Modifying the Suffixation Preference across Domains

Julie M. Hupp (hupp.34@osu.edu)
Department of Psychology
1179 University Drive
The Ohio State University-Newark
Newark, OH 43055, USA

Vladimir M. Sloutsky (sloutsky.1@osu.edu) & Peter W. Culicover (culicover.1@osu.edu)
Center for Cognitive Science
1961 Tuttle Park Place
The Ohio State University
Columbus, OH 43210, USA

Abstract

One important task of language acquisition involves the ability to distinguish between an inflectional derivation of a word, which is a variant of the word, and a completely new word. This ability is often influenced by a suffixation preference. Previous research has demonstrated that the suffixation preference may not be sub-served by a language-specific mechanism and that a domain general mechanism may underlie this preference. However, for the domain-general mechanism to be a plausible candidate, it has to exhibit flexibility enabling it to account for various types of inflectional morphology existing across languages. This research established that the suffixation preference is both flexible and transferable across domains, which suggests that the suffixation preference is driven by a cognitive mechanism that is both domain-general and flexible in nature.

Keywords: inflections, domain general, language.

Introduction

One of the important tasks of language acquisition is the ability to distinguish between an inflection of a word, which is a variant of the form of this word (e.g., *can* / *cans*), and a completely new word (e.g., *can* / *scan*). Across languages there are multiple types of inflection, including suffixation (e.g., adding a morpheme after the stem), prefixation (e.g., adding a morpheme before the stem), infixation (e.g., adding a morpheme inside the stem), and nonconcatenative devices (e.g., interleaving a string of vowels within a string of consonants). It has been suggested in the typological literature that there is a preference in natural language for suffixation (Bybee, Pagliuca, & Perkins, 1990; Cutler, Hawkins, & Gilligan, 1985; Cysouw, 2001; Dryer, 2005; Hall, 1988; Hawkins & Cutler, 1988; Hawkins & Gilligan, 1988). More specifically, Dryer (2005) reports that of 772 languages surveyed that use inflectional morphology, 64% have at least a moderate preference for suffixing, while only 19% had a similar preference for prefixing, and 17% had no preference for one over the other.

There is also evidence for the suffixation preference during language acquisition (Clark, 1998). One piece of supporting evidence presented by Clark is a slower rate of inflectional acquisition in prefixing languages (e.g., Mohawk) in comparison to suffixing languages in children. Furthermore, Clark found that English-speaking children imitate nonsense words with nonsense suffixes more easily than nonsense words with nonsense prefixes. In addition, Bruening and Brooks (2007) found that when referencing two identical objects, young children were more tolerant of word-form variations if the variation occurred at the end of the word rather than at the beginning. This research suggests that children interpret suffixed words to be more similar to the original word than are prefixed words.

While it is clear that consistency of an inflection type within a language (e.g., either suffixation or prefixation) assists the language learner in distinguishing inflected words from unrelated words, the reason for the cross-linguistic preference for suffixation (compared to other forms of inflection) is less clear.

One theoretical possibility is that the suffixation preference stems from factors that are specific to language (or speech). In particular, it is possible that the suffixation preference stems from constraints built into the structure of the language, which makes it easier to learn word variations when the modifications are at the end of the word. Another possibility is that the beginning portion of the word is its most salient part (e.g., Clark, 1991; Hawkins & Cutler, 1988) or that the early portion of a word is critical for word activation (e.g., Erdeljac & Mildner, 1999; Marslen-Wilson, 1987; Rodd, 2004; Tyler & Wessels, 1983; Wallace, Stewart, Sherman, & Mellor, 1995). In addition, it is possible that since affixes form a closed class, which is much smaller than the open class of roots (see Hawkins & Gilligan, 1988), the amount of communicated information is on average higher for roots than for affixes. Therefore in a suffixing language, the listener can narrow down the lexical candidates faster than in a prefixing language.

Another theoretical possibility is that the suffixation preference stems from factors that are not specific to language or speech. For example, it could be argued that known attentional and memory factors predict that it is easier to detect variations in the beginning of a temporal structure than in the end (e.g., primacy effect). One such

factor could be a greater distinctiveness of items in the beginning of a temporal sequence (e.g., Neath, 1993). For the domain of music, Repp (1992) reported that participants are less likely to detect a lengthened event in a musical performance when it occurs at the end of a musical phrase.

It is possible that language learning reflects the same constraints that are responsible for the differences in type of inflectional morphology across languages. Gasser (1994) proposed a computational account of language acquisition, according to which words occur in time, and the information that appears first is the key to identification. This account predicts the advantage of processing information at the beginning of a sequence, and the advantage should hold for both linguistic and non-linguistic sequences. Under this account, words are a special case of sequentially presented information, and the suffixation preference would be a special case of preference for the beginning of a sequence.

In support of this idea, previous research by Hupp, Sloutsky, and Culicover (2004) established that the suffixation preference is not limited to language. In experiments using forced-choice similarity judgment tasks, the suffixed (Post-changed) item was judged as more similar to the target than the prefixed (Pre-changed) item with linguistic as well as visual and musical stimuli. These results supported the notion that the suffixation preference is also present in the musical and visual domains, thus suggesting that this preference could be a general property of processing temporal sequences and not just of processing language. However, cross-linguistic studies demonstrate that people readily learn inflectional patterns other than suffixation. Therefore, the suffixation *preference* in the domain of language is just that, a preference, and not a rigid constraint. Given the flexibility within the language domain, finding flexibility in non-linguistic domains would further support the general cognitive account of the suffixation preference in language. Furthermore, if learning of inflectional morphology is sub-served by language-specific mechanisms, there should be little or no transfer of a learned preference between language and other domains. At the same time, finding transfer to and from language would generate even stronger support for a general cognitive mechanism responsible for temporal sequence processing that includes language.

This research addresses these issues by first training participants to attend to the end of a sequence and to consider a prefixed item to be more similar to a target item. This is to train participants to show the opposite preference than what was found in Hupp et al. (2004). Then, the transfer of this newly learned preference was measured within and across domains. To determine the change in preference, each participant's test score in a given domain was compared to a no-training baseline from previous research (Hupp et al., 2004). Participants were either trained in the language or visual condition for a prefixed item preference (opposed to the suffixed item preference observed in previous research). Then, they were tested in one of three domains: language, music, or visual. This testing consisted of a forced-choice similarity judgment task in which participants had to decide which of the two test items (Pre-changed or Post-changed) was more similar to a target, with each item being a sequence of syllables, musical notes, or visual objects.

Method

Participants

The participants were undergraduate students from The Ohio State University who participated to fulfill a psychology course requirement. There were 53 participants in the language training condition (32 men and 21 women). Of these participants, 16 were subsequently tested in the language condition, 17 in the music condition, and 20 in the visual condition. There were an additional 50 participants in the visual training condition (33 men and 17 women). Of these participants, 18 were subsequently tested in the visual condition, 16 in the language condition, and 16 in the music condition. Three additional participants were excluded for failing to correctly answer at least 70% of the catch trials during the testing phase.

Materials

Language Stimuli The stimuli were 42 triads, each consisting of a 2-syllable artificial target word (discrete monosyllabic sequences) followed by two test words. The target words were created using *Cool Edit* software (Syntrillium Software Corporation, 2000) by randomly connecting discrete syllables recorded by a female speaker (e.g., *Ta-Te*) with .06 sec between syllables (see Johnson & Jusczyk, 2001; Saffran, Aslin, & Newport, 1996, for details of similar stimuli creation). All possible unique consonant-vowel syllables were created (e.g., Ba, Be, Bi, Bo, Bu) for a total of 90 syllables. Then, each syllable was assigned a number, and using a random number generator, they were combined to form words and add inflections. Therefore, each syllable could appear in any of the word positions at random. Some syllable combinations were excluded if their meaning seemed inappropriate or humorous. Test words were created by either adding a randomly selected syllable to the beginning of the target word (Pre-changed item: *BE-Ta-Te*), to the end of the target word (Post-changed item: *Ta-Te-BE*), adding nothing to the target word (Identical: *Ta-Te*), or changing the target word completely (Different: *Pu-La-Fi*). See Table 1 for example stimuli.

In the critical test trials (used in both the training and testing phase), one of the test words was the target with a syllable added to the beginning (Pre-changed item), and the other test word was the target with a syllable added to the end (Post-changed item). These two types of test items paired against one another made up 25 of the triads. In addition, there were 15 catch trials and 2 practice trials, which were exclusively used in the testing phase. The catch trials, unlike test items, had a correct answer. Given that each catch trial had a correct answer, the goal of these trials was to control for overall accuracy.

Table 1: Example language stimuli.

		Item Type		
		Target	Test 1	Test 2
Test Trials	Pre-Post	Ta-te Pe-ja	Be-ta-te Pe-ja-ci	Ta-te-be Ci-pe-ja
Catch Trials	Pre-Identical	Ve-ga Da-zo	Va-ve-ga Da-zo	Ve-ga Fo-da-zo
	Post-Identical	Ma-ya Go-zu	Ma-ya-yo Go-zu	Ma-ya Go-zu-ne
	Pre-Different	Ho-mu Me-he	Ro-ho-mu Mi-lo-bi	Pu-la-fa To-me-he
	Post-Different	Za-vi Ra-co	Za-vi-ze Gu-na-ri	Fu-no-bo Ra-co-we
	Identical-Different	Zo-no To-ri	Zo-no Ti-le-hi	Ga-lu-me To-ri

Music Stimuli Each triad was made up of a 2-note target melody and two test melodies. The melodies were arpeggiated, and all keys (major and minor) were represented. The test items were created in *Cool Edit* software (Syntrillium Software Corporation, 2000) by adding notes to either the beginning (Pre-changed item) or the end (Post-changed item) of the target melodies using a similar randomization process to form 31 sets as with the language stimuli. There were 2 practice trials, 14 test trials, and 15 catch trials used only in the testing phase.

Visual Stimuli The stimuli consisted of object sequence videos created using *Macromedia Flash* software (Macromedia Studio MX, 2002). There were a total of 25 objects that were randomly combined to create the target sequences using a similar randomization process as in previous conditions to form 42 triads. See Table 2 for example stimuli. The target sequences were composed of either all red, blue, green or orange shapes. Each set consisted of a target sequence made of two simple objects that flashed for 1 sec each while centered at the top of the computer screen (e.g., Cross, Heart). Then, 1 sec later, the first of two test sequences appeared at the bottom of the screen. There was 1 sec in between each test sequence, and the order of the test sequences was counterbalanced across sets. The first test sequence appeared on the bottom left of the computer screen, and the second test sequence appeared on the bottom right of the screen. Within a sequence, all objects flashed from the same location, and all sequences presented one object at a time.

The test items were created by adding an object (e.g., Diamond) for 1 sec either at the beginning of the target sequence (Pre-changed item; Diamond, Cross, Heart), at the end of the target sequence (Post-changed item: Cross, Heart, Diamond), no change at all to the target sequence (Identical: Cross, Heart) or change the sequence completely (Different: Star, Light Bulb, Lock). The object that was added was of a different color than the target sequence: a red target sequence would have a blue object added (and vice-versa), and green and orange were similarly paired. Once again, there were 2 practice trials, 25 test trials, and 15 catch trials.

Table 2: Example visual stimuli.

		Item Type		
		Target	Test 1	Test 2
Test Trials	Pre-Post	○ ▣ / ♫ ☡	⬊ ○ ▣ / ♫ ☡ ➘	○ ▣ ⬊ / ➘ ♫ ☡
Catch Trials	Pre-Identical	⬗ ▰ / ☀ ○	☽ ⬗ ▰ / ☀ ○	⬗ ▰ / ● ☀ ○
	Post-Identical	▰ 🔒 / ★ ◗	▰ 🔒 ⬊ / ★ ◗	▰ 🔒 / ★ ◗ ☾
	Pre-Different	☡ ▦ / 🔒 ⊕	⟋ ☡ ▦ / ▬ ◰ ☡	🔒 ☀ ☾ / ♥ 🔒 ⊕
	Post-Different	◆ ♫ / ⬗ ○	◆ ♫ ➘ / ● ◗ ➘	▼ ◗ ⬈ / ⬗ ○ ▼
	Identical-Different	★ ⚑ / ◰ ⟋	★ ⚑ / ◆ ◗ ◯	◗ ▼ ⬈ / ◰ ⟋

Design and Procedure

Participants were trained on either the language or the visual stimuli, and then they were tested with language, music, or visual stimuli. *Presentation* software (Neurobehavioral Systems, 2003) was used to deliver the instructions, present the stimuli, and record the responses.

In both of the training conditions, the participants were instructed that in different languages, different aspects of a word contain the meaning, and they would be tested on their ability to learn such rules. They were told that in some languages, if two words had the same ending, then the words had similar meanings. They were instructed to select the word that had the same meaning as the target word. The goal of training was to change the established Post-changed item preference found in previous research (Hupp et al., 2004) to a Pre-changed item preference.

In both training conditions, all of the participants were presented with a 2-part target item followed by two test items, and they were to decide which of the test items was more similar in meaning to the initial target item. They were not explicitly instructed to pay attention to any particular element of the sequence. In this case, feedback on the correct answer as well as the correct button to press was provided following each of the first 3 trials (e.g., "The correct answer was *Bee-Ta-Tee* (F)") to assure that the participants understood what was being expected of them (e.g., to select the Pre-changed item as most similar to the

target). Then, the participants were presented with 8 no-feedback trials.

After training for a Pre-changed item preference in the language or visual domain, the participants took part in a seemingly unrelated testing phase in which their preferences were assessed in one of the three domains (language, visual or music). The goal of the testing phase was to measure their change in suffixation preference in one of the three domains after language or visual training.

Language Training Condition The training stimuli consisted of 11 test trials chosen at random with a few trivial qualifications (e.g., approximately equal numbers of each type of test item occurring first). Each set consisted of a 2-syllable artificial target word followed by two test words (Pre-changed item and Post-changed item). A Pre-changed item preference would be demonstrated if words that have a syllable added to the beginning were judged to be more similar to the original target word than if a syllable was added to the end of the original target word.

Visual Training Condition The training stimuli consisted of 11 test trials with each set consisting of a 2-part visual sequence followed by two test sequences (Pre-changed item and Post-changed item). This subset was chosen at random with some minor qualifications (e.g., approximately equal number of each set color). In addition to the basic instructions given in the language training condition, the participants in the visual training condition were instructed that in some cultures, sequences of objects are used for words. They were told that in some languages, if two words had the same ending, then the words had similar meanings (e.g., if two sequences end in the same object, then they share meanings). In this case, a Pre-changed item preference would be demonstrated if sequences that have an object added to the beginning were judged to be more similar to the original target sequence than if an object was added to the end of the original target sequence.

Language Testing Condition Each participant received 2 randomly ordered practice trials, and then the remaining 14 test trials and 15 catch trials were presented in random order.

The participants were instructed that they would hear several sets of words. For each set, they would hear a 2-syllable target word followed by two test words, and they were to decide which of the test words was more similar to the original target word. If the first test word was most similar, they were to press "F" on the keyboard, and if the last test word was most similar, they were to press "L". To start each trial, they were instructed to press the spacebar.

There was 1 sec in between each word, and the order of the test words for all trial types was counterbalanced across sets. For example, in the Pre-Post test items, the Pre-changed test item occurred first 50% of the time. The target word was presented from both of the computer speakers while the first test word was presented only from the left speaker and the second test word was presented only from the right speaker.

Music Testing Condition The overall design and procedure was identical to the language condition, but instead of hearing words, the participants were instructed that they would hear a small target musical melody followed by two test melodies. From this, they were to decide which test melody was the most similar to the original target melody.

Visual Testing Condition The overall design and procedure were similar to the previous conditions, but the participants were instructed that they would see a target sequence of objects on the top of the screen followed by two test sequences on the bottom of the screen. They were to decide which test sequence was more similar to the initial target sequence.

Results

Language Training Condition Participants were accurate on catch trials across all three test domains with 94.17% accuracy when they were tested in language, 94.00% when they were tested in visual, and 93.33% when they were tested in music (above chance, one-sample ts > 22.00 ps < .001, ds > 11.00). The percentage of Post-changed item responses for the testing phase (i.e., after training) was compared to its respective baseline (i.e., the language condition of Hupp et al., 2004). From this comparison, a difference score between Pre-changed item preference in the trained condition and the baseline was calculated for every participant. Mean raw scores, from which difference scores were derived are presented in Table 3. Note that a difference score of zero would reflect no change in preference after training, and therefore no successful transfer of such a preference, whereas a positive score indicates successful training and/or transfer.

As expected, given the extremely similar nature of the tasks, once the participants were successfully trained for a Pre-changed item preference in the language domain, testing in the language domain revealed lower Post-changed item response scores (M = 39.29%) than without training (M = 88%), with the difference score being reliably above 0, one-sample t (31) = 4.49, p < .001, d = 1.55.

More importantly, after participants were trained for a Pre-changed item preference in the language domain, this preference transferred to both music and visual domains. After training in language, participants exhibited evidence of a significant decrease in Post-changed item responses in the music domain and in the visual domain, with all difference scores being reliably above 0, one-sample ts > 2.9, ps < .01, ds > 1.0. This was a marked change compared to the baseline tendencies found in Hupp et al. (2004). In short, when participants were trained to attend to the end of a word in the language domain and then were tested either in the language, music or visual domain, this change in preference even transferred to non-trained domains.

Table 3: Calculation of difference scores.

Train	Test	Baseline Post Score	Post Score after Train	Difference Score
Lang	Lang	88.00	39.29	48.71
	Mus	71.56	42.44	29.12
	Vis	91.53	62.14	29.39
Vis	Vis	91.53	29.37	62.16
	Mus	71.56	51.79	19.77
	Lang	88.00	34.38	53.62

Visual Training Condition In this condition, participants were accurate on catch trials across all three test domains with 97.92% accuracy when they were tested in language, 94.44% when they were tested in visual, and 93.78% when they were tested in music (above chance, one-sample ts > 24.50, ps < .001, ds > 11.50). Once again, a difference score between the percentage of Post-changed item responses for the testing phase and the average Post-changed preference observed in Hupp et al. (2004) was calculated for every participant in each test condition. Mean raw and difference scores after visual training are also presented in Table 3.

As expected, once the participants were successfully trained for a Pre-changed item preference in the visual domain, testing in the visual domain revealed lower Post-changed item scores than without training, with the difference score being reliably above 0, one-sample t (33) = 5.93, p < .001, d = 2.03.

Similar to the language training condition, after participants were trained in the visual domain, this training transferred to the other two domains, with participants exhibiting a significant decrease in Post-changed item responses in both the music domain and in the language domain, with all difference scores being reliably above 0, one-sample ts > 2.2, ps < .05, ds > .75. This was again a marked change compared to the baseline tendencies found in Hupp et al. (2004).

Discussion

Overall, when participants were trained to attend to the end of a sequence in the language or visual domain, they exhibited a shift towards a Pre-changed item preference in similarity judgments within the trained domain and transferred this learned preference to other domains. Both findings are important: the learning flexibility and transfer of preference across domains supports the idea that the suffixation preference is not specific to language, but is rather a product of a domain-general mechanism for processing temporal information. This is necessary to account for the different inflectional patterns in various language systems. However, we do not suggest that general visual or musical processing would differ for speakers of prefixing and suffixing languages.

The reported findings have implications for the understanding of language acquisition and language processing. Language acquisition and processing are thought to be sub-served by mechanisms that are specific to language. However, there is a growing body of evidence that aspects of language acquisition and processing stem from general mechanisms (e.g., Christiansen & Chater, 2001; Gomez & Gerken, 2001; Newport & Aslin, 2004; Saffran, 2003; Saygin, Dick, Wilson, Dronkers, & Bates, 2003). Although inflectional morphology is only one aspect of language, the fact that it appears to be sensitive to cognitive factors that are not specific to language brings new evidence to the debate.

There was also evidence of differential transfer across the domains. As was demonstrated, transfer within the same domain (Vis train, Vis test) should be the highest, while transfer to a very different and less familiar domain (Vis train, Mus Test) should be lower. This difference could possibly be due to the similarity of the domains or the familiarity that the participants had with memorizing temporal sequences in any one of these domains. This needs to be investigated further.

In addition, to better understand this phenomenon, it is necessary to study this process in a cross-linguistic sample which includes bilingual or monolingual speakers of languages that show differential inflectional patterns. For example, speakers of languages that rely more heavily on infixation or prefixation may show differential patterns of processing the sequential information. Examining this will inform our current theory.

This research demonstrated that for sequential processing, the suffixation preference is flexible and a modified preference is transferable across domains. The cognitive mechanism that may account for the cross domain performance could explain the suffixation preference in language, and the flexibility/transferability of this preference would account for the variety of inflectional systems cross linguistically. If learning of an inflectional morphology is sub-served by language-specific mechanisms, there should be little or no transfer of a learned preference between language and other domains, but this research suggests otherwise. These results reveal that language's suffixation preference may stem from mechanisms of sequential processing that are not specific to language.

References

Bruening, P. R., & Brooks, P. J. (2007, March). Children's tolerance of word-form variation. Poster session presented at the biennial meeting of the Society for Research in Child Development, Boston, MA.

Bybee, J. L., Pagliuca, W., & Perkins, R. D. (1990). On the asymmetries in the affixation of grammatical material. In

W. Croft, K. Denning & S. Kemmer (Eds.), *Studies in typology and diachrony*. Amsterdam: John Benjamins Publishing Company.

Christiansen, M. H., & Chater, N. (2001). Connectionist psycholinguistics: Capturing the empirical data. *Trends in Cognitive Science, 5*, 82-88.

Clark, E. V. (1991). Acquisitional principles in lexical development. In S. A. Gelman & J. P. Byrnes (Eds.), *Perspectives on language and thought: Interrelations in development*. Cambridge, MA: Cambridge University Press.

Clark, E. V. (1998). Morphology in language acquisition. In A. Spencer & A. M. Zwicky (Eds.), *The handbook of morphology*. Malden, MA: Blackwell.

Cutler, A., Hawkins, J. A., & Gilligan, G. (1985). The suffixing preference: A processing explanation. *Linguistics, 23*, 723-758.

Cysouw, M. (2001, July). The (a)symmetry of inflectional person marking. Paper presented at the Fourth International Conference of the Association for Linguistic Typology, Santa Barbara, CA.

Dryer, M. S. (2005). Prefixing versus suffixing in inflectional morphology. In M. Haspelmath, M. S. Dryer, D. Gil, & B. Comrie (Eds.), *The world atlas of language structures*. Oxford: University Press.

Erdeljac, V., & Mildner, V. (1999). Temporal structure of spoken-word recognition in Croatian in light of the cohort theory. *Brain and Language, 68*, 95-103.

Gasser, M. (1994). Acquiring receptive morphology: A connectionist model. *Annual Meeting of the Association for Computational Linguistics*, 32, 279-286.

Gomez, R. L., & Gerken, L. A. (2001). Infant artificial language learning and acquisition. In M. Tomasello & E. Bates (Eds.), *Language development: The essential readings*. Malden, MA: Blackwell Publishers.

Hall, C. J. (1988). Integrating diachronic and processing principles in explaining the suffixing preference. In J. A. Hawkins (Ed.), *Explaining language universals*. New York, NY: Basil Blackwell.

Hawkins, J. A., & Cutler, A. (1988). Psycholinguistic factors in morphological asymmetry. In J. A. Hawkins (Ed.), *Explaining language universals*. New York, NY: Basil Blackwell.

Hawkins, J. A., & Gilligan, G. (1988). Prefixing and suffixing universals in relation to basic word order. *Lingua*, 74, 219-259.

Hupp, J. M., Sloutsky, V., & Culicover, P. (2004). The importance of temporal information for inflection-type effects in linguistic and non-linguistic domains. In R. Alterman & D. Kirsh (Eds.), Proceedings of the XXVI Annual Conference of the Cognitive Science Society, 613-617. Mahwah, NJ: Erlbaum.

Johnson, E. K., & Jusczyk, P. W. (2001). Word segmentation by 8-month-olds: When speech cues count more than statistics. *Journal of Memory & Language*, *44*, 548-567.

Macromedia Studio MX (2002). Macromedia Flash MX [Computer software]. San Francisco: Author.

Marslen-Wilson, W. (1987). Functional parallelism in spoken word recognition. *Cognition, 25,* 71-102.

Neath, I. (1993). Distinctiveness and serial position effects in recognition. *Memory & Cognition*, *21*, 689-698.

Neurobehavioral Systems (2003). Presentation (Version .76) [Computer software]. Albany, CA: Author.

Newport, E. L., & Aslin, R. N. (2004). Learning at a distance I: Statistical learning of non-adjacent dependencies. *Cognitive Psychology, 48*, 127-162.

Repp, B. H. (1992). Probing the cognitive representation of musical time: Structural constraints on the perception of timing perturbations. *Cognition, 44*, 241-281.

Rodd, J. M. (2004). When do leotards get their spots? Semantic activation of lexical neighbors in visual word recognition. *Psychonomic Bulletin & Review, 11,* 434-439.

Saffran, J. R. (2003). Statistical language learning: Mechanisms and constraints. *Current Directions in Psychological Science, 12*, 110-114.

Saffran, J. R., Aslin, R. N., & Newport, E. L. (1996). Statistical learning by 8-month-old infants. *Science*, *274*, 1926-1928.

Saygin, A. P., Dick, F., Wilson, S. W., Dronkers, N. F., & Bates, E. (2003). Neural resources for processing language and environmental sounds: Evidence from aphasia. *Brain, 126,* 928-945.

Syntrillium Software Corporation. (2000). Cool Edit (2000 version) [Computer software]. Phoenix, AZ: Author.

Tyler, L. K., & Wessels, J. (1983). Quantifying contextual contributions to word-recognition processes. *Perception & Psychophysics, 34*, 409-420.

Wallace, W. P., Stewart, M. T, Sherman, H. L., & Mellor, M. D. (1995). False positives in recognition memory produced by cohort activation. *Cognition, 55*, 85-113.