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THE INFLUENCE OF VARIOUS VISUAL INPUT TYPES ON L2 LEARNERS' MEMORY FOR PHONOLOGICAL FORMS OF NEWLY-LEARNED WORDS

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Showalter and Hayes-Harb (2013) reported that native English speakers who were exposed to tone marks (e.g., <gí>) outperformed learners not exposed to tone marks (e.g., <gi>) during a word learning task involving a Mandarin-like mini lexicon. The present study investigated whether the word form learning benefit reported in Showalter and Hayes-Harb (2013) is necessarily orthographic. Subjects were assigned to word learning conditions providing the pseudo-Mandarin stimuli from Showalter and Hayes-Harb in addition to various other types of visual information: screen color, screen position, and combinations of position, color, and letters. Results from Showalter and Hayes-Harb were not replicated. Text position was found to provide a benefit over other non-orthographic visual information (color), as well as orthographic information (tone marks). The findings suggest that orthography, while a likely contributor to a performance benefit, is not the only beneficial visual information during word learning. At this time, there is a need for studies that investigate the benefit of other types of visual information.

INTRODUCTION

Recent evidence suggests that written input can powerfully influence the acquisition of second language words and their phonological forms. It has been found that "misleading" written forms can cause learners to misremember the auditory forms of words (e.g., Young-Scholten, 2002; Brown, Hayes-Harb & Smith, in prep; Hayes-Harb, Nicol & Barker, 2010). For example, Hayes-Harb et al. (2010) taught native English speakers an artificial second language (L2) lexicon in two conditions: one where subjects were exposed to spelled forms that were congruent with English grapheme-phoneme correspondences (e.g., hear [fɑʃə]; see <fasha>), or one where the spelled forms were incongruent with English grapheme-phoneme correspondences (e.g., hear [fɑʃə]; see <faza>). At test, subjects in the incongruent condition were more likely to misremember the pronunciations of the newly-learned words—that is, these subjects misremembered the word [fɑʃə] as [fɑzə]. They interpreted this finding as indicating that subjects' memory for the newly-learned word's phonological forms was negatively impacted by the written input when the native language (L1) and the (artificial) L2 differed in grapheme-phoneme correspondences. In addition, Brown et al. (in prep) demonstrated that access to spelled forms in the L2 input can interfere with native English speakers' acquisition of German final obstruent devoicing. They taught native English speakers

"German-like" words in two conditions: one in which subjects saw spelled forms (e.g., hear [krɑt]; see <krad>), and one where no spelled forms were provided. At test, participants who saw <krad> misremembered the word as [krɑd], suggesting that in cases where auditory forms and written forms conflict, written input may override the auditory input.

On the other hand, we have also seen cases where learners exposed to words' written forms can exhibit more accurate memory for the words' phonological forms than learners who do not see written forms (e.g., Escudero, Hayes-Harb & Mitterer, 2008), though the literature also contains a number of counterexamples (Simon, Chambless & Alves, 2010; Showalter & Hayes-Harb, 2015; Hayes-Harb & Hacking, 2015).

Escudero et al. (2008) provided evidence that native Dutch speakers were more likely to have established contrastive lexical representations for newly-learned English-like words distinguished by /æ/ and /ɛ/ when they saw the words' spellings (the letters <a> and <e>) than when they did not. Showalter & Hayes-Harb (2013) explored whether such facilitative effects depend crucially on the familiarity of the written symbols to the learners—they asked whether unfamiliar but nonetheless systematic written symbols can be used by learners to accurately remember the phonological forms of words. In this study, 26 English speakers learned a set of eight Mandarin-like words differentiated by lexical tone. The words involved two sequences of segments ([fian] and [gi]) with four tones each (tones 1,2,3,4) to form eight distinct "words". Tone 1 is a high-level tone, tone 2 is high-rising, tone 3 is low-falling-rising, and tone 4 is high-falling. Each word was paired with a nonobject "meaning" (see Figure 1); the (randomly-assigned) connection of a phonological form and a meaning was intended to constitute a lexical item. Subjects were randomly assigned to one of two word learning conditions, distinguished by the presence/absence of unfamiliar diacritic lexical tone marks on Pinyin (Romanized) written forms (e.g., <gi> vs. <gí>). During a word learning phase, each auditory word and its corresponding image (accompanied by a written form) was presented to subjects who were simply instructed to "learn the new words and their meanings".

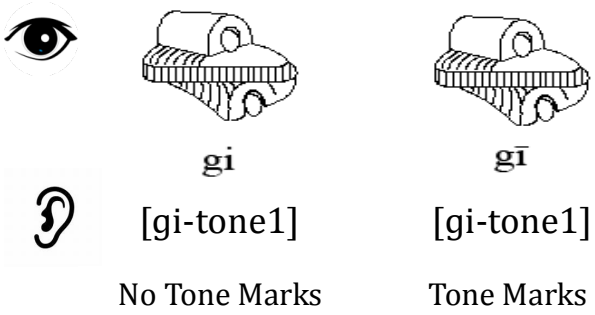

Figure 1. Example word learning trials, by word learning condition (Showalter & Hayes-Harb, 2013).

The word learning phase, which consisted of eight presentations of each word presented in a random order, was followed immediately by a criterion test. In the criterion test, a two-way forced-choice auditory word-picture matching task, subjects heard an auditory

form, saw a picture, and were asked to indicate by button press whether the word and picture (no longer accompanied by the written form) matched. The criterion test was intended only to ensure that subjects had reached a minimum level of word learning, and thus focused only on subjects' ability to distinguish [fian] words from [gi] words, but not minimal tone pairs (e.g., [gi-tone 1] from [gi-tone 2]). The criterion test involved 32 items—16 matched items (e.g., the picture that subjects were taught to associate with [gi-tone 1] presented along with the auditory form [gi-tone 1]). Subjects repeated the word learning – criterion test sequence until they reached 90% accuracy on the criterion test. The final test was identical to the criterion test except that subjects now were asked to distinguish between the minimal tone pairs. Showalter & Hayes-Harb (2013) found a significant effect of word learning condition on final test performance, with subjects in the Tone Marks condition exhibiting higher accuracy than subjects in the No Tone Marks condition. They concluded that the availability of orthographic tone marks in the input can help native English speakers learning pseudo-Mandarin remember lexical tone, and crucially, that even these unfamiliar written symbols influenced L2 word form learning.

Research Question

Given Showalter & Hayes-Harb's (2013) finding that native language familiarity with the specific written symbols is not a precondition for the symbols to influence novel word form learning, we now ask whether the word form learning benefit associated with the availability of tone marks reported by Showalter and Hayes-Harb (2013) is necessarily orthographic in nature. Specifically, we ask: To the extent that written forms can provide systematic visual cues to L2 phonological contrasts, might non-orthographic systematic visual cues similarly support novel word form learning? To answer this question, we conducted a replication and extension of Showalter & Hayes-Harb (2013), with a number of new word learning conditions in which each of the four lexical tone contrasts co-occur reliably with particular types of visual information, such as computer screen colors, screen position of images representing words' meanings, and screen position of words' written forms.

METHODS

All auditory and visual stimuli, procedures, and equipment used in the present study are identical to those used in Showalter and Hayes-Harb (2013). In addition to replicating the original two conditions (Tone Marks and No Tone Marks, which we now refer to as 'Image + Letters + Tone Marks' and 'Image + Letters', respectively), we created four new word learning conditions. These conditions involved manipulating two non-orthographic visual variables: screen position and screen color. The aim was to provide new types of systematic visual cues that could readily be presented on a computer screen. In the 'Image + Letters + Color' condition, subjects saw a picture and the letters only (i.e., without tone marks; e.g., <gi>), with the screen background color differing depending on the tone (tone 1: green, tone 2: yellow, tone 3: pink, tone 4: turquoise). In this way, the systematic visual information concerning tone that was provided to subjects in this condition was encoded in the screen color. In the 'Image + Letters + Position' condition, the only systematic visual cue to tone was encoded in the corner of the screen in which the letters (without tone marks) appeared. The picture was presented in the

center of the screen, while the positions of the written forms varied (tone 1: top left, tone 2: top right, tone 3: bottom left, tone 4: bottom right). In the 'Image + Position' condition, no letters were presented, and the systematic cue to tone was encoded in the position of the picture (tone 1: top left, tone 2: top right, tone 3: bottom left, tone 4: bottom right). Finally, we included the 'Image' condition, where only the image appeared, in the center of the screen, with no systematic visual cue to tone. The six word learning conditions (four new plus the two original Showalter & Hayes-Harb (2013) conditions) are summarized in Table 1. Example visual stimuli from each word learning condition are included in the Appendix.

Table 1
The Six Word Learning Conditions (S&HH = Showalter & Hayes-Harb, 2013)

	Orthographic		**Non-Orthographic**	
Word Learning Condition	**Letters**	**Tone Marks**	**Screen Position**	**Screen Color**
Image + Letters + Color *Systematic info: Screen color*	✔			✔
Image + Letters + Position *Systematic info: Position of text*	✔		✔	
Image + Position *Systematic info: Position of image*			✔	
Image + Letters + Tone Marks *Systematic info: Tone marks (S&HH)*	✔	✔		
Image + Letters *Systematic info: None (S&HH)*	✔			
Image *Systematic info: None*				

RESULTS

To determine the effect of word learning condition on subjects' ability to distinguish between the minimal tone pairs, we first converted the proportion correct scores to d' scores (see Figure 2). Next, we looked at the relationship between the number of word learning cycles required to reach criterion (see Table 2). The d' scores and number of word learning cycles were significantly correlated (Pearson r = .299, p= .001, n= 120); we thus included word learning cycles as a covariate in subsequent analyses. The d' scores were first submitted to an ANCOVA with word learning condition (six levels) and number of word learning cycles as a covariate. The main effect of word learning condition was not significant ($F(5,114)=1.330$, $p=.256$, partial eta squared=.055). Because we were interested in the difference in performance between pairs of word learning conditions, we followed up with a number of planned comparisons. The significant pairwise comparisons are: Image + Letters + Position > Image + Letters + Color ($p=.013$), Image + Letters + Position > Image + Letters ($p = .030$), and Image +

Letters + Position > Image + Letters + Tone Marks (p = .012). These are indicated with asterisks in Figure 2. Thus, the only word learning condition that led to significantly more accurate performance than any others was the Image + Letters + Position condition.

Table 2
Mean Word Learning Cycles Required to Pass the Criterion Test, by Word Learning Condition (standard deviation)

Word Learning Condition	Mean Word Learning Cycles	Mean d'
Image + Letters + Color	1.60 (1.00)	1.006 (1.14)
Image + Letters + Position	1.95 (.83)	1.626 (1.32)
Image + Position	2.50 (1.05)	1.82 (1.15)
Image + Letters + Tone Marks	1.85 (.75)	1.22 (0.93)
Image + Letters	1.80 (.83)	1.38 (1.09)
Image	2.50 (1.40)	1.50 (1.10)

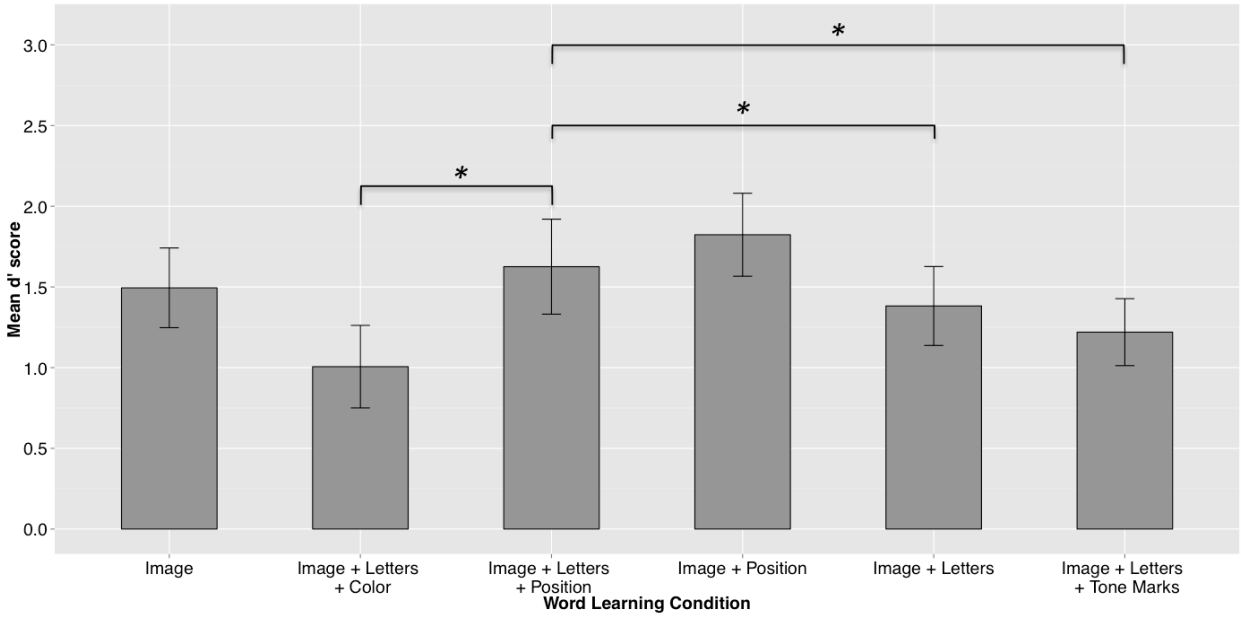

Figure 2. Mean d' scores by word learning condition; whiskers represent one standard error of the mean; asterisks indicate significant pairwise comparisons.

The comparison between the Image + Letters + Tone Marks and the Image + Letters conditions (those from Showalter & Hayes-Harb, 2013) was not significant; we thus did not replicate the previous finding that the availability of tone marks in the written input facilitated the acquisition of lexical tone contrasts by native English speakers.

DISCUSSION

Recall that our research question was: Is the word form learning benefit associated with the availability of tone marks reported by Showalter and Hayes-Harb (2013) necessarily orthographic in nature? Of the six word learning conditions in the present study, the only one that resulted in significantly higher d' scores than other conditions was the 'Image + Letters + Position', with subjects' performance significantly higher than in the 'Image + Letters + Colors', 'Image + Letters' and the 'Image + Letters + Tone Marks' conditions. Why subjects in this condition performed so well, or indeed why these subjects did not also outperform subjects in the remaining two conditions, is unclear. However, that subjects in this condition outperformed, in particular, participants in the 'Image + Letters + Tone Marks' suggests that the answer to our research question is "no". The more accurate performance with the availability of a non-orthographic visual cue as compared to tone marks indicates that the benefit experienced by learners exposed to systematic visual information does not crucially rely on that information being orthographic in nature. In this case, we have provided evidence that non-orthographic systematic visual cues similarly support novel word form learning, at least in the case of lexical tone learning under the present study conditions.

We are left with the question of why only one of the non-orthographic visual cues conditions resulted in significantly more accurate performance than other conditions. First, why did the position of the **word** (Image + Letters + Position) but not position of the **picture** (Image + Position) result in a word form learning advantage? It is worth noting that in fact, descriptively, subjects in the Image + Position condition had the most accurate performance overall, though their performance was not significantly more accurate than that of any others in the ANCOVA, when the number of word learning cycles were taken into account. While the performance of this group was high, so was the mean number of word learning cycles required to pass the criterion test (mean = 2.5 cycles in this condition). It is also unclear why the position of the letters and not the color of the screen led to more accurate performance, though it is noteworthy that Godfroid, Ryu and Lin (2015) also provide evidence that a color-related cue did not positively impact native English speakers' acquisition of Chinese lexical tone. Future research may help to clarify theses questions, and may consider additional non-orthographic visual cues, as those explored here are not exhaustive of possible visual cues to novel phonological contrasts.

We also wish to stress that our current findings may challenge the robustness of written input effects, in that we did not replicate the Showalter and Hayes-Harb (2013) finding that subjects who had access to tone marks in the written input outperformed those who did not. In addition, while Showalter and Hayes-Harb did not find a correlation between the number of word learning cycles and accuracy at the final test, we found a significant

correlation in the present study. Further research, including replication studies, may clarify these issues.

In summary, we have provided evidence that the influence of written input on L2 word form learning may not be an exclusively orthographic effect. Specifically, we found that native English speaking participants exposed to non-orthographic by systematic visual (word position) cues to Mandarin lexical tone in fact outperformed participants who were exposed to orthographic (diacritic) cues. In this way, the present study contributes to an increased understanding of language learners' use of available cues to novel phonological contrasts in the input, and highlights the need for further research into the utility of various input types in supporting second language word learning.

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Catherine E. Showalter (catherine.showalter@utah.edu) is a doctoral student in the Department of Linguistics at the University of Utah. She currently works as a researcher in the Speech Acquisition Lab in the department. Her research has (thus far) focused primarily on the interaction of orthography and phonology in tasks completed by adult second language learners. Current research involves grapheme-phoneme correspondences and investigation of perceptual adaptability. Her other interests include second language phonological acquisition, non-native phonotactic acquisition, and creation of the lexicon.

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APPENDIX

The following are example visual stimuli from each of the six word learning conditions (for [fian-tone 1]).

Image + Letters + Color *(green background)*

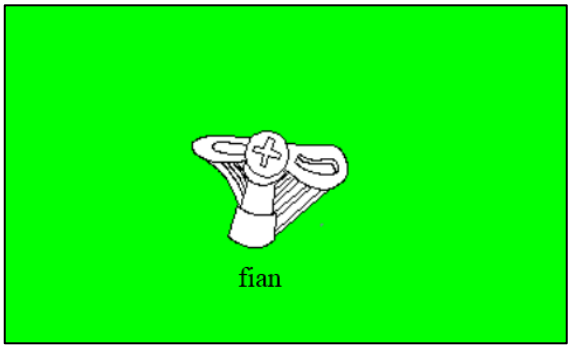


Image + Letters + Position

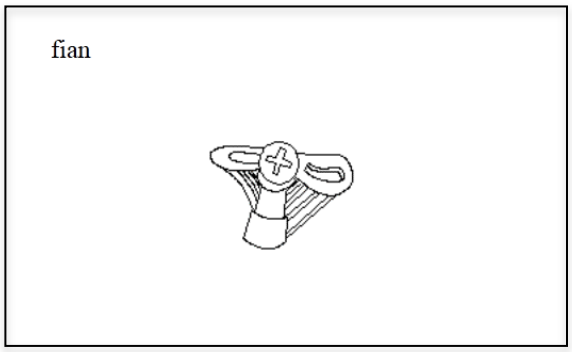


Image + Position

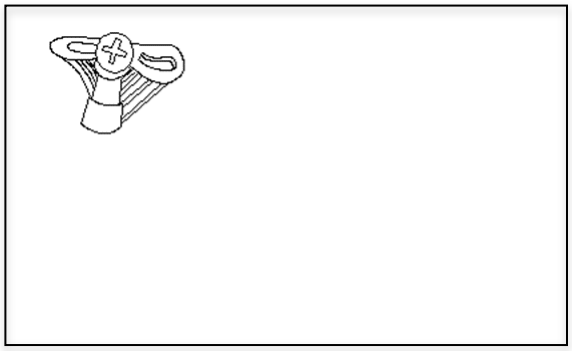


Image + Letters + Tone Marks

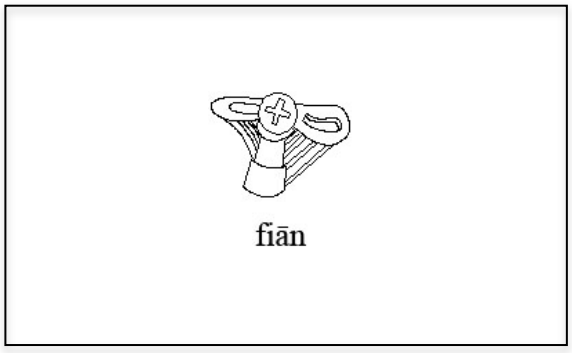
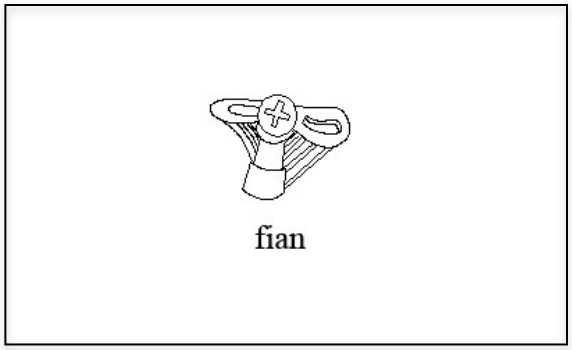


Image + Letters



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