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EMPIRICAL STUDY

Enhanced Second Language Vocabulary Learning Through Phonological Specificity Training in Adolescents

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This longitudinal randomized trial study investigated the effects of phonological specificity training on second language (L2) vocabulary learning. Eighty-six Dutch secondary-school students participated in one of two experimental conditions or in an animacy judgment (active control) condition. Participants in the phonological specificity training (with phonological manipulation) and the picture selection (without phonological manipulation) experimental conditions had to select the corresponding picture from among competitors after hearing a word. Phonological specificity training resulted in increased learning (measured through word translation) compared to the control condition on the posttest whereas picture selection produced increased learning only for participants with larger initial vocabulary sizes. Both experimental conditions showed increased learning for participants with larger vocabulary sizes on the retention test. Compared to picture selection, phonological specificity training showed more learning immediately after intervention for words with nonnative contrasts. Results suggest

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that phonological features can augment (meaning-focused) L2 vocabulary learning interventions.

Keywords reading; second language; young learners; decoding fluency; secondary education

Introduction

Vocabulary learning, one of the core components of language competence (Meara, 1996), is a major obstacle in second language (L2) acquisition (Meara, 1980). Most research on and teaching methods of L2 vocabulary learning have focused entirely on teaching word meaning although a substantial body of research has emphasized the importance of word form (for a review, see, e.g., Schmitt, 2008). Both word meaning and word form have been shown to be related to the quality of lexical representations (Perfetti & Hart, 2002). However, few studies have investigated the relationship between the specificity of word form representations and L2 vocabulary acquisition, and the studies that do exist have focused on orthographic rather than on phonological form (e.g., Barcroft, 2002; Bogaards, 2001). In this study, we investigated whether L2 vocabulary learning in secondary-school students can be facilitated by focusing on the phonological specificity (i.e., phonological form) of L2 lexical representations in a form-focused vocabulary learning intervention.

L2 Vocabulary Learning: Contribution of Meaning and Form

The lexical quality hypothesis (Perfetti, 2017; Perfetti & Hart, 2002; Perfetti & Stafura, 2014) focuses on the quality of the lexical representations in the mental lexicon to explain differences in performance between readers. Perfetti and Hart conducted a combination of orthographic, phonological, and semantic tasks and found the lexical knowledge structure to be more coherent, with stronger connections between orthographic and phonological structures, in proficient than in less proficient first language (L1) readers. Thus, according to the lexical quality hypothesis, lexical retrieval (in both reading and writing) is facilitated by high-quality lexical representations in the mental lexicon in terms of meaning (e.g., semantics) and form (e.g., phonology). Hence, enhancement of either meaning or form could also be expected to facilitate L2 vocabulary learning.

With respect to meaning, many studies have addressed the role of word meaning in L2 vocabulary learning (see, e.g., Schmitt, 2008). Research has suggested that, in the initial stages of L2 acquisition, vocabulary is acquired through paired-associate learning (e.g., de Groot, 2006; Hummel, 2010) and that L2 learners rely heavily on L1–L2 associations to retrieve L2 words from the mental lexicon (Chen & Leung, 1989). This is not surprising given the accumulation of evidence pointing to a shared mental lexicon that stores the conceptual meanings of words that can be used by multiple language systems (e.g., de Bot, 1992; Chee, Tan, & Thiel, 1999). More advanced L2 learners, in contrast, have direct access to the meanings of L2 words (Chen & Leung, 1989). However, L2 vocabulary instruction, in most cases, is entirely devoted to teaching word labels, and this does not take into account the incremental and multidimensional nature of the learning process (Schmitt, 2008).

With respect to form, previous research has suggested that form-based instruction benefits the word learning process (Schmitt, 2008). However, it is unclear whether these findings generalize to L2 word learning. On the one hand, Barcroft (2002) suggested that meaning-focused L2 vocabulary learning may inhibit (orthographic) form-focused L2 vocabulary learning and vice versa. This may be due to a lack of attentional resources available during L2 vocabulary learning. On the other hand, learners may benefit from form-based instruction because learners tend to have phonological representations that are influenced by the phonology of their L1 (e.g., Flege, 1995; Kuhl & Iverson, 1995). As a result, L2 lexical representations with unfamiliar L2 sounds tend to be less specified, and learners may experience difficulties retrieving words with unfamiliar sounds from their mental lexicons. For example, Dutch lacks a distinction between word-final voiced and voiceless obstruents and between /æ/ and /ɛ/ (as in *paddle–pedal*); as a result, Dutch L2 learners of English show spurious word activation in lexical decision when they encounter these L2 English consonant (Broersma & Cutler, 2008) and vowel (Broersma, 2012) contrasts. Using the visual world paradigm (Cooper, 1974), Weber and Cutler (2004) found that their L2 listeners showed longer and more frequent fixations for target words with unfamiliar sounds paired with confusable distractors (e.g., *stamp* [stæmp]–*stekker* [stɛkər]), but not vice versa. Follow-up research suggested that this asymmetric pattern was due to participants' orthographic knowledge of the target words (Darcy, Daidone, & Kojima, 2014; Escudero, Hayes-Harb, & Mitterer, 2008). In addition, L2 learners acquire novel words more quickly when these words have been produced by multiple speakers (Barcroft & Sommers, 2005), which may be the result of more robust abstract (i.e., phonological) representations, as suggested by Sommers and Barcroft (2011) or the result of word categories with larger numbers of exemplars (Craik & Kirsner, 1974; Palmeri, Goldinger, & Pisoni, 1993).

In a relevant study, focusing on both word meaning and word form, van Goch, McQueen, and Verhoeven (2014) developed a paradigm to enhance the specificity of words' phonological representations (i.e., word form), and subsequent research has revealed positive effects of this phonological specificity training on both vocabulary learning and phonological awareness in kindergartners learning their L1 and L2 (van Goch et al., 2014; Janssen, Segers, McQueen, & Verhoeven, 2015). However, these previous studies did not tease apart the effect of the meaning-focused elements of phonological specificity training (form–meaning mapping) from the phonological elements in this training (i.e., phonological manipulation in the phonological specificity training). Because both elements have been shown to benefit L2 vocabulary learning (see Schmitt, 2008), it is unclear which elements drive the word-learning effect in phonological specificity training.

The question therefore arises as to the extent to which training that combines meaning-focused and phonological form-focused learning (i.e., full phonological specificity training), which corresponds to the phonological specificity training condition in this study, enhances L2 vocabulary learning more than similar training that does not include the focus on word forms (i.e., partial phonological specificity training), which corresponds to the picture-selection condition here. In this study, we addressed this question by means of a phonological specificity training intervention adapted from van Goch et al. (2014). In this paradigm, participants saw four pictures on a computer screen and heard a stimulus (i.e., target word) that matched one of these four pictures. The instruction was to click on the corresponding picture. Targets were always presented with two random fillers and one phonologically related competitor.

The Current Study

We conducted a randomized controlled trial study to tease apart the effects of the semantic and phonological elements in phonological specificity training on L2 word learning in first-year students in secondary education. First, during a pretest, we tested participants' L2 word knowledge, English word-decoding skills, and general English vocabulary knowledge. Second, 1 week after the pretest, participants were assigned to one of three conditions. We created two training conditions: (a) a phonological specificity training condition similar to van Goch et al. (2014), which combined meaning-focused and form-focused learning (i.e., with target words paired with phonological competitors), and (b) a picture-selection condition, which did not contain phonological competitors but was otherwise identical.

In the phonological specificity training condition, the presence of phonological competitors during picture selection was expected to improve the lexical specificity of the phonological representations of the target words. The lexical quality hypothesis (Perfetti & Hart, 2002) would predict that the enhanced semantic representations facilitate (L2) vocabulary learning. We also created an active control condition, in which we used an animacy decision task (where participants had to decide whether each target word referred to a living or a nonliving item), which has been shown to contribute to the storage of lexical items in semantic memory (Pecher & Raaijmakers, 2004) because this task requires deep semantic processing (Fliessbach, Buerger, Trautner, Elger, & Weber, 2010). The animacy task was therefore expected to enhance the lexical specificity of the semantic representation in the framework of the lexical quality hypothesis (Perfetti & Hart, 2002). We used these conditions to test various components of the phonological specificity training paradigm separately. We subsequently tested participants' L2 word knowledge directly after the intervention (posttest) and 4 to 5 days after the intervention (retention test).

In addition to these training conditions, various word and student characteristics may also influence L2 vocabulary learning and the effectiveness of vocabulary instruction. First, we considered the Levenshtein distance (Levenshtein, 1966) between the L2 English target word and its L1 translation, which indicated the number of character edits required to change the English target word into its L1 translation and thus the degree of orthographic (and phonological) overlap between these words. Levenshtein distance can be expected to influence L2 word learning because crosslinguistic overlap influences L2 lexical retrieval (e.g., Dijkstra, Grainger, & Van Heuven, 1999). Second, word frequency can be expected to have an effect on L2 word learning because words are remembered more easily by beginners (and to a lesser extent by more advanced learners) if words are paired with frequent L1 words (de Groot, 2006; Lotto & de Groot, 1998), although such an effect of L2 word frequency might be relatively small (de Groot & Keijzer, 2000).

The primary student characteristics that we considered were L2 word-decoding ability (e.g., Meschyan & Hernandez, 2002), which is still developing in first-year secondary-school students (e.g., van de Ven, Voeten, Steenbeek-Planting, & Verhoeven, 2018) and initial English vocabulary size, both of which may reflect the amount of learners' exposure to English. We had three main research questions:

1. What are the effects of picture-selection and of phonological specificity training on L2 word learning compared to that of animacy judgment as a control condition?

2. To what extent are the effects of picture-selection versus those of phonological training dependent on word characteristics such as L1–L2 overlap, L1/L2 word frequency, and contrast type (consonant/vowel)?
3. To what extent are the effects of picture-selection versus those of phonological training dependent on student characteristics (word-decoding, vocabulary)?

On the basis of the lexical quality hypothesis (Perfetti & Hart, 2002), for Research Question 1, we predicted that vocabulary learning would be most successful in the phonological specificity training condition because this condition contained strong cues for enhancing the lexical specificity of both phonological and semantic representations. The picture-selection condition was expected to be somewhat less effective because it contained strong cues for enhancing the lexical specificity of the semantic representations (identical to the phonological specificity training condition) but limited cues to enhance the lexical specificity of the phonological representations. With respect to the active control condition (i.e., animacy decision task), different predictions could be made. On the one hand, the active control condition might be less effective than the picture-selection condition because the lexical selection in the two training conditions might lead to deeper semantic processing than does the animacy decision in the active control condition. On the other hand, the active control condition might be more effective than the picture-selection condition because of an enhanced testing effect. After all, in the second half of the active control condition, participants needed to retrieve lexical items on the basis of acoustic input alone (without any corresponding pictures), and this might lead to a stronger testing effect compared to the other two conditions.

Regarding Research Question 2, we predicted that phonological training effects would be influenced by the presence of (to-be-learned) unfamiliar phonological contrasts. We also expected words with unfamiliar consonant contrasts to be acquired more easily than those with unfamiliar vowel contrasts because obstruent devoicing only occurs in word-final positions in Dutch (i.e., obstruent voicing contrasts are allowed in other positions) whereas the unfamiliar vowel contrast (i.e., /æ–ɛ/) never occurs in Dutch. In addition, we expected that word frequency would predict which words students knew prior to the intervention and that L2 words would be learned more easily if they were combined with highly frequent L1 translation equivalents, in line with Lotto and de Groot (1998) and de Groot (2006).

With respect to Research Question 3, we expected the effects of picture selection to be influenced by lexical quality (i.e., word decoding and initial L2 vocabulary knowledge). Because both may reflect the amount of exposure to English, we predicted larger and more sustained effects of picture selection for students with stronger L2 word decoding skills and larger L2 vocabulary sizes because of their semantically rich English lexical representations, which would enhance the learning and retrieval of novel English words.

Method

Participants

Our sample consisted of first-year pre-university students in Dutch secondary education. Dutch secondary education has a tracked system, and about 20% of the children go to this pre-university or highest track (Statline, 2017). The parents or caregivers of the participants were informed about the intervention and allowed to give their passive consent. However, we received active consent from the participants. The parents of two participants did not allow them to participate in the study. Further, one participant was excluded from the study because she was an English native speaker. In total, 86 students (52 boys, 34 girls) from a single school participated in this study ($M_{\text{age}} = 12$ years 5 months, $SD = 6$ months) from three different classes. Eighty-six percent of the participants were raised monolingual (Dutch). The remaining participants either reported being early bilinguals (9.3%) or late bilinguals (3.4%).

Target Stimuli

To begin with, 48 minimal triplets were constructed. These triplets contained two unfamiliar target words (e.g., *mace* and *maze*) and a familiar control word (e.g., *mail*). In contrast to the original protocol by van Goch et al. (2014)—which included familiar phonologically related target competitors in Block 1 (e.g., *mace–mail*), unfamiliar phonologically related target competitors in Block 2 (*mace–maid*), and phonologically related target competitors in Block 3 (*mace–maze*)—we excluded unfamiliar phonologically related competitors in order not to make the intervention overly complex. Target word pairs and familiar control words were selected on the basis of an inspection of the course materials used in primary and first-year secondary education. We included four types of target word pairs: (a) those with unfamiliar consonant contrasts (final obstruent voicing, as in *mace–maze*), (b) those with familiar consonant contrasts (e.g., *bike–bite*), (c) those with unfamiliar vowel contrasts (/æ–ɛ/, as in *paddle–pedal*), and (d) those with familiar vowel contrasts (e.g., *net–nut*). We selected final obstruent voicing and /æ–ɛ/ contrasts because these contrasts are difficult to perceive for Dutch listeners and lead to spurious lexical activation (Broersma & Cutler, 2008; Darcy et al., 2014; Escudero et al., 2008; Weber

& Cutler, 2004). The target word pairs with unfamiliar contrasts (/æ–ɛ/) or familiar contrasts in unfamiliar positions (i.e., word-final voiced obstruents, such as /b, d, g/) differed in only one acoustic–phonetic feature (e.g., obstruent voicing or place of articulation) whereas the target pairs with familiar contrasts could differ in more than one acoustic–phonetic feature (see Appendix S1 in the Supporting Information online). Consonant contrasts always focused on the word-final phoneme whereas vowel contrasts were located (approximately) in word-medial positions. Although seven of our triplets with familiar contrasts contained word-final voiced obstruents, the obstruent voicing distinction in these word pairs with familiar contrasts was never contrastive (i.e., voiceless counterparts were excluded).

Instruments

We first tested participants' English word-decoding skills and general English vocabulary as well as their target word knowledge. All these tests were administered during the pretest period, 1 week before the intervention. Target-word knowledge was also assessed with a posttest (immediately after the intervention) and a retention test (4 to 5 days after the intervention). On the pretest, posttest, and retention test for target-word knowledge, participants were instructed to translate the target words from Dutch into English.

English Word Decoding

We measured English word decoding by means of a standardized test (Steenbeek-Planting, Kleijnen, & Verhoeven, 2008). Dutch–English cognates and homonyms were excluded from the test. Moreover, because Dutch and English share several orthographic rules, English words that could be pronounced correctly with Dutch orthographic knowledge alone were excluded as well. Words in the English reading test increased in length and decreased in word frequency. Participants were instructed to read the words as quickly and accurately as possible. The test consisted of 108 words in total, and the score was the number of words read correctly within 1 minute.

General English Vocabulary

We assessed participants' English vocabulary size at the onset of the intervention using LexTALE (Lemhöfer & Broersma, 2012), which is a paper-and-pencil lexical decision task consisting of 60 lexical items (40 existing words, 20 pseudowords). The score was the number of correct decisions. Participants were given 10 minutes to complete the task.

Table 1 Design of the phonological specificity training condition

Block	Word pair	Example
Block 1	Target word A	*mace*
	Familiar control	*mail*
Block 2	Target word B	*maze*
	Familiar control	*mail*
Block 3	Target word A	*mace*
	Target competitor B	*maze*
Block 4	Target word B	*maze*
	Target competitor A	*mace*

Target-Word Translation

We measured participants' recall of the target words (i.e., the targets to be learned during the intervention) by means of a paper-and-pencil Dutch–English translation task which consisted of the 96 target words (see Appendix S1 in the Supporting Information online). Participants were allowed 10 minutes to complete the task.

Training Conditions

This study investigated the effects of an adapted version of van Goch et al.'s (2014) phonological specificity training—a training that integrates semantic and phonological elements—on L2 English word learning. The intervention was presented to participants using Inquisit (2014) software. Participants were distributed across the phonological specificity training condition ($n = 28$), picture-selection condition ($n = 29$), and active control condition ($n = 29$). The amount of exposure to the target words was equal across conditions, and all condition sessions lasted approximately 15 minutes.

Phonological Specificity Intervention

The intervention started with five practice items to familiarize participants with the task. This was followed by four training blocks (48 trials each). Each target word occurred twice as a target and once as a competitor (see Table 1). On each trial, four pictures were shown on a computer screen: two experimental items (i.e., a target and a familiar control or two targets) and two familiar filler items (see Figure 1). The positions of these pictures were fully randomized. For each triplet, one of the two unfamiliar target words was presented in the first block, the other in the second (both combined with the same familiar control, as shown in Table 1). Similarly, one of the two unfamiliar target words was

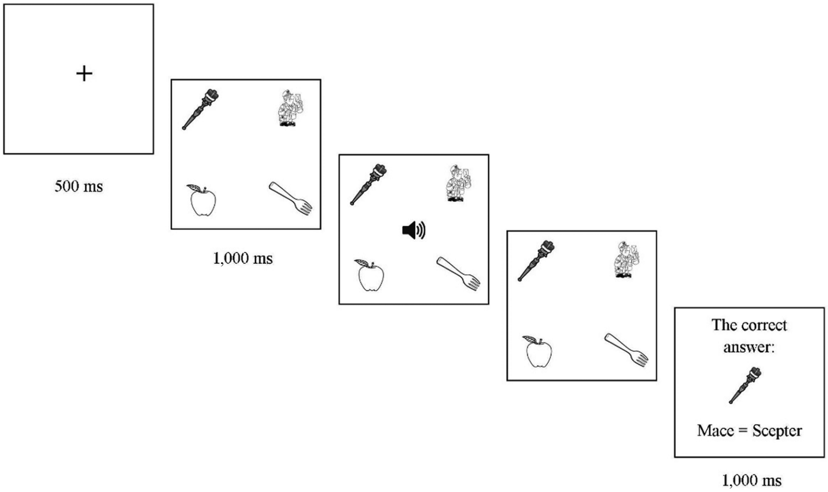

Figure 1 Time sequence of a single trial in the phonological specificity training condition.

presented as a target word in the third block and as a competitor in the fourth block, and then vice versa.

During each trial, participants were instructed to click on the picture that corresponded to the auditory stimulus presented, which was the first target word for each triplet in the first and third blocks and the second target word in the second and fourth blocks. The assignment of target words to blocks and to trial positions within blocks was randomized across subjects. Every trial started with a fixation cross (500 milliseconds), which was followed by the four pictures (1,000 milliseconds). The auditory stimulus was then presented while the four pictures remained on the screen. Subsequently, and in addition to the original paradigm, participants were provided with feedback indicating the correct answer and the appropriate Dutch–English translation (1,000 milliseconds), regardless of the correctness of their response (see Figure 1).

Picture Selection

The setup of the picture-selection condition was identical to that of the phonological specificity intervention with one exception. In contrast to the full intervention, participants were now presented with phonologically unrelated familiar control words in the first two blocks and with phonologically unrelated target competitors in the last two blocks (see Table 2 and Figure 2). For instance, participants could be presented with the unrelated word *peak* (which served as

Table 2 Design of the picture selection condition

Block	Word pair	Example
Block 1	Target word A	*mace*
	Familiar control	*peak*
Block 2	Target word B	*maze*
	Familiar control	*peak*
Block 3	Target word A	*mace*
	Target competitor B	*dice*
Block 4	Target word B	*maze*
	Target competitor A	*dice*

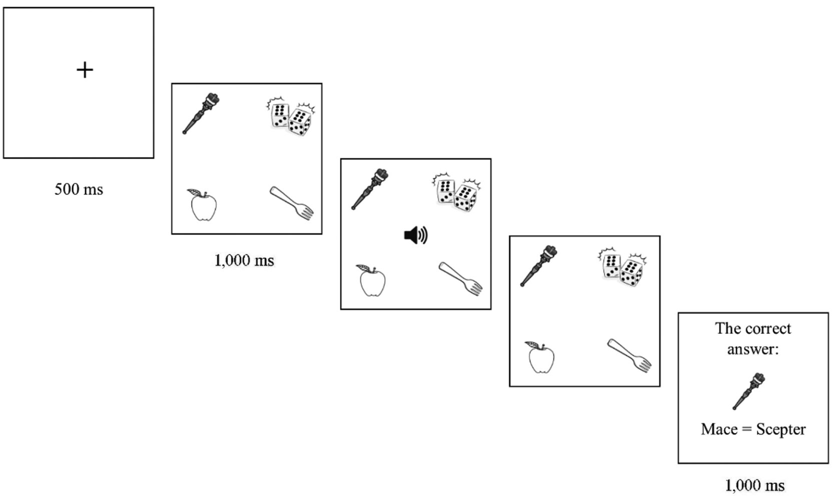

Figure 2 Time sequence of a single trial in the picture selection condition.

a familiar control, paired with *peace* in the full intervention condition) instead of *mail* in the first two blocks and with the unrelated word *dice* (which served as a target word, paired with *dyes* in the full intervention condition) in the last two blocks. Participants heard each target word as frequently as they had in the phonological specificity training intervention condition.

In sum, the two training conditions—phonological specificity intervention and picture selection—contained various elements that may contribute to L2 vocabulary learning. First, the testing effect was an integral part of the paradigm. The testing effect refers to the well-attested phenomenon of (lexical) retrieval operations enhancing long-term (lexical) knowledge (for a review, see Roediger

Table 3 Design of the active control condition

Block	Word pair	Example
Block 1	Target word A	*mace*
Block 2	Target word B	*maze*
Block 3	Target word A	*mace*
Block 4	Target word B	*maze*

& Butler, 2011). Second, both training conditions required picture selection; that is, participants needed to match pictures with lexical items, which has been shown to facilitate L2 vocabulary learning (e.g., Tonzar, Lotto, & Job, 2009), contributing to the lexical specificity of the semantic representations of the target words. Finally, the phonological specificity training also contained a phonological manipulation that could enhance L2 vocabulary learning.

Active Control Condition

The active control condition contained the same target words as the two training conditions. Participants in this condition were instructed to provide animacy judgments for these target words (i.e., to indicate whether the target was living or nonliving) by pressing a button. The experiment again consisted of four blocks, and each block contained either of the two members of each word pair (see Table 3). In the first two blocks, participants heard the target word and saw the corresponding picture, and then they made an animacy judgment. In the last two blocks, participants heard only the target word and subsequently made an animacy judgment. Participants heard each target word as frequently (and in similar orders) as they had in the two training conditions. There were 29 animate and 67 inanimate target words.

In the first two blocks, each trial started with a fixation cross (500 milliseconds), which was followed by the target picture (1,000 milliseconds). Subsequently, the auditory stimulus was presented while the picture remained on the screen. Participants were then provided with feedback indicating the correct answer and the appropriate Dutch–English translation (1,000 milliseconds) regardless of the correctness of their response (see Figure 3). The last two blocks were similar to the first ones except that no pictures were shown. Similar to the phonological specificity training and picture-selection conditions, the active control condition involved paired-associate learning and was expected to produce a testing effect.

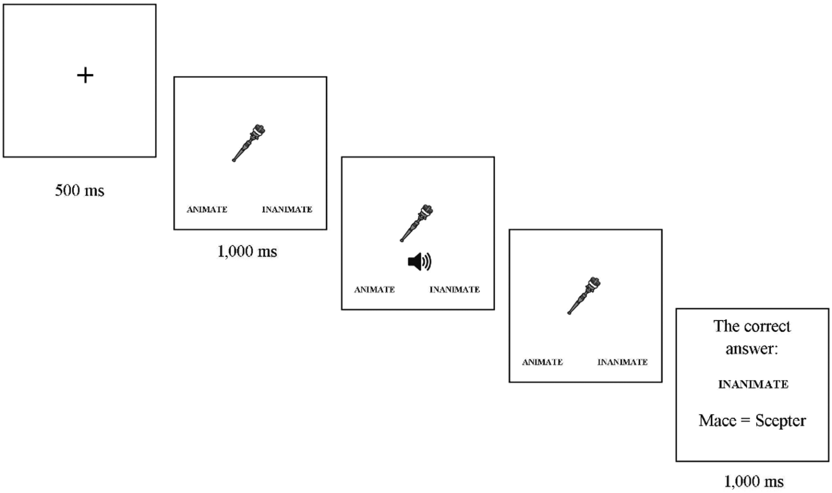

Figure 3 Time sequence of a single trial in the active control condition.

Procedure

We conducted a randomized controlled trial in which participants were randomly assigned to one of the three conditions (phonological specificity intervention, picture selection, or active control) on the basis of their LexTALE, target-word translation, and English decoding scores on the pretest. The LexTALE and target-word translation tests were conducted in class by the first author. The decoding tests were administered individually in a separate room by the first author or by one of several bachelor's- or master's-level students in educational science who were trained for this purpose.

Data Analysis

The results were analyzed using generalized linear mixed-effects models with the logit link function (Jaeger, 2008) in R (R Core Team, 2016), which allowed for analysis of the correctness of participants' translations of the target words as a binomial variable (correct/incorrect). We present separate analyses for the comparison between the pretest and posttest (Model 1a) and for the comparison between the pretest and retention test (Model 1b) to prevent overfitting. Because the results of these two analyses were highly similar, they are discussed in tandem.

Included in the analyses were the dependent variable correctness (a binary variable indicating whether participants translated a given word correctly during

Table 4 Descriptive statistics for the test measures

Measure	*M*	*SD*
English word decoding	67.90	10.98
General English vocabulary	35.19	5.79
Target translation (pretest)	20.72	10.86
Target translation (posttest)	47.15	19.94
Target translation (retention test)	39.81	19.53

the pretest versus the posttest [in Model 1a] or during the pretest versus the retention test [in Model 1b]), the independent variables time (a binary variable coded as pretest versus posttest [in Model 1a] and pretest versus retention test [in Model 1b]), condition (coded as phonological specificity training, picture selection, or active control), contrast type (consonant or vowel), Dutch word frequency expressed as the log-transformed word frequencies based on CELEX (Baayen, Piepenbrock, & Gulikers, 1995), English word frequency expressed as the log-transformed word frequencies based on the Corpus of Contemporary American English (Davies, 2008), English decoding (score on the English word decoding task), vocabulary (score on the LexTALE vocabulary task), and Levenshtein distance (the number of character modifications required to change a Dutch word into its English target translation). Moreover, we included the following control predictors: trial number, gender, and native language (Dutch or non-Dutch). Finally, we included random intercepts for participant, word (i.e., items), and random slopes.

The fixed-effects structure of the model was obtained by means of a stepwise variable-selection procedure in which variables were included if they resulted in a significantly better model fit. All continuous variables were standardized to a mean of zero and centered to avoid multicollinearity (Belsley, Kuh, & Welsch, 1980). After determining the fixed-effects structure, we tested, for each fixed effect, whether the inclusion of a random slope improved the model fit, by means of chi-square tests (Baayen, 2008). This procedure was used in all logistic regression analyses reported in this study. For all categorical variables, we used dummy coding.

Results

The descriptive statistics for all measures are provided in Table 4. Participants correctly translated 21.58% of the target words during the pretest, 49.11% during the posttest, and 41.47% during the retention test. Table 5 shows the

Table 5 Pearson correlations between the pretest measures

Measure	1	2	3
1 English word decoding	—		
2 General English vocabulary	.47*	—	
3 Target word translation	.65*	.53*	—

Note. $^{*}p < .01$.

correlations between the pretest measures. These correlations indicate that there were strong relations between the various language measures. Five participants were missing during (one of) the two test sessions for the pretests, 13 participants during the intervention and posttest, and 3 participants for the retention test. Participants who were absent during the intervention were also classified as missing for the retention test. In total, 80 participants were included in the analyses comparing the three conditions whereas 54 participants were included in the additional analyses comparing only the two training conditions. For the dependent variable, positive values indicate more incorrect than correct responses.

The comparison between the pretest and the posttest is summarized in Table 6, and the comparison between the pretest and the retention test is summarized in Appendix S2 in the Supporting Information online. First, for both models, we found a significant time × condition × vocabulary interaction. For the comparison between the pretest and the posttest (see Figure 4), this interaction showed that participants translated more words correctly at the posttest compared to the pretest, across conditions, but participants in the phonological specificity training condition learned more new words than did those in the active control condition. In the picture-selection condition, only participants with relatively large initial English vocabulary sizes acquired more new words than did participants with similar vocabulary sizes in the active control condition. For the comparison between the pretest and the retention test (see Figure 5 and Appendix S2 in the Supporting Information online), enhanced word learning (relative to the active control condition) was restricted to relatively large initial English vocabulary sizes in both training conditions.

Moreover, again for both models, we found a significant main effect for English decoding, which showed that participants with stronger English decoding skills at the outset of the study gave more correct translations across time points. In addition, we found significant main effects for Dutch word frequency, English word frequency, and Levenshtein distance, and a significant time × En-

Table 6 Translation accuracy across pretest and posttest (Model 1a)

Predictor: Random effects	Variance explained	χ^2
Participant	0.71	3568.40***
Participant × Time (posttest)	0.63	117.24***
Participant × Levenshtein Distance	0.01	15.73**
Participant × Trial number	0.04	29.44***
Word	5.20	957.80***
Word × Time (posttest)	1.27	187.45***
Word × English decoding	0.07	36.93***
Word × Vocabulary	0.03	12.76*
Predictor: Fixed effects	*b*	*z*
Intercept	2.01	5.07***
Time (posttest)	−2.40	−10.52***
Condition (PST)	0.26	1.03
Condition (picture selection)	0.32	1.32
Dutch word frequency	−0.51	−3.20**
English word frequency	−1.04	−4.31***
English decoding	−0.80	−6.50***
Vocabulary	−0.29	−1.76
Levenshtein distance	0.12	2.47*
Trial number	0.15	3.57***
Time (posttest) × English word frequency	0.44	2.97**
Time (posttest) × Vocabulary	0.29	1.99*
Condition (PST) × Vocabulary	−0.01	−0.03
Condition (picture selection) × Vocabulary	−0.08	−0.32
Time (posttest) × Condition (PST)	−0.75	−3.05**
Time (posttest) × Condition (picture selection)	−0.64	−2.58**
Time (posttest) × Condition (PST) × Vocabulary	−0.38	−1.54
Time (posttest) × Condition (picture selection) × Vocabulary	−0.52	−2.28*

Note. PST = phonological specificity training.
*$p < .05$, **$p < .01$, ***$p < .001$ (two-tailed). The categories provided in parentheses are compared to the reference categories.

glish word frequency interaction. We did not find any effects for contrast type (i.e., whether target words differed in a consonant or vowel). The significant main effect for Levenshtein distance showed that a higher orthographic similarity between the L1 word and the L2 counterpart resulted in more correct translations across time points. The significant frequency effects indicated that

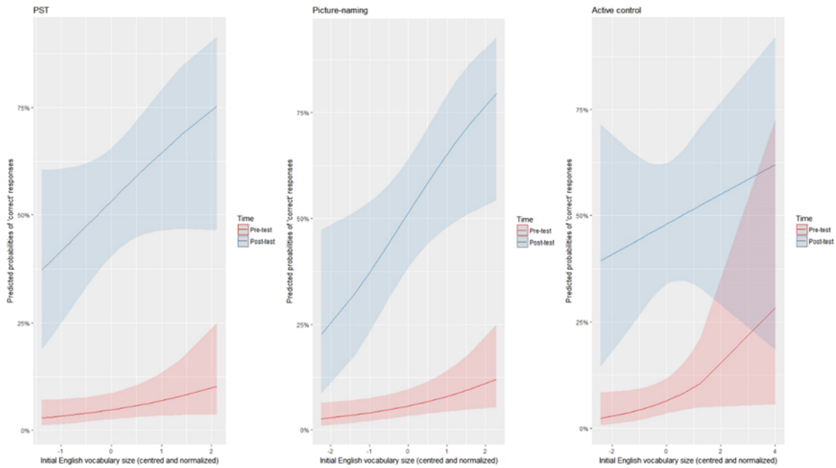

Figure 4 Predicted probabilities of correct responses for the pretest/posttest in the phonological specificity training (left), picture selection (middle), and active control (right) conditions. [Color figure can be viewed at wileyonlinelibrary.com]

participants performed better for English words with a more frequent Dutch translation and for more frequent English words, although in the latter case, this effect became smaller after the intervention.

Finally, there was a significant main effect for the control variable trial number, which indicated that participants performed better at the beginning than toward the end of the test, although this effect varied significantly across participants as shown by the random slope of trial number for participant. It appears that this random slope reflected the different strategies employed by the participants while performing the target-word translation task. Although some participants took all the time required to translate the target words to the best of their ability and had to rush toward the end to complete the test, others took a more pragmatic approach and started by translating the relatively easy target words.

Subsequently, we fitted two additional models (Model 2a comparing the pretest and the posttest and Model 2b comparing the pretest and the retention test) to assess the effects of the phonological specificity training in more detail. In these models, we included the same random and fixed variables as in the previous models except for Levenshtein distance because target words that contained unfamiliar sound contrasts also tended to have larger Levenshtein distances than those of their Dutch counterparts. In addition, we included contrast

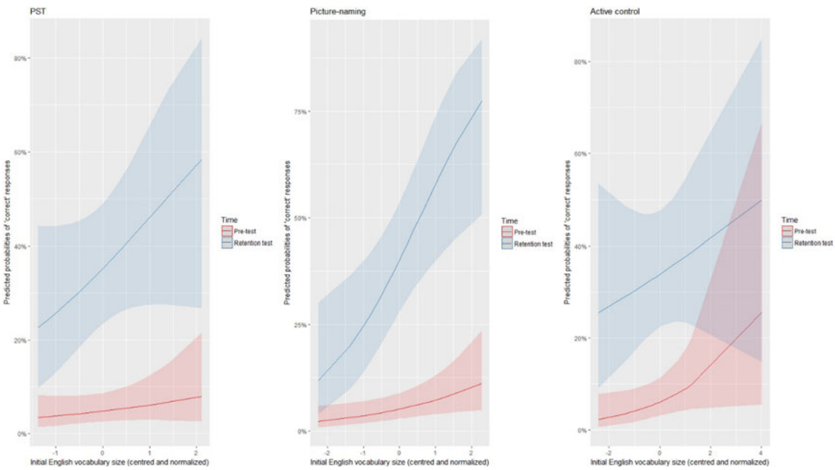

Figure 5 Predicted probabilities of correct responses for the pretest/retention test in the phonological specificity training (left), picture selection (middle), and active control (right) conditions. [Color figure can be viewed at wileyonlinelibrary.com]

familiarity (whether the English target word contained the non-Dutch sounds trained during the intervention) as a predictor variable. Further, we restricted our analyses to the two training conditions, which were identical except for the phonological manipulation. This also prevented overfitting because comparisons that were of less interest (i.e., those with the active control condition) were absent. We used one-tailed tests for contrast familiarity because phonological specificity training has been shown to enhance the specificity of phonological representations of L2 words with unfamiliar phonological contrasts (Janssen et al., 2015), which in turn is expected to facilitate lexical retrieval (Perfetti & Hart, 2002).

In Model 2a (see Table 7), we found a significant time × condition × contrast familiarity interaction, $b = -0.40$, $z = -1.61$, $p = .05$ (one-tailed), for the comparison between the pretest and the posttest. This interaction showed that participants in the picture-selection condition learned fewer novel words with unfamiliar phonological contrasts (learning gain: 26.33%) than with familiar contrasts (learning gain: 32.21%) whereas participants in the phonological specificity training condition showed similar learning gains for words with unfamiliar (learning gain: 29.81%) and familiar (learning gain: 30.93%) phonological contrasts. In Model 2b (see Appendix S3 in the Supporting

Table 7 Phonological specificity training relative to picture selection training for words with unfamiliar and familiar sound contrasts (Model 2a)

Predictor: Random effects	Variance explained	χ^2
Participant	0.63	628.82***
Participant × Time (posttest)	0.64	88.80***
Participant × Trial number	0.02	12.45**
Word	5.04	2310.60***
Word × Time (posttest)	1.36	135.62***
Word × English decoding	0.09	25.01***
Predictor: Fixed effects	*B*	*z*
Intercept	3.05	8.14***
Time (posttest)	−3.03	−10.79***
Condition (PST)	−0.16	−0.64
Contrast familiarity (unfamiliar)	−0.43	−0.91
Dutch word frequency	−0.62	−4.03***
English word frequency	−1.00	−4.15***
English decoding	−0.91	−6.60***
Vocabulary	−0.30	−2.33*
Trial number	0.12	3.65**
Time (posttest) × English word frequency	0.47	2.93**
Time (posttest) × Contrast familiarity (unfamiliar)	0.29	0.94
Condition (PST) × Contrast familiarity (unfamiliar)	0.25	1.31
Time (posttest) × Condition (PST)	0.03	0.09
Time (posttest) × Condition (PST) × Contrast familiarity (unfamiliar)	−0.40	−1.61†

Note. PST = phonological specificity training.
$^{*}p < .05$, $^{**}p < .01$, $^{**}p < .001$ (two-tailed).
$^{\dagger}p = .05$ (one-tailed). The categories provided in parentheses are compared to the reference categories.

Information online), this effect was attenuated, $b = -0.39$, $z = -1.52$, $p = .06$ (one tailed).

Discussion

This randomized controlled study investigated the contribution of a phonology- and semantics-based vocabulary learning paradigm—phonological specificity training (adapted from van Goch et al., 2014)—to L2 vocabulary learning in

Dutch first-year secondary students. Participants were assigned to one of three conditions: (a) a phonological specificity training condition (picture selection with a phonological manipulation), (b) a picture-selection condition (picture selection without a phonological manipulation), and (c) an active control condition (animacy judgement). All three conditions made use of the well-attested testing effect (Roediger & Butler, 2011). Participants heard each target word twice across conditions. We addressed three research questions: (a) What are the effects of picture-selection and phonological specificity training on L2 word learning compared to those of an active control condition (animacy judgment)? (b) To what extent do the word characteristics of L1–L2 overlap, L1/L2 word frequency, and contrast type (consonant/vowel) predict L2 word learning? and (c) To what extent do the learner characteristics of L2 word decoding and initial English vocabulary knowledge predict L2 word learning?

Effect of Training on Vocabulary Development

First, we compared the two training conditions to the active control condition. We found that, directly after the intervention, students exposed to the phonological specificity training had learned more new English words compared to those in the active control condition. In the picture-selection condition, participants with relatively large vocabulary sizes also learned more new English words compared to participants in the active control condition. We speculate that participants with smaller vocabularies prior to the intervention had less specified initial phonological representations, and as a result, they benefited more from the phonological manipulation in the phonological specificity training, which was absent in the semantic condition. On the retention test, we found that the additional effects of training increased, relative to the control condition, with increasing initial English vocabulary size across training conditions.

Our finding that phonological specificity training facilitates L2 English word learning supports the lexical quality hypothesis (Perfetti, 2017; Perfetti & Hart, 2002; Perfetti & Stafura, 2014), suggesting that learners benefit from a mixed L2 vocabulary training method that combines meaning-focused and form-focused elements. This result contradicts previous findings by Barcroft (2002). Possibly, the form-focused orthographic elements targeted by Barcroft required more cognitive resources than did the form-focused phonological elements in our study, and this may explain these divergent findings. Participants in the two training conditions may also have benefited from picture selection because this has been shown to enhance the lexical specificity of semantic representations (Tonzar et al., 2009). In addition, the phonological specificity training condition contained a phonological manipulation that may have also enhanced L2 vocabulary learning. Moreover, participants with larger initial vocabulary sizes had better word-learning skills and/or long-term memory and therefore showed more sustained word-learning effects. Our finding that phonological elements may enhance L2 vocabulary learning is in line with suggestions by Sommers and Barcroft (2011), who found enhanced learning after exposure to words produced by multiple speakers.

Second, we compared the two training conditions to examine the differential learning effects for words with familiar and unfamiliar sound contrasts. We focused on the unfamiliar /æ–ɛ/ vowel contrast and final obstruent voicing contrasts that do not occur in Dutch (participants' L1) and that cause spurious word activation in Dutch listeners (e.g., Broersma, 2012; Broersma & Cutler, 2008). The results showed that phonological specificity training, which contained a phonological manipulation focused on these nonnative contrasts, yielded similar learning gains for words with familiar and unfamiliar sound contrasts. In contrast, picture-selection training yielded lower learning gains for words with unfamiliar sound contrasts. This difference between the two training conditions appeared smaller on the retention test compared to the posttest. Yet, the descriptive differences between learning gains at the posttest and retention test showed highly similar patterns. For the phonological specificity training, there were marginal differences in learning gains for words with familiar and unfamiliar contrasts. However, for the picture-selection training, the magnitude in learning gains for words with familiar and unfamiliar contrasts was 5.9% on the posttest versus 5.4% on the retention test.

Overall, the differential learning effect for words with unfamiliar sound contrasts between the two training conditions showed that the phonological manipulation in the phonological specificity training facilitated L2 vocabulary learning, despite the small number of exposures (i.e., two for each target word). The absence of any effects of contrast type suggests that similar learning effects occurred for minimal triplets with vowel and consonant contrasts. It is important to note, however, that there was a difference in participants' prior familiarity with these contrast types because obstruent voicing can occur in nonfinal positions in the participants' L1 (Dutch) whereas the vowel contrast /æ–ɛ/ cannot.

We also found a positive relation between individual differences in L2 decoding skills and L2 word learning, which agrees with Perfetti's (2010) decoding, vocabulary, and comprehension triangle model. Because we had only one measure of L2 decoding (i.e., administered during the pretest) and because L2 decoding skills are known to be still developing in first-year secondary school students (e.g., van de Ven et al., 2018), we could not demonstrate a causal relationship between L2 decoding skills and L2 word learning. Follow-up research should further address this issue.

Last but not least, our results showed a clear influence of the lexical characteristics of both L1 and L2 word frequency on L2 word learning. We found that the frequency of a L1 word predicted translation accuracy equally well before and after the intervention. The frequency of a L2 word, on the other hand, was a better predictor of the translation accuracy before rather than after the intervention. This finding corroborates previous research showing that L2 words tend to be remembered most easily by beginner-level learners if these words are paired with frequent L1 words (de Groot, 2006; Lotto & de Groot, 1998). The role of English word frequency became smaller after the intervention probably because there was a larger learning potential for low-frequency than for high-frequency target words. Moreover, we found that L2 participants were better at translating L2 words with a large orthographic overlap with their L1 counterparts, as measured by the Levenshtein distance between these words. This finding shows that crosslinguistic overlap facilitates the retrieval of L2 words from the mental lexicon in line with previous research (e.g., Dijkstra et al., 1999).

Underlying Mechanisms

These findings raise the question of what mechanisms underlie the effect of phonological specificity training on L2 vocabulary learning. We hypothesize that phonological specificity training enhances the perception and phonological representation of nonnative phonological contrasts and thereby facilitates the acquisition of word pairs that contain these contrasts. On the one hand, L2 phonological contrasts may exist in the L1 but in different contexts. For example, Dutch has word-final devoicing but allows obstruent voicing contrasts in other positions. As a result, Dutch listeners use different cue-weighting strategies than do L1 listeners when they process English word-final obstruent voicing contrasts (Broersma & Cutler, 2008). We speculate that, in these situations, phonological specificity training facilitates the use of cue-weighting strategies that are specific to English.

On the other hand, L2 phonological contrasts may be completely absent in the L1. Escudero et al. (2008) found that, as a result of exposure to spelling, L2 learners may confuse unfamiliar vowel sounds (e.g., /æ/) with similar-sounding familiar vowel sounds (e.g., /ɛ/), but not vice versa. On the basis of this finding, Escudero et al. suggested that L2 listeners may require explicit contrastive information to create separate representations of minimal pairs that contain such unfamiliar vowel contrasts. Phonological specificity training, in contrast to the learning task in Escudero et al., combines target words with phonological competitors. Thus, phonological specificity training provides learners with explicit contrastive information that may allow them to create separate lexical entries for word pairs containing unfamiliar contrasts. Thus, phonological specificity training may enhance learners' sensitivity to acoustic–phonetic differences that are phonemic in the L2 but allophonic in the L1, which is in line with Janssen et al. (2015).

Our finding that the long-term effects of phonological specificity training appeared to be restricted to participants with relatively large L2 vocabulary sizes suggests that the duration of the phonological specificity training effect on L2 vocabulary learning either depends on the degree of semantic integration of newly acquired words or on underlying (L2) vocabulary learning skills. The long-term effects of phonological specificity training may possibly be extended to learners with smaller L2 vocabularies after more exposure.

Limitations

This study has limitations that should be acknowledged. First, the phonological specificity intervention was brief and was restricted to two exposures to each lexical item. Larger learning gains and more sustained learning may possibly be achieved after more extensive training. Second, this study focused on the effects of phonological specificity training on L2 word learning, and it is unclear whether this training also enhanced the phonological representations of the contrasts that participants had been trained on. Future studies could address this question either by using a phonemic awareness task or by measuring participants' realizations of the relevant phonological contrasts and by testing their ability to discriminate these contrasts, before and after training. Further, the absence of any effects of contrast type may have resulted from a confound between contrast type (consonant/vowel), degree of familiarity (completely unfamiliar/unfamiliar in word-final position), and contrast position (word medial/word final). Future studies should address this issue experimentally, by controlling for type and position of the contrasts concerned. Moreover, follow-up research should investigate the extent to which individual differences in L2 perception skills with respect to these contrasts influence the effectiveness of phonological specificity training for L2 vocabulary learning. Finally, this study did not control for participants' phonological working memory and their cognitive control ability, which have been shown to predict individual differences in L2 learning. Future research may test whether these measures can explain individual differences in the impact of phonological specificity training on word learning.

Conclusion

Although L2 vocabulary learning in schools focuses primarily on teaching word meaning rather than form (e.g., Schmitt, 2008), the current findings suggest that L2 vocabulary learning may benefit from form-based instruction. More specifically, a 15-minute word-learning intervention focusing on the phonological specificity of the target words enhanced L2 English word learning in pre-university L2 learners, and this effect occurred both immediately after the intervention and during the retention test (4 to 5 days after training). The intervention appeared to be particularly effective for acquiring L2 (English) words with nonnative sound contrasts, suggesting that L2 learners may benefit from exposure to minimal pairs that contain these contrasts (such as *paddle–pedal* for Dutch learners of English). Taken together, the current findings highlight the importance of phonological skills in L2 vocabulary learning.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1. Stimulus Materials for Phonological Specificity Training.
Appendix S2. Comparison of Pretest and Retention Test.
Appendix S3. Effect of Phonological Specificity Training on Retention Test.

Appendix: Accessible Summary (also publicly available at https://oasis-database.org)

Enhanced Second Language Vocabulary Learning by Training Unfamiliar Sound Contrasts

What This Research Was About and Why It Is Important

When introducing new words in a second language, teachers often prioritize word meanings and focus less on other aspects of word knowledge, such as how the words sound. However, knowledge about how to notice and perceive the sounds of words can help. In this study, researchers tested the effectiveness of vocabulary training that targeted the sounds of words as well as their meaning. The researchers found that this type of sound perception training was more effective than training without a sound perception component and training that focused on only one characteristic of word meaning.

What the Researchers Did

- The researchers tested 86 secondary school learners in the Netherlands, aged 11–13, all native speakers of Dutch.
- The participants were randomly assigned to one of three vocabulary training groups in which they heard unknown English words, such as *maze* or *dice*.

  - In the +perception training group (28 learners), the participants heard a new word and then had to choose from four pictures that depicted its meaning. The participants had to listen carefully because the words corresponding with one of the pictures differed in only one sound which was known to be difficult for learners who have Dutch as their first language (e.g., *s* versus *z* at the ends of words are confusable). For instance, they heard *mace* and had to choose between pictures of a maze and a mace and two other, unrelated pictures.
  - In the –perception training group (29 learners), the participants performed the same task, except that the words were not presented in close pairs based on one difference in sound. For example, the participants heard *maze* and had to choose between images of a maze and a (mountain) peak, in addition to two other, unrelated pictures.
  - In the control group (29 learners), the participants heard the same words but had to indicate whether the word referred to something “living” or “non-living.” For instance, after hearing *maze*, they would choose “non-living.” Thus, in both the control and –perception training, the participants’ attention was focused on meaning, not sounds.

- None of the groups wrote the words down during the training; they only heard the words.
- All groups received "correct/incorrect" feedback on their response, in addition to the spellings of the novel English words and their Dutch translations.
- To determine the effectiveness of training in the three groups, the researchers tested participants in a vocabulary posttest (immediately after training) and a retention test (4–5 days after training).
    - Participants had to translate written Dutch words into the new English words, in writing.

What the Researchers Found

- The +perception training group outperformed the control group on the posttest.
- The –perception training only helped learning for participants who already had larger English vocabularies to begin with (as assessed on tests before the study).
- Most importantly, the +perception group scored the highest on the posttest for confusable words—that is, words that differ by only one sound that does not occur in the participants' native language.

Things to Consider

- Vocabulary training that includes a focus on perceiving sounds that are difficult and that change the meaning of words might be beneficial. In essence, learners would find it useful to hear new words (instead of only reading them) and to attach meaning to the words.
- Vocabulary training helped learners write the new words, even though the training mainly focused on listening rather than writing.

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