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# Can native-language perceptual bias facilitate learning words in a new language?

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## Abstract

Acquiring a language relies on distinguishing the sounds and learning mappings between meaning and phonetic forms. Yet, as shown in previous research on child language acquisition, the ability to discriminate between similar sounds does not guarantee success at learning words contrasted by those sounds. We investigated whether adults, in contrast to young infants, are able to attend to phonetic detail when learning similar words in a new language. We tested speakers of Korean and Mandarin to see whether they could use their native-language-specific perceptual biases in a word-learning task. Results revealed that participants were not able to fully capitalize on their perceptual abilities: only faster learners – as independently assessed by baseline trials – showed enhanced learning involving contrasts in phonetic dimensions informative in their native language. This suggests that attention to phonetic detail when learning words might only be possible for adults with better learning skills or higher motivation.

**Keywords:** word learning; non-native speech perception; second language acquisition

## Introduction

Humans are able to take advantage of many different resources available to them in the course of learning. For example, when learning a new language – whether in infancy or adulthood – humans actively search for regularities by analyzing the input in several alternative ways (e.g., examining either adjacent or non-adjacent dependencies; Gómez, 2002), and are able to simultaneously entertain multiple implicit theories about the input's underlying structure (e.g., Gerken, 2010). One of the complex features of learning a language is that listeners must perform concurrent analyses of the input at different levels of processing and integrate these multiple pieces of information at once. If, for example, we zoom in to the level of processing single words, one needs to encode phonetic cues and, at the same time, map the phonetic form onto meaning. This task may be particularly hard for beginner second language (L2) learners who are not yet familiar with the L2 sound system, especially when they are processing words with novel sounds that do not exist in their native language (L1). However, there is evidence that learners capitalize on whatever pieces of information are available to them to achieve this task: they might use lexical cues to make inferences about sound categorization (Feldman, Myers, White, Griffiths, & Morgan, 2011), and – conversely – take advantage of perceptual learning on sound categorization to help them make inferences about the lexicon (Perfors & Dunbar, 2010). The question we are addressing in this paper is another piece of this puzzle.

Specifically, we know that prior language knowledge is one of the starting points when learning a new language: L1-based perceptual biases can facilitate perception of novel sound contrasts that differ along phonetic dimensions informative in L1 (Pajak, 2010a, 2010b; Pajak & Levy, in prep.), and can

affect interpretation of distributional information from novel language input (Pajak & Levy, to appear). How efficiently, then, do adults capitalize on their L1-based phonetic generalizations when learning the lexicon in a new language?

Intuitively, it might seem that whatever perceptual abilities adults have, they should be able to use them both when distinguishing sounds and when learning novel words. That is, if they hear a distinction between sounds *b* and *p*, they should be able to easily distinguish between words like *ban* and *pan*. However, the picture emerging from prior research is far less clear. In fact, research with young infants suggests that the ability to discriminate perceptually between similar sounds does not in general guarantee immediately successful learning of words that are contrasted by those sounds. At 14 months, infants can easily discriminate the sounds *b* and *d*. However, when taught that a novel object is called a *bih*, but later on is referred to as a *dih*, infants do not notice this mispronunciation (Stager & Werker, 1997). The initial explanation proposed for this result was the limited resource hypothesis (Stager & Werker, 1997; Werker, Fennell, Corcoran, & Stager, 2002): since attending to fine phonetic detail while learning new words is computationally very demanding, young infants – who have limited attentional and cognitive resources – might have difficulty accessing all phonetic detail when focusing their attention on learning meaning. Subsequent research showed that 14-month-old infants succeed only with additional contextual information or under less demanding learning conditions (Fennell & Werker, 2003; Fennell, Waxman, & Weisleder, 2007; Rost & McMurray, 2009; Swingley & Aslin, 2002; Thiessen, 2007; Yoshida, Fennell, Swingley, & Werker, 2009).

Some evidence suggests that adults might have similar difficulties when learning words in a new language. In a study by Perfors and Dunbar (2010), native speakers of English were first trained on discriminating a non-native contrast between a prevoiced and a voiceless unaspirated stop ([gipur] vs. [kipur]), and then taught word-picture mappings using minimal-pair words distinguished by this non-native contrast. The results showed that while participants performed better than chance at learning similar words with the exact contrast they had been trained on ([gipur]-[kipur]), they were at chance at learning words contrasted by sounds with an analogous contrast ([bipur]-[pipur]). This was despite the fact that, after perceptual training on [g]-[k], participants were able to distinguish [b] and [p] perceptually. Thus, just like 14-month-old infants, adults had difficulty differentiating between similar words in a word-learning task, even though they could tell these words apart in a pure perceptual task.<sup>1</sup>

<sup>1</sup>Better performance on [gipur] and [kipur] might have been due

However, the difficulty in learning similar-sounding words found by Perfors and Dunbar (2010) might have a purely perceptual basis. That is, learners’ ability to discriminate a pre-voiced [b] vs. a voiceless unaspirated [p] might not have been sufficiently robust to be of any use in a word-learning task. This is similar to the intuition of Perfors and Dunbar, who point out that learners’ representations of [b] and [p] categories might have been too fragile to see any advantage in word learning. If this reasoning is correct, then the comparison between 14-month-olds and adults in Perfors and Dunbar’s (2010) study is less warranted because, at 14 months, infants have difficulty learning the words *bih* and *dih* despite easily discriminating between the sounds *b* and *d*.

In the study reported here we achieve a more direct comparison with the situation of 14-month-old infants by investigating how adults learn similar-sounding words that they can distinguish perceptually due to their L1-based phonetic generalizations. Specifically, we used two distinctions: *length* (e.g., [taja]-[tajja]) and *place* of articulation between alveolo-palatal and retroflex sounds (e.g., [gotɕa]-[gotɕa]). Our participants were native speakers of Korean and of Mandarin, who were previously shown to have differential perceptual sensitivity to these two distinctions, as illustrated in Figure 1 (Pajak, 2010a, 2010b; Pajak & Levy, in prep.). In particular, Korean speakers were shown to be better than Mandarin speakers at discriminating consonant length contrasts ([m]-[mm], [n]-[nn], [l]-[ll], [s]-[ss], [f]-[ff], [j]-[jj], [w]-[ww]), but the reverse was true for the alveolo-palatal vs. retroflex place contrasts ([ɕ]-[ʂ], [tɕ]-[ʂ], [ʑ]-[ʑ], [dʑ]-[dʑ]). This result was likely due to the fact that Korean has length distinctions, and Mandarin does not, but Mandarin has alveolo-palatal and retroflex sounds, while Korean does not (Lin, 2001; Sohn, 2001). Crucially, however, these perceptual sensitivities cannot be attributed to direct L1-to-L2 phonetic category transfer alone (as has been generally proposed for these types of perceptual patterns; Major, 2008) because not all of the tested speech sounds exist in Korean or Mandarin.<sup>2</sup> Consequently, Pajak hypothesized that perceptual advantages in non-native speech processing can arise from sensitivity to phonetic *dimensions* that are informative in L1, and not just sensitivity to specific L1 categories. In this study we test whether these perceptual advantages are exploited during word learning.

## Experiment

Participants learned novel word-picture mappings, where each word was in a minimal pair with either a *length* dis-

to the familiarity with these lexical items from perceptual training, which is consistent with infants also performing better on familiar words (Swingley & Aslin, 2002).

<sup>2</sup>Korean mostly uses length distinctions on vowels (e.g., [pu] ‘fire’ vs. [pu:l] ‘blow’), but some long consonants ([ll], [nn], [mm]) arise from phonological assimilation processes (Sohn, 2001), and Korean tense obstruents ([p̚], [t̚], [k̚], [s̚], [tɕ̚]) have sometimes been analyzed as long (Choi, 1995). As for Mandarin, alveolo-palatals and retroflexes exist as allophones of the same phonemic category, and voiced obstruents ([ʑ], [dʑ], [dʑ]) are entirely absent (except [ʑ]) since Mandarin has obstruent distinctions in aspiration, not voicing (Lin, 2001).

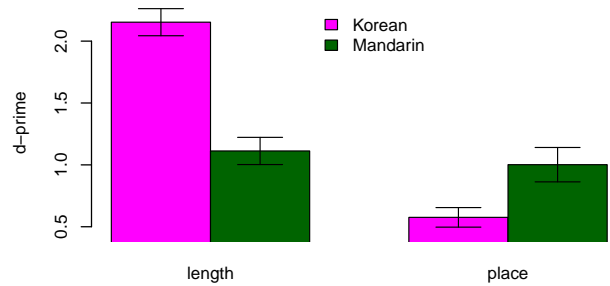


Figure 1: Perceptual discrimination results (Pajak, 2010a, 2010b; Pajak & Levy, in prep.).

inction or an alveolo-palatal vs. retroflex *place* distinction. We predicted that if adult L2 learners are able to attend to phonetic detail by using their L1-based resources when learning a new lexicon, then we should observe the same pattern in both the perceptual discrimination and the word-learning tasks: that is, Korean speakers should be better at learning *length* minimal pairs, and Mandarin speakers better at learning *place* minimal pairs.

## Method

**Participants** 54 undergraduate students at UC San Diego participated in the experiment for course credit or payment. Half were speakers of Korean, and the other half were speakers of Mandarin. Participants varied in terms of their length of residence in the US: some were born in the US, while others immigrated at some point after birth or were international students who arrived very recently. Consequently, they varied in English proficiency. Importantly, however, they all learned Korean or Mandarin from birth, reported high proficiency in those languages, and still used them regularly, predominantly with family. In most cases they had some high school and/or college exposure to Spanish or French. Some Mandarin speakers were also familiar with Taiwanese, mostly through family exposure. All participants reported no history of speech or hearing problems.

**Materials** The materials consisted of 16 nonce words of the form CVC(:)V, where each was in a minimal pair differing only in the middle consonant (a subset of contrasts tested by Pajak, 2010a, 2010b; Pajak & Levy, in prep.). There were 12 *length* words, with either a short or a long middle consonant, and 4 *place* words, with either an alveolo-palatal or a retroflex consonant (both pronounced as in Polish, which has a distinction similar to Mandarin), as illustrated in Table 1.

The materials were recorded in a soundproof booth by a phonetically-trained native speaker of Polish. There were 10 tokens recorded for each word. For *length* words, two tokens of each word with long consonants were chosen for the experiment. Subsequently, words with short consonants were created by shortening the tokens with long consonants in a way that, for each word and each recording, the naturally-recorded long consonant was reduced to half its duration so as

Table 1: Stimuli (in IPA).

LENGTH WORDS		PLACE WORDS	
<i>short</i>	<i>long</i>	<i>alveolo-palatal</i>	<i>retroflex</i>
taja	tajja		
tala	talla		
diwa	diwwa	gotça	gotṣa
difa	diffa	goza	goṣa
kema	kemma		
kena	kenna		

to maintain a constant 2:1 duration ratio (cross-linguistically, the long-to-short consonant ratio varies between 1.5 to 3; Ladefoged & Maddieson, 1996). For *place* words, two tokens each were chosen for the experiment with the goal of maximizing the similarity between the words in minimal pairs with regards to how vowels were pronounced, but at the same time choosing tokens with clearly enunciated middle consonants.

Each word was paired with a picture of a different kind of mushroom (see two examples in Fig. 2), which were chosen in order to include objects that were unfamiliar to our participants, but not so unfamiliar that participants would find them bizarre and hard to remember. We selected pictures that varied in shape and color so as to maximize visual differences between them. We created four different one-to-one word-to-picture mappings that were counterbalanced between participants in order to make sure that the results were not driven by any peculiarities in the mappings we chose.

**Procedure** Participants sat in front of a computer, and responded by using a mouse. They were instructed that in this experiment they would be learning a novel language, and, specifically, the language’s words for mushrooms. The experiment was completed in a single session. There were 4 training blocks (each with 128 trials, about 10-15min long) and 4 testing blocks (each with 64 trials, about 5min long), interleaved. Blocks were separated by self-terminated breaks. In each trial, two pictures were presented on a computer screen (see Fig. 2), and a word was played through headphones with a delay of 500ms. Participants were asked to click on the picture that they thought went with the word. In training, feedback was provided following the response in the form of the correct picture staying on the screen. A mouse click triggered the start of the next trial. Presenting feedback after participant’s response meant that the early responses were necessarily random. Participants were told to guess at first, and that through feedback they would eventually learn the correct word-to-picture mappings. In testing, no feedback was provided.

The training trial types consisted of picture pairs that were always associated with dissimilar word pairs (e.g., *taja-diwa*, *gotça-kemma*) so that participants were not directly alerted to the distinctions of interest. The testing trial types were always different from the training trials. There were four types of tri-



Figure 2: Example of a screen shot that participants saw throughout the experiment.

als in testing depending on the minimal-pair contrast that corresponded to the pictures, as illustrated in Table 2: (i) *length* (24 trials per block), (ii) *place* (8 trials), (iii) filler-dissimilar (16 trials), and (iv) filler-similar (16 trials). The critical trials consisted of the critical minimal-pair picture pairings (i.e., pairs of pictures whose corresponding words were a minimal pair): *length* pairs and *place* pairs. The filler trials consisted of *dissimilar* pairs, always differing in the first CV sequence, and *similar* pairs that shared the initial CV sequence. The picture position was counterbalanced. The trial order was pseudo-randomized: we created four randomized lists, and then altered them manually so that the same word was never repeated in two consecutive trials. Furthermore, the minimal-pair trials were always separated by at least two other trials. Each participant heard each list once, with a different list for each block. The block order was counterbalanced across participants.

Table 2: Trial types in testing.

CRITICAL PICTURE PAIRS		FILLER PICTURE PAIRS	
<i>type</i>	<i>example</i>	<i>type</i>	<i>example</i>
<b>Length</b>	taja-tajja	<b>Dissimilar</b>	tala-goza
<b>Place</b>	gotça-gotṣa	<b>Similar</b>	tala-taja

## Results

We analyzed accuracy scores from testing with mixed-effects logit models (Jaeger, 2008). We included random intercepts for participants and items, and random slopes for participants and items for all effects of interest that were manipulated within participants or within items. We controlled for participants’ nonverbal IQ, self-reported L1 proficiency, and current L1 exposure and use by adding them as fixed effects to the models. Although we present data for the four test blocks separately for purposes of visualization, in statistical analyses we collapse across test block.

As a sanity check, we expected that all participants, regardless of language background, should perform best on *filler-dissimilar* trials, slightly worse on *filler-similar* trials, and worst on *critical* trials. These overall results were borne out, as illustrated in Figure 3. In a model with fixed effects of TRIAL TYPE (*filler-dissimilar*, *filler-similar*, *critical*)

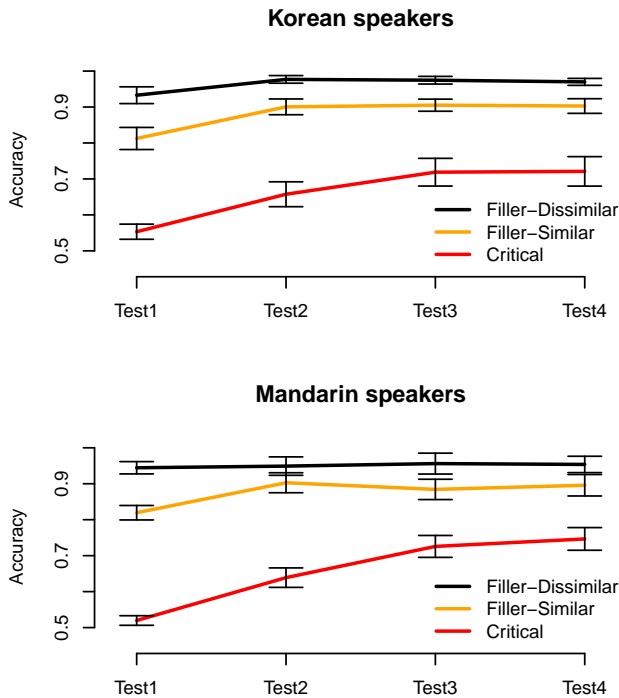


Figure 3: Proportion of correct responses on critical and filler trials (in all figures, error bars are standard errors).

and LANGUAGE (*Korean, Mandarin*), we found that the responses in the *filler-dissimilar* condition were significantly higher than in the *filler-similar* condition ( $p < .001$ ), which in turn were higher than in the *critical* condition ( $p < .001$ ). Neither LANGUAGE nor its interactions were significant in the model. Furthermore, a log-likelihood ratio test comparing the full model to a reduced version which did not contain LANGUAGE revealed no evidence that language background significantly contributed to the model ( $\chi(5) = 2.20; p = .82$ ), thus suggesting that there were no significant differences between the two language groups in overall response patterns.

Next, we compared Korean and Mandarin speakers on critical trials in a model with fixed effects of CRITICAL TRIAL TYPE (*length, place*) and LANGUAGE (*Korean, Mandarin*). If learners are able to capitalize on their L1-based perceptual generalization when beginning to learn new words, we should observe a difference in performance between the two language groups in line with their perceptual biases: Korean speakers should be more accurate on *length* pairs, and Mandarin speakers more accurate on *place* pairs. However, there was no significant interaction between CRITICAL TRIAL TYPE and LANGUAGE ( $p=.21$ ), indicating that Korean and Mandarin speakers did not differ in their accuracy when learning similar-sounding words that differed in either length or place. These results are illustrated in Figure 4. This is in striking contrast to perceptual discrimination results (Fig. 1; Pajak, 2010b, 2010a; Pajak & Levy, in prep.), where – using similarly constructed stimuli – Korean speakers clearly outperformed Mandarin speakers on perception of length con-

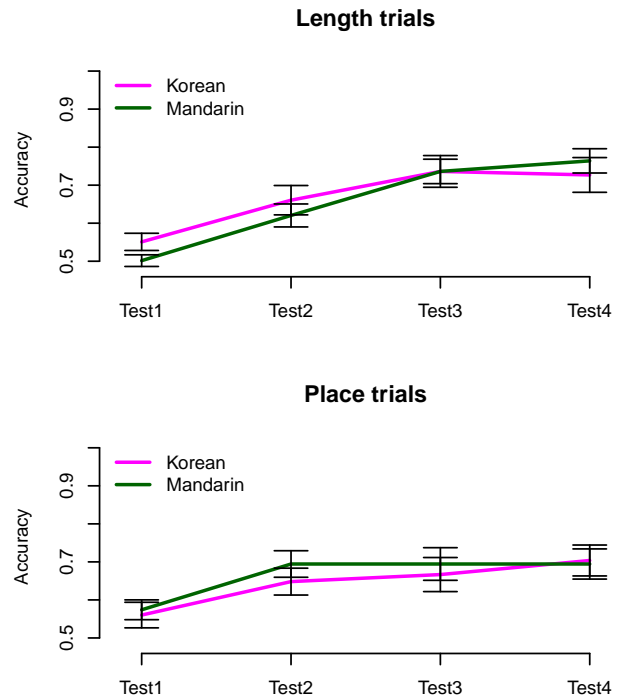


Figure 4: Proportion of correct responses on critical trials.

trasts, and the reverse was true for place contrasts.

However, we know that learners vary in their attention, motivation and learning skills. Thus, we asked whether only better learners are able to use their L1 resources and attend to fine phonetic detail in word learning. To answer that question we split the participants into two halves, top- and bottom-scoring on filler trials. We chose this way of doing the median split due to the fact that performance on fillers was a dimension independent from the variables of interest. The median score on all fillers combined was 94.5% accuracy. There were 7 participants who scored right at 94.5%, who were then split based on their performance on *dissimilar* fillers alone. The distribution of participants in terms of their language background was fairly equal in both groups: Korean=13 and Mandarin=14 in the top half, and Korean=14 and Mandarin=13 in the bottom half. The filler scores for both top-scoring and bottom-scoring participants are provided in Table 3 (next page). Both groups were highly accurate on filler pairs (at least 80% accuracy), but there was much more variability in the bottom-scoring group.

The results split by top-scoring vs. bottom-scoring participants are illustrated in Figures 5 and 6. Even by visual inspection alone, the results on critical trials look strikingly different in the top vs. bottom-scoring group: in the top half, participants were clearly improving in the course of the experiment (with the biggest jump from Test1 to Test2), while in the bottom half, participants' responses were close to chance throughout the experiment, with only minimal signs of learning (namely, Mandarin speakers seemed to improve on *length* trials toward the end of the experiment). We analyzed these

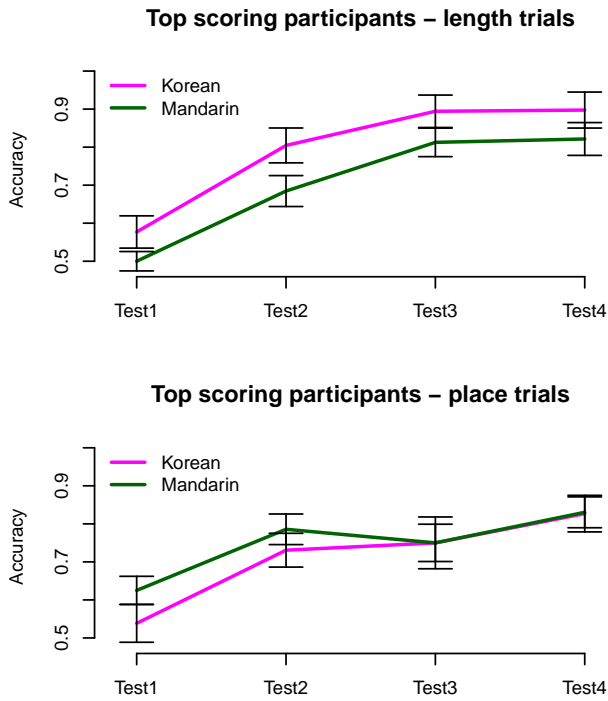


Figure 5: Faster learners: proportion of correct responses on critical trials.

Table 3: Proportion of correct responses on filler trials (standard errors in parentheses).

FILLER TYPE	TOP HALF		BOTTOM HALF	
	<i>Korean</i>	<i>Mandarin</i>	<i>Korean</i>	<i>Mandarin</i>
Test 1	.95 (.01)	.92 (.01)	.80 (.04)	.84 (.02)
Test 2	.98 (.01)	.98 (.01)	.90 (.02)	.87 (.05)
Test 3	.98 (.01)	.97 (.01)	.90 (.01)	.86 (.05)
Test 4	.99 (.00)	.99 (.01)	.89 (.02)	.86 (.05)

results with a model with fixed effects of CRITICAL TRIAL TYPE (*length*, *place*) and LANGUAGE (*Korean*, *Mandarin*), and an additional fixed effect of FILLER PERFORMANCE (*top*, *bottom*). We found a significant three-way interaction between CRITICAL TRIAL TYPE, LANGUAGE, and FILLER PERFORMANCE ( $p < .01$ ), indicating distinct response patterns for Korean vs. Mandarin speakers on *length* and *place* trials depending on their overall success rate in learning, as measured by their accuracy on filler trials. (A regression analysis treating filler performance as a continuous covariate yielded similar results).

For the top-scoring group, we found the pattern indicating that participants were taking advantage of their perceptual biases: Korean speakers more accurate on *length* trials than Mandarin speakers, but not on *place* trials, as indicated by a significant interaction between CRITICAL TRIAL TYPE and LANGUAGE ( $p < .01$ ). Furthermore, a model examining *length* trials only revealed a significant main effect of

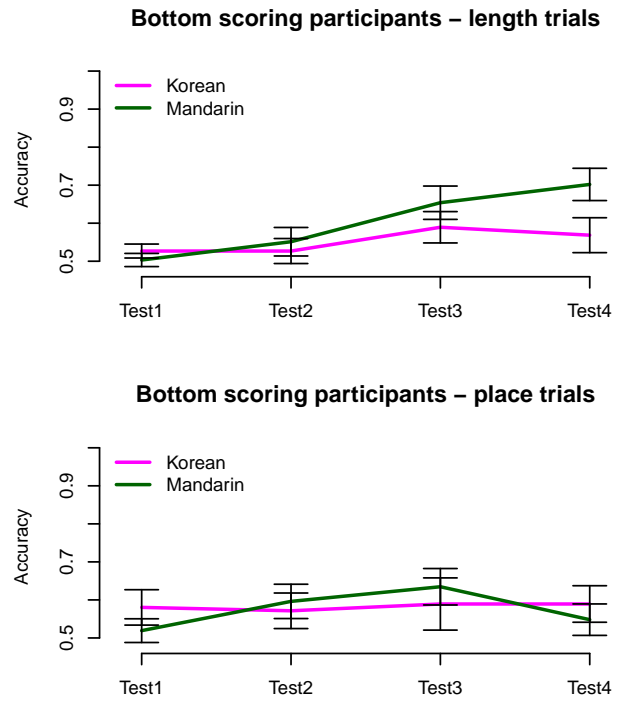


Figure 6: Slower learners: proportion of correct responses on critical trials.

LANGUAGE ( $p < .05$ ). On *place* trials, Korean and Mandarin speakers were not significantly different, but the numerical tendency was the opposite of that seen in the *length* trials: Mandarin speakers were slightly more accurate than Korean speakers.

For bottom-scoring participants, on the other hand, we found no significant interaction between CRITICAL TRIAL TYPE and LANGUAGE. There were also no significant differences between Korean and Mandarin speakers when only *length* ( $p = .21$ ) or only *place* trials ( $p = .99$ ) were examined. However, Mandarin speakers did seem to improve on *length* – but not *place* – trials toward the end of the experiment. It is unclear why Mandarin, but not Korean speakers showed this improvement, especially since – if anything – it was Korean speakers who seemed to perform slightly better on filler trials in the bottom-scoring group. As for the learning asymmetry – improvement on *length*, but not on *place* – it could be that *length* was simply easier to learn, perhaps due to it being a more salient cue (note that in the perception study, Fig. 1, *length* contrasts were obviously easier than *place*) and due to the fact that the stimuli included significantly more *length* words compared to *place* words, thus allowing more opportunity for perceptual learning of the *length* contrast.

Why did some learners succeed at using their perceptual abilities while others did not? The individual measures we collected indicate that the top-scoring and the bottom-scoring groups did not differ in nonverbal IQ nor L1 proficiency. However, the bottom-scoring participants did, on average, immigrate to the US later in life, and, consequently, had lower

English proficiency. This suggests that there might be an advantage for more balanced bilinguals (consistent with findings by Kaushanskaya & Marian, 2009), or perhaps students less accustomed to the US educational system have more overall difficulty performing these kinds of tasks in a laboratory setting.

## Discussion

Previous work (Pajak, 2010a, 2010b; Pajak & Levy, in prep.) has shown beneficial effects of L1 properties on L2 discrimination, but what about learning? For the populations as a whole there was no clear effect indicating that participants made effective use of their native-language resources, but there is evidence that the faster learners (as independently assessed by filler performance) were able to do so. This is in contrast to the discrimination results we cited, where L1-based perceptual advantages were observed for all participants. This result suggests that there is something inherently hard about the early stage of word learning that precludes attention to fine phonetic detail that is otherwise available during phonetic processing. This is even more surprising given that adults have well-developed attentional and cognitive capacities, but nevertheless fail to use them in this task. It is still an open question as to what exactly made the faster group of learners succeed at using their L1 resources and attending to fine phonetic detail. Perhaps they were more attentive throughout the experiment, more motivated, or had better learning skills.

Overall, the results reported here shed some more light on the interaction between sound perception and word learning in adults. In particular, they suggest that perceptual resources are not easily used when learning minimal-pair words. An intriguing possibility – consistent with results from infant studies (Thiessen, 2007; see also Feldman, Griffiths, & Morgan, 2009) – is that learners' initial strategy is to assume that similar sounding minimal pairs are homophones, and only phonetic evidence from non-minimal pairs (or explicit information about the number of categories) pushes them to revise that assumption. This kind of parsimony might benefit learning when there is uncertainty about phonetic category boundaries – a possibility that we plan to pursue in future research.

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