	1	ziye	glert	1
na	trosk	1	tay	sleft	1	ziye	plohst	1
poh	flirb	1	tay	sparl	1	ziye	pralb	1
poh	flisp	1	tay	starp	1	ziye	pralk	1
poh	glert	1	tay	swohst	1	ziye	skuln	1
poh	klard	1	tay	trelt	1	ziye	sleft	2
poh	pralk	1	tay	trosk	1	ziye	sparl	1
poh	skuln	1	voh	drisk	1	ziye	starp	1
poh	sleft	1	voh	klard	2	ziye	swohst	1
poh	sparl	1	voh	plohnt	1	ziye	trosk	1
poh	starp	2	voh	pralb	1			

Frequencies of F Words to A or C Words, Across a Phrase Boundary

drisk	jusk	1	plohnt	klor	1	starp	gorf	1
drisk	kerm	1	plohnt	kwim	1	starp	prov	1
drisk	klor	1	plohnt	lerd	1	starp	slom	1
drisk	skige	1	plohnt	malb	1	starp	zirl	1
flirb	brole	2	plohnt	spag	1	swohst	brole	1
flirb	drame	1	pralb	filk	1	swohst	frim	1
flirb	filk	1	pralb	klor	1	swohst	klor	1
flirb	gurk	1	pralb	spag	2	swohst	malb	1
flirb	klor	1	pralb	stoom	1	swohst	stoom	1
flirb	kwim	2	pralb	werf	1	swohst	tasp	1
flirb	nort	2	pralk	prov	1	trelt	drame	1
flirb	rilm	1	pralk	ralt	1	trelt	gurk	1
flirb	slom	1	pralk	slom	1	trelt	ralt	1
flirb	spag	1	pralk	slub	1	trelt	skige	1
flirb	tasp	1	pralk	spag	1	trelt	spag	1
flisp	clab	1	pralk	tasp	1	trelt	swiv	1
flisp	klor	1	skuln	klor	1	trosk	clab	1
flisp	slom	1	skuln	spag	1	trosk	drame	2
flisp	spag	1	sleft	bleef	1	trosk	jusk	1
glert	klor	1	sleft	brole	1	trosk	kerm	1
glert	nort	1	sleft	clab	1	trosk	klor	1
glert	stoom	1	sleft	gorf	1	trosk	kwim	1
glert	zirl	1	sleft	klor	1	trosk	lerd	1
klard	gleeb	1	sleft	rilm	1	trosk	slub	2
klard	nort	1	sparl	bleef	1	trosk	spag	2
klard	slub	1	sparl	frim	1	trosk	stoom	1
klard	werf	1	sparl	gleeb	1	trosk	tasp	1
plohnt	clab	1	sparl	swiv	1			