Second language learners acquire reduced word forms just like they acquire full forms

From exposure

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We investigated the effect of auditory exposure on the recognition of full (*i.e.*, canonical) and reduced (*i.e.*, with weakened or deleted sounds) word forms by beginner second language (L2) learners. We taught three participant groups the same French schwa words. One group was trained only on the full (*i.e.*, with schwa) forms, one group on the reduced forms (*i.e.*, without schwa) only, and one group on both the full and reduced forms of each word. We then tested participants' recognition of both forms in an auditory lexical decision task. We found that participants' accuracy for a form was proportional to the exposure they received at training for that form. Both participants' groups trained on one form recognized the untrained form in about a third of the trials. We conclude that exposure is a crucial factor in learning L2 reduced forms and that listeners use both retrieval from storage and goodness of fit (including reconstruction) mechanisms, in the same way for full as for reduced forms.

Keywords: exposure, reduction, L2 acquisition, speech recognition, pronunciation variation

Introduction

In everyday speech, words are more often produced with fewer or incompletely realized segments than in formal speech (for a review, see Ernestus & Warner, 2011). For example, in casual English, a word like *ordinary* can be pronounced as [ɔnri] (Johnson, 2004). These incompletely realized word pronunciation variants are called reduced forms, in contrast to what are termed full (or citation) forms. Native (henceforth L1) speakers have no problem comprehending highly reduced forms in context, and can recognize mildly (*i.e.*, deviating from the full form in only one phoneme) reduced forms presented with only very limited to no context

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(Ernestus et al., 2002). Non-native language (L2) learners, in contrast, have great difficulties understanding reduced forms, even in context (e.g., Brown & Hilferty, 1986; Ernestus et al., 2017; Shockey & Bond, 2015). This raises the question of why this is the case and how L2 learners can be taught to recognize reduced forms. These questions are relevant for improving language courses and for the theory underlying language teaching as well as for theories of speech processing.

One obvious cause for why L2 listeners have difficulties recognizing reduced forms may be lack of *exposure* to these forms. Several studies on foreign language textbooks have shown that classroom teaching heavily relies on written language and does not integrate spoken language pronunciation variation (e.g., Askildson, 2008; Carter & McCarthy, 1995; Fonseca-Greber & Waugh, 2003). L2 learners thus seldom hear reduced forms. The hypothesis that learners' difficulties with reduced forms is due to lack of exposure is supported by Brand and Ernestus (2018), who tested French natives, and Dutch learners of French in a lexical decision task (LDT) on full and reduced forms of French 'schwa words' (e.g., [ʃəmɛ̃, ʃmɛ̃] *chemin* 'way'). The participants also subjectively rated the frequencies of occurrence of each form for each experimental word on a Likert scale as a proxy measure for how much exposure they had received to each form prior to the experiment. Both natives and advanced learners had reacted more quickly and more accurately to a form (both full and reduced) in the LDT, the more frequent they had judged it to occur in everyday life. Importantly, the advanced leaners' recognition results better correlated with their own than with the natives' frequency ratings. This strongly suggests that exposure is an important factor in comprehending reduced forms.

The precise role of exposure in the recognition of reduced forms for beginner learners has not been investigated systematically. Previous studies focused on explicit instruction (e.g., Ahmadian & Matour, 2014; Brown & Hilferty, 1986; Kennedy & Blanchett, 2014) and left the role of exposure alone unexplored. The question is therefore still open what the exact effect is of exposure on how L2 beginner learners comprehend mildly and regularly reduced spoken L2 word forms.

More specifically, it is still unclear whether recognition accuracy of a form is proportional to the amount of exposure received to that form and whether this holds to the same extent for reduced and full forms. If both forms are equally easy to learn and store, we would expect that L2 listeners who are equally often exposed to the full as the reduced forms of a word comprehend both forms equally well. Similarly, we would expect that at least the same amount of exposure is needed in L2 to learn new words in their reduced as in their full forms. In contrast, if more exposure is needed for learning reduced forms, full and reduced words are very likely processed differently in speech perception, possibly due to some L1-L2 perception problem.

The relation between exposure and recognition is linked to whether and how word forms are stored in the mental lexicon. Several researchers have argued that frequency effects as found by Brand & Ernestus (2018) indicate that listeners store reduced forms in their mental lexicons (Bürki & Frauenfelder, 2012; Ranbom & Connine, 2007; Seyfarth, 2014). The reasoning is that, if the forms' frequencies affect recognition, these frequencies must be stored, and if the frequencies are stored, the forms themselves are stored as well. Under this assumption, exposure to reduced forms would result in lexical storage of these forms, so that listeners can comprehend reduced forms by retrieving them from their mental lexicons. A low amount of exposure would lead to imprecise or weak mental lexical representations.

Little is known yet about how many encounters with a form are required for this form to be robustly stored in the mental lexicon and available for speech recognition. Episodic theories of human speech comprehension put forward that every token ('occurrence') a listener hears is stored in the mental lexicon and that the resulting 'cloud' is used for the match between auditory stimuli and mental word representations (e.g., Goldinger, 1996; Pierrehumbert, 2002). If learning can be based on a single token ('one shot learning'), we would expect that, if a listener is presented with an unknown form (e.g., reduced) a second time, this (reduced) form could be recognized more easily the second than the first time. In contrast, hearing a single token of a known word in a similar, yet new form (e.g., in a mildly reduced instead of a full form) could destabilize the learned old form in the L2 listener's mental lexicon and thereby negatively impact the recognition of the known form, for several reasons. The variation may introduce uncertainty resulting in a single lexical representation for the new word that is less precise and consequently less easy to activate. Alternatively, a new lexical representation may be created for the word, reflecting the new pronunciation variant, that competes with the representation of the old variant (e.g., Dumay et al., 2004; Gaskell & Dumay, 2003).

Next to the 'look-up'-mechanism of the reduced form in the mental lexicon, an alternative mechanism for recognizing reduced forms is via *reconstruction* of the corresponding stored full form (available in the listener's mental lexicon). Reconstruction is important as, contrary to the 'look-up mechanism', it generalizes to novel words: reconstruction processes allow listeners to recognize reduced forms that they have not yet encountered before but that display a common reduction process.

Reconstruction processes are assumed to be triggered by specific properties of the reduced forms. For example, reduced forms may contain phoneme clusters that are illegal in full forms (e.g., English 'cathedral' can be reduced to /kθiːdrəl/, while /kθ/ is not a legal onset in English full forms), and the illegality of consonant clusters may spark reconstruction processes. Evidence for reconstruction processes from the reduced to the full form has been found for Dutch (Ernestus, 2009), English (Pitt, 1998), and French (Spinelli & Gros-Balthazar, 2007) native listeners.

Reconstruction of the full form can also occur via the orthographic representation of words. Racine et al. (2014) found that native French readers respond equally fast to the full and the reduced forms of schwa words that in speech only occur in their reduced forms (e.g., /braslɛt/, 'bracelet') but are written in their full forms (e.g., *bracelet*), whereas pre-readers comprehend the forms that occur in speech the fastest. The readers thus appeared to have created mental representations of the full forms based solely on orthographic knowledge, and these full representations are applied as efficiently in speech comprehension as the representations for the reduced forms. Lexical representations based on orthography thus seem to be as robust as lexical representations based on acoustic input for speech comprehension, for native speakers at least (e.g., Rastle, et al., 2011; Ziegler & Ferrand, 1998).

Yet, little research has investigated, in the absence of orthographic representations, whether L2 learners can create L2 phonological rules that allow them to comprehend previously unheard reduced forms by reconstructing them to known forms, even though L2 learners' ability to create L2 phonological rules has been attested. For example, Chan and Leung (2014) exposed, without explicit instruction, Cantonese native speakers who never learnt Spanish before to verbs ending in *-ar* and accented on the last syllable or ending in *-o* and accented on the penultimate syllable. At test, participants were able to transfer the L2 word stress rule to untrained words in two pronunciation tasks.

The current study

Based on the literature review presented above, we formulated two main research questions, of which the first one can be split into two.

RQ1: Are L2 listeners' problems with recognizing reduced forms simply due to a lack of exposure to reduced forms[1]?

RQ1a: Is recognition accuracy of a form proportional to the amount of exposure received to that form and to the same extent for reduced and full forms?

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1. This question has been partly addressed in Morano et al. (2015). The present paper extends that conference proceeding by re-analyzing the data and comparing it to new data from 80 new participants.

RQ1b: What is the effect of hearing a first token of a previously unencountered form (e.g., *la pelouse* 'the lawn' pronounced [lapluz]) of a known word on the recognition of the second token of this form (e.g., [lapluz] again) and on the recognition of the previously encountered form (e.g., [lapəluz])?

RQ2: Can L2 learners use reconstruction processes to recognize reduced forms?

To answer our research questions, and to have full control over our participants' exposure to our test stimuli, we conducted a study in which we taught Dutch beginner learners of French so-called 'schwa words' (*i.e.*, words starting with a consonant followed by a schwa, thereafter Trained Schwas).[2] In French, such words, like *chemise* 'shirt', can be pronounced in full ([ʃəmiz]) or reduced without the schwa ([ʃmiz]).

Schwa alternation in spoken French has been extensively studied (see Racine, 2008, for a review). Bürki et al. (2011) collected from literature no less than 20 variables potentially influencing the presence versus absence of schwa in native speech. They tested 17 of these variables on a corpus of over 4000 schwa word tokens taken from French news broadcasts. They found five variables to be significantly predicting the presence versus absence of schwa: speech rate, schwa position in the word, word position in the utterance, number of consonants in the consonant sequence (Grammont, 1914), and respect of the sonority principle (stops < fricatives < nasals < liquids) in this sequence. French schwa deletion also varies per speaker (Hansen, 1994) and per region (Léon, 2005).

In context, reduced French schwa words are often resyllabified (Racine & Grosjean, 2000; e.g., with the preceding definite article, e.g., *la chemise* [la.ʃə.miz] can be pronounced [laʃ.miz] in its reduced form, with "." indicating syllable boundaries) to avoid an illegal onset cluster in the word-initial syllable. We presented the schwa words after a definite determiner ([lə] or [la], depending on the word's gender) so that the presence of schwa is optional and depends on how easy the resulting consonant sequence is to pronounce.

We have chosen Dutch learners since French schwa reduction is a mild regular reduction pattern that Dutch learners struggle to comprehend (Brand & Ernestus, 2018; Matter, 1986; Nouveau, 2012). While French schwa alternation is mostly considered to be a categorical phenomenon (e.g., Côté & Morisson, 2007; Racine & Grosjean, 2002) and almost speech register independent; in Dutch, as in English, schwa reduction is mostly a gradient phenomenon (Van Oostendorp, 2012), which almost only occurs in casual speech. Dutch listeners are thus familiar

2. In a pre-test in which 12 participants only did the LDT of this study without any training, the overall accuracy was 15% and 25% on the reduced and full forms respectively.

with schwa-deletion but not in the same way as French natives. Furthermore, both Dutch and French natives have been shown to reconstruct schwa forms in their respective native languages to avoid illegal clusters, thus making it possible for L2 Dutch listeners to transfer their L1 reconstruction processes (Ernestus, 2009; Spinelli & Gros-Balthazar, 2007).

We taught three participant groups the same schwa words. One group of participants was trained only on the reduced forms, while a second group was trained only on the full forms (resembling classroom instruction). These two groups probably assumed the form they learnt was the canonical form. The third group was trained on both the full and the reduced forms of each word (resembling the natural situation for L1 listeners). For this group, it will have been clear that the two forms represent possible pronunciations of the same word, and we expect this group to lexically store both forms.

The training used only pictures and audio recordings; the participants thus never saw the orthographic forms of the trained words. Immediately after training, we tested all participants with the same auditory lexical decision task on both the full and the reduced forms of the Trained Schwa words so that we could compare the results from the three groups.

In the lexical decision task, all test words were always repeated. We analysed participants reactions to the first tokens to address RQ1a and RQ1b and to the second tokens to address RQ1b. The first occurrence (henceforth denoted 'prime') and second (henceforth 'target') of a trained schwa word either matched in their pronunciation (*i.e.*, both occurrences were pronounced in full, or both occurrences were reduced), or mismatched in their pronunciation (*i.e.*, if the prime was reduced, the target was in full, and *vice versa*). In this way, we could compare trained and untrained targets that were preceded by either a matching or mismatching prime.

Methods

Participants

All participants in this study were Dutch natives who studied French in high school for maximally three years and were thus beginner L2 French learners. They were paid for their participation. None of them reported any hearing impairment.

We trained and tested three groups of 40 participants (*i.e.*, in total 120 participants). The Full Form Exposure group (FullExposed for short) was trained only on the words' full forms. The Reduced Form Exposure group (RedExposed for short) was trained only on the words' reduced forms. The Both Forms Exposure group (BothExposed for short) received the same amount of training for the full and reduced forms.

The participants were between 18 and 27 years old (*M*=21). Twelve were left-handed and 25 were male. Prior to the experiment, the participants rated their skills in French on a zero (very bad) to five (very good) point scale. They rated themselves on average at 1.5 for reading, 1.1 for listening, 0.7 for writing, and 0.8 for speaking. The Mann Whitney statistical test did not show statistically significant differences between the groups. At the end of the experiment, the participants performed the French LexTALE vocabulary test (Brysbaert, 2013), consisting of 120 trials (60 words and 60 non-words), and obtained similar Ghent scores (N selected words – 2 * N non-words selected): −2 for the BothExposed, −1 for the FullExposed and −2 for the FullExposed group.

Materials

Training materials

During the training phase, the participants learned 24 real, depictable, bisyllabic words with schwa in their initial syllables (e.g., *semoule* 'semolina', /səmul/; see Appendix 1 for all the word types used in this study). These words are not typically taught at beginner level and thus unlikely to have been encountered by our participants. The words started with one consonant and were considered by native speakers as equally acceptable in their reduced (e.g., /smul/) and full (e.g., /səmul/) form (Racine, 2008). Absence of schwa in the Trained Schwas did not lead to voicing assimilation in the resulting consonant sequence (e.g., words such as cheval /ʃəval/, which is reduced to /ʃfal/, were not selected). The proportion of words starting with legal clusters in their reduced forms (3 out of 24 Trained Schwas; 12.5%) was similar to the proportion found by Spinelli and Gros-Balthazar (2007) in the Brulex database (Content et al., 1990) of similarly constructed words (14.2%). Eleven of the 24 Trained schwas respected the sonority principle as operationalised by Bürki et al. (2011).

To better hide the aim of the experiment, we also included 24 real, depictable words without schwa (Trained Fillers) in the training. These Trained Fillers consisted of twelve monosyllabic and twelve bisyllabic words (e.g., *neige* /nɛʒ/ 'snow'; see Appendix 1). They were chosen from two beginners' textbooks frequently used in the Netherlands (*Franconville* and *Grandes Lignes*).

We selected 48 pictures to uniquely represent the Trained Schwas and the Trained Fillers from three free-of-rights picture databases.

Testing materials

In the lexical decision experiment, the 24 Trained Schwas and 24 Trained Fillers were intermixed with 24 real words without schwa (Non-Trained Fillers) and 24 real words with schwa (Non-Trained Schwa words), as well as 96 phonotactically legal pseudowords. In this way, the test stimuli consisted of as many schwa words as non-schwa words and as many real words as pseudowords.

We ensured that the Non-Trained Schwas and Fillers were likely to be known by our participants by choosing all Fillers and 13 schwa words from the beginners' textbooks previously mentioned and eleven schwa cognates from Dutch or English (e.g., *menu* 'menu', pronounced in both French and Dutch /məny/). We created the pseudowords on the basis of the 96 real words. We reused the first syllable (or consonant, or consonant cluster for monosyllabic words) of each word to which we concatenated a syllable or sound sequence that is legal in French, that is not a word in itself, and that matches as much as possible the Consonant-Vowel (CV) structure of the second syllable of the real word. For instance, *remarque* (/rəmark/) and *ville* (/vil/) formed the basis for *recombre* (/rəkõbr/) and vade (/vad/), respectively.[3] Finally, we selected six more non-schwa real words and created six pseudowords for practice trials.

Recordings and speakers

A female Dutch native speaker produced the Dutch translations of the 48 words used during training. A male French native speaker from Paris (speaker Fr1) recorded all 204 French word types preceded by a definite determiner (*le* or *la*). He first produced them in a careful speech style (by enunciating clearly) and then in a casual speech style (by reducing pronunciation effort, and, for the schwa words and pseudowords, by not pronouncing the schwa). A female French native speaker (speaker Fr2) recorded the words used during the training as well. She listened to the recordings from speaker Fr1 and repeated each stimulus after him. We selected the two best tokens for each speech style from speaker Fr1, and the best four from speaker Fr2.

The stimuli were recorded in a sound attenuated booth at a 44.1kHz sampling rate and 16-bit resolution on a mono channel. The stimuli were manually segmented just before the definite article until the end of the word and normalized for loudness (average: 68dB) with Praat (Boersma & Weenink, 2001). Figure 1 illustrates the stimuli with two tokens of *pelouse* 'lawn'.

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3. The gender of a pseudoword, which conditions the choice of the definite determiner, was chosen to be the same as the real words which end in the same syllable as the pseudoword.

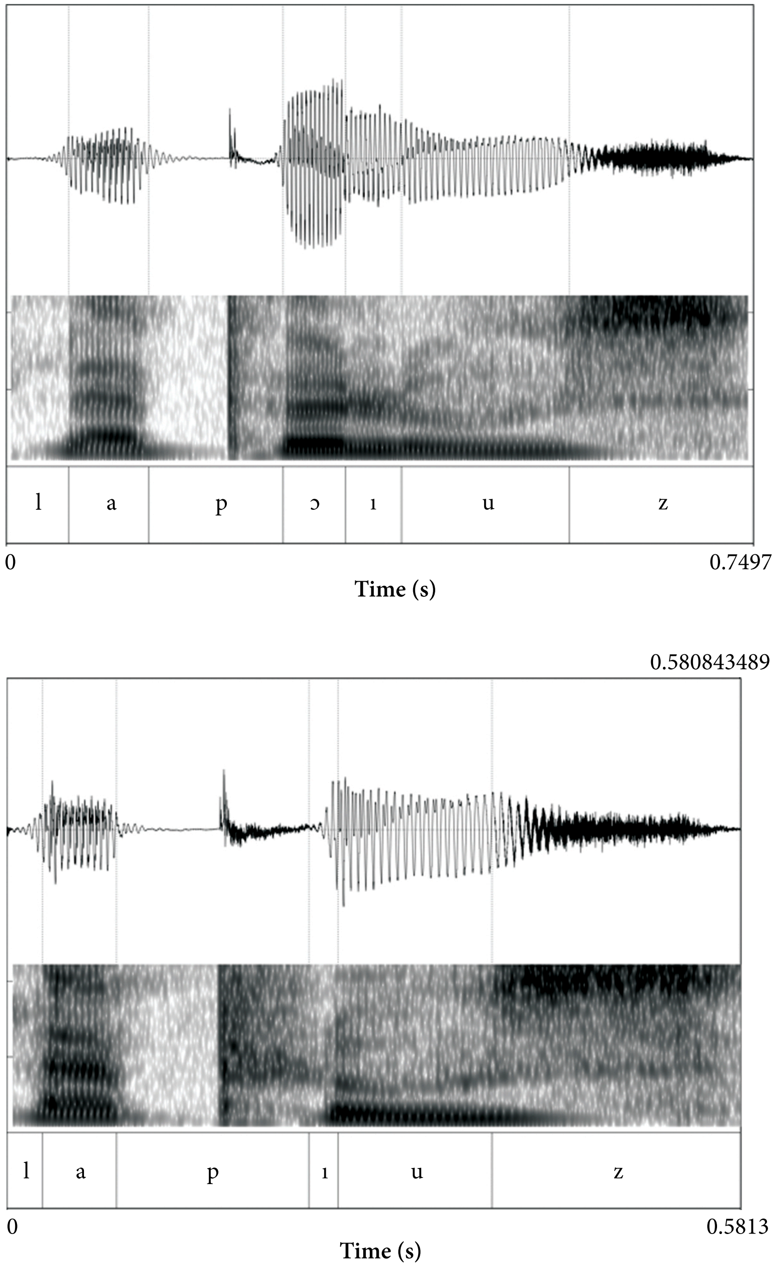

Figure 1. Two tokens of word type *la pelouse*, one full (top) and one reduced (bottom)

As can be seen in Table 1, all word tokens recorded in casual speech style were shorter than the corresponding tokens recorded in careful speech style, for both speakers and for all word types (on average 121 ms shorter for schwa words, 126 ms shorter for non-schwa words). As the average schwa had a duration of 87 ms, the word averages show that the duration difference between the full and reduced forms of the schwa words is not only due to the presence versus absence of schwa; the other segments were also shortened in the reduced tokens.

Table 1. Average durations (in milliseconds) of the entire schwa words and of the schwa within the words, split per French native speaker, per stimulus type, and per speech style. Standard deviation is indicated between parentheses

		Trained Schwas		Non-Trained Schwas	
Speaker		**Reduced**	**Full form**	**Reduced**	**Full form**
Fr2 – Training	whole stimulus	597 (72)	732 (94)	n.a.	n.a.
	schwa	0 (0)	86 (20)	n.a.	n.a.
Fr1 – Test	whole stimulus	579 (74)	723 (102)	568 (86)	665 (99)
	schwa	1* (6)	88 (22)	0 (0)	80 (16)

* No tokens of reduced forms had traces of schwa except for *revers* ‘back hand’, with 40 and 35 ms long schwas.

Test trials

For the lexical decision task, we created five stimulus lists. Each list contained all of the 192 word types (48 trained words, 48 fillers, and 96 pseudowords), 72 of which were repeated (including all 24 Trained Schwas), leading to 264 trials in one list. Half of the stimuli were words and half were pseudowords, and approximately half of the stimuli were reduced and half were in full. The Trained Schwas were repeated either as a variant match (*i.e.*, prime and target were either both reduced or both full) or as a variant mismatch (*i.e.*, when the prime was reduced, the target was full, and *vice versa*). We pseudo-randomized the trials respecting the following constraints: (1) the very first stimulus and the first stimulus after the break in the middle of the task were not Trained Schwas; (2) two Trained Schwas did not occur in a row; (3) the second occurrence (*i.e.*, the target) of a given Trained Schwa could not be separated from the first occurrence (*i.e.*, the prime) by more than 100 trials (average lag: 60, range: 21–99); and (4) no more than eight real words or pseudowords occurred in a row.

From each list, we created a set of four sub-lists so that all 24 Trained Schwas were repeated in each of the four possible combinations of full/reduced prime and full/reduced target equally often in the resulting (5*4=) 20 stimulus lists. Each list was assigned to two participants.

To familiarize the participants with the task, we created 16 practice trials consisting of the twelve practice items, four of which were repeated. All participants heard all the practice trials in the same order, prior to the actual test.

Procedure

The 120 participants were trained and tested individually in a sound attenuated booth. The stimuli were always presented over headphones at a comfortable listening volume. The training and the testing procedures were conducted in PsychoPy (Peirce, 2007).

Participants were first introduced to the meanings of the 48 pictures: they saw each picture once while hearing the corresponding Dutch word. Then the learning phase started. The participants saw the 48 pictures one by one again and heard, for each picture, four tokens of the corresponding French word in a sequence (speaker Fr2): four full tokens for the Fullexposed group, four reduced tokens for the RedExposed group, and two reduced and two full tokens in random order for the BothExposed group. The participants were instructed to learn the picture-word associations.

Afterwards, the participants had six rounds of training in which, upon hearing a French word, they had to click on the corresponding picture on the screen. In every round, the 48 words were played once, in random order. The number of pictures per trial displayed on the screen increased at each practice round, from four to six, and was then maintained at six pictures. If the participant clicked on the correct picture, a green check mark briefly appeared on the picture and the next trial begun; otherwise, a red cross appeared and the participant could click on another picture. After each practice round, the participant's accuracy was displayed on the screen. By the end of the training, each training group had heard every training word exactly 10 times.

Immediately after training, the participants were tested with the auditory lexical decision task. They were instructed to press the 'yes' button of a button box with their dominant hand if the word they heard was a real word in French and to press the 'no' button with their other hand if they thought it was not or if they had any doubt. The next stimulus started 1s after the participant's response or, in case of time out, 3.5s after stimulus onset. After the 16 practice trials, the experiment leader checked if the participant understood the instructions and that the volume was at comfortable level. There was a two-minute pause after the first half of the stimuli. To discourage guessing and to reward participants' learning efforts, accuracy feedback (in percentages of correct answers) was displayed after the practice trials, before the break, and at the end of the task. After the auditory lexical decision task, the participants performed the French LexTALE vocabulary test (Brysbaert, 2013).

Results

Real and pseudo words accuracies

In the lexical decision task, the FullExposed group showed an overall accuracy of 76.43% ($SD = 5.72$), the RedExposed group of 75.42% ($SD = 4.24$), and the BothExposed group of 77.28% ($SD = 6.17$). The participants' average accuracies by stimulus type are presented in Table 2. All groups obtained high accuracy scores in correctly rejecting pseudowords and accepting Non-Trained Fillers, which shows that participants took the task seriously. More importantly, all the participants' recognition of the Trained Fillers was at ceiling, indicating that all groups were able to apply the knowledge they acquired during training for recognizing the test items.

The three groups did not statistically significantly differ in their accuracies to the pseudowords nor any of the real word filler categories as was shown by generalized mixed effect models (see Appendix 2 Tables 1 to 3). However, the RedExposed group was significantly more accurate on the full Non-Trained Schwa Fillers and significantly less accurate on the reduced Non-Trained Schwa Fillers than the two other groups (see Appendix 2 Table 4). Possibly, the new reduced forms the group were trained on may have formed competitors for the reduced Non-Trained Schwa Fillers, which made these reduced Non-Trained Schwa Fillers more difficult to recognize. This latter explanation is in line with findings by Gaskell and Dumay (2003) who showed that newly acquired words may serve as competitors for words the participants knew before.

Statistical analysis of the Trained Schwas

The participants' accuracy on the reduced form of the Trained Schwa *peluche* 'teddy bear' was at ceiling for all groups (100%, 100%, and 95% accuracy for the FullExposed, the RedExposed, and the BothExposed groups, respectively), probably because the item's reduced form is also a real word in Dutch (*pluche* /plyʃ/ 'plush'). Since our participants had already been exposed to the reduced form of *peluche*, albeit in Dutch, the item *peluche* was discarded (160 datapoints, 4% of all Trained Schwas trials) from all analyses. Furthermore, 19 out of the remaining 6992 Trained Schwa trials (0.27%) were discarded since they were time outs.

Table 2. Average accuracy scores, in percentage correct answers, for the different types of stimuli for each group. Confidence intervals are indicated between parentheses (estimated by prop.test in R)

Group	BothExposed	FullExposed	RedExposed	Average
Stimulus category				
Pseudo-words	81.32 (80.23–82.36)	82.78 (81.73–83.79)	82.73 (81.68–83.74)	82.28 (81.67–82.87)
Non-Trained Fillers	84.02 (81.79–86.02)	86.04 (83.91–87.93)	82.86 (80.58–84.93)	84.31 (83.06–85.47)
Trained Fillers	96.58 (95.35–97.51)	97.25 (96.11–98.07)	96.83 (95.63–97.72)	96.89 (96.25–97.42)
Non-Trained Schwa Fillers reduced	31.66 (27.54–36.07)	32.29 (28.14–36.72)	23.22 (19.56–27.32)	30.37 (28.26–32.55)
Non-Trained Schwa Fillers full	54.60 (50.02–59.11)	50.52 (45.95–55.09)	64.09 (59.59–68.36)	56.52 (54.20–58.80)
Trained Schwas	67.52 (65.36–69.61)	57.18 (54.93–59.41)	53.89 (51.63–56.14)	65.57 (64.47–66.66)

To address RQ1b, we planned to analyse both the accuracy and the reaction times of the second occurrences of the Trained Schwas. Unfortunately, the participants made too many mistakes on the second occurrences (42% average error rate for the three groups) to analyse the reaction times of the correctly answered matching and mismatching targets following a correctly answered prime: There were only 99 data points left on average per condition ($SD=35$). Including the incorrect trials was not an option since these trials were answered with a different hand than the correct trials. Moreover, additional cognitive processes may occur when participants make errors, producing additional noise in the analyses. We therefore only analysed accuracy scores.

We analysed all the accuracy data from this study using the software R (R Development Core Team, 2007) and generalized linear mixed effects models with the binomial link function and the BOBYQA optimizer (Powell, 2009). We included participant and word type as random predictors. The *p*-values reported for all our models were computed based on Satterthwaite's approximations with the R package lmerTest (Kuznetsova et al., 2017). The coefficients of R squared marginal (R2m) and R squared conditional (R2c) were estimated using the piecewiseSEM package.

Our predictors of interest were Experimental Group (with levels FullExposed, RedExposed, BothExposed), and either Reduction of the stimulus (full or reduced form) when looking at all three groups together, or Training (trained form or not) when looking at the RedExposed and FullExposed groups only. Our control predictors were Trial number to account for fatigue or habituation effects and, for the analyses on the Trained Schwas' second occurrences, Distance between prime and target (in number of trials, thus ranging between 21 and 99). Note that Trial number and Distance were independent from each other. In the statistical analyses, both control variables were divided by 100 to resolve convergence issues (this scaling does not affect the modeling).

To reach the models reported in this paper, we first started fitting models including all our predictors of interest and control predictors. Interactions were then tested for all our predictors of interest. We then built new models by removing one by one predictors or interactions of predictors that were not statistically significant. The resulting models were compared using the Akaike Information Coefficient (AIC). A predictor was retained in the model if including it in the model lowered the AIC of the model by at least two points and if an analysis of variance performed between the models with and without the predictor was significant. Non-significant predictors were excluded from the models unless they appeared in significant interactions. Finally, random slopes on our random effects were tested individually for all fixed effects and their interactions. A random slope was retained in the model if including it lowered the AIC by minimally two points.

First occurrences

To investigate whether recognition accuracy of the full and the reduced forms is to the same extent proportional to the exposure received (RQ1a), we looked at the participants' accuracy to the *first* occurrences of the Trained Schwas (Trained Schwa primes) in the lexical decision task (2748 trials; see Appendix 2 Table 5). Figure 2 shows that the participants trained on one type of pronunciation variant only (*i.e.*, FullExposed and RedExposed groups) were much more accurate in the lexical decision task on that type than on the other type. The participants trained on both types (BothExposed Group) obtained similar accuracy scores on the full and the reduced forms, though they were slightly more accurate on the full than on the reduced forms (70.61% and 64.11%, respectively). To verify the statistical significance of these results, we ran a statistical analysis of the Trained Schwa primes for all three groups. The final lmer model is presented in Appendix 2 Table 5.

Our first finding is that the BothExposed Group did not recognize the full forms statistically more often than the reduced forms, as shown by the absence of a significant main effect of Reduction when the BothExposed group is on

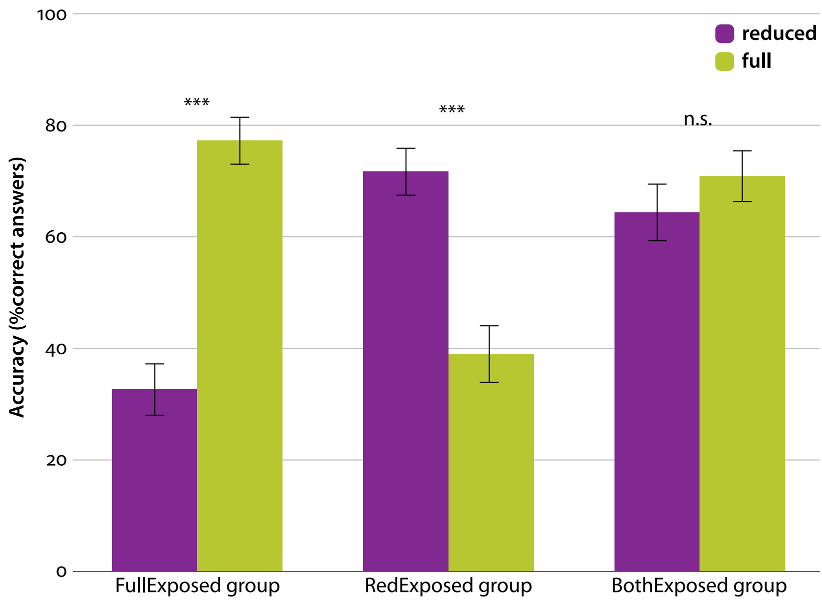

Figure 2. Accuracies in percentage of correct answers to the first occurrences of the full *vs.* the reduced Trained Schwas per experimental group. Error bars are 95% confidence intervals

the intercept ($\beta = 0.34$, $S.E. = 0.21$, $z = 1.61$, $p = .11$).[4] The 6.50% accuracy difference found between the full and the reduced forms for the BothExposed group, mentioned in the previous paragraph and visible in Figure 2, is thus not statistically significant, indicating that equal exposure led to similar recognition of both forms.

We then looked at whether the BothExposed group was less accurate than the RedExposed and FullExposed groups on the forms these groups were trained on, which could be the case because the BothExposed group had received half as much exposure to each form. For reduced forms, we found a statistically significant simple main effect of Group between the FullExposed and the BothExposed groups ($\beta = -1.81$, $S.E. = 0.27$, $z = -6.73$, $p < .001$) and between the FullExposed and the RedExposed groups ($\beta = 2.24$, $S.E. = 0.27$, $z = 8.20$, $p < .001$), shown after releveling to have the FullExposed group on the intercept), but not between the

4. In Morano et al. (2015), we reported a statistically significant difference in accuracy for the BothExposed group between the full and the reduced forms. In that statistical analysis, only testing the BothExposed group, Reduction was not statistically significant as random slope on Item and was thus not retained in the final model, which left the simple fixed effect of Reduction statistically significant.

RedExposed and the BothExposed groups ($\beta = 0.43$, $S.E. = 0.27$, $z = 1.60$, $p = .11$). The RedExposed and the bothExposed groups appeared equally accurate on the reduced forms, while the FullExposed group was less accurate than the other two groups. Conversely, when the full forms were on the intercept (via releveling), the simple main effect of Group was significant between the BothExposed group and the RedExposed group ($\beta = -1.71.$, $S.E. = 0.27$, $z = -6.41$, $p < 0.001$), but not between the BothExposed group and the FullExposed group ($\beta = 0.37$, $S.E. = 0.27$, $z = 1.36$, $p > .1$). The BothExposed group appeared just as accurate as the FullExposed group in comprehending the full Trained Schwas, while the RedExposed group was significantly less accurate. Finally, we found a significant random slope of Reduction on Item indicating that the effect of Reduction varied per Trained Schwa (note that this effect depended on which group was on the intercept but that the model with the interaction of Reduction and Group as random slope on Item failed to converge).

To answer RQ2 (Can L2 learners use reconstruction processes to recognize reduced forms?), we looked at the participants' accuracy to the untrained primes. As can be seen in Figure 2, the RedExposed group was slightly more accurate on the form they had not been trained on (39.12% accuracy on the full Trained Schwas) than the FullExposed group (32.31% accuracy on the reduced Trained Schwas), which would indicate that they were better able to reconstruct the untrained forms. To verify whether this accuracy difference was statistically significant, we analysed the Trained Schwas' first occurrences for the RedExposed and FullExposed groups only (1833 trials; see Appendix 2 Table 6) and we recoded the variable Reduction into the variable Training, indicating whether the Trained Schwa was heard in a form the participants had been trained on or not. We found a significant interaction of Training and Experimental Group: the difference in accuracy between the trained and untrained forms was significantly larger for the FullExposed group than for the RedExposed group (44.57% *v s.* 32.76%, see Figure 2). We did not find a simple main effect of Experimental Group, independently from whether the trained forms ($\beta = 0.35$, $S.E. = 0.36$, $z = 0.98$, $p > .1$) or the untrained forms ($\beta = 0.47$, $S.E. = 0.31$, $z = 1.52$, $p > .1$) were on the intercept. It thus seems that the FullExposed group was slightly, though not significantly, better at recognizing the trained forms than the RedExposed group, while the RedExposed group was slightly, though not significantly, better at recognizing the untrained forms than the FullExposed group. The combination of these two differences led to the significant difference between the trained and untrained items being larger for the FullExposed Group than for the RedExposedGroup. The interaction of Training and Experimental Group was also significant as a random slope on Word type, indicating that the effect of the interaction was more relevant for some words than for others.

Second occurrences

To assess the effect of the first token of the untrained form (e.g., *la pelouse* 'the lawn' [lapluz] as prime for the FullExposed group) on the recognition of the following token of this untrained form (e.g., [lapluz] again at target) as well as the recognition of the trained form of the same word (e.g., [lapəluz] at target; RQ1b), we analysed the participants' accuracy to the *second* occurrences of the Trained Schwas. The results are summarized in Figure 3). In the absence of any significant simple effect or interaction of Experimental Group, the RedExposed and FullExposed groups data were collapsed in Figure 3. Our first predictor of interest was 'Training' (*i.e.*, whether the target was heard in a form the participants had been trained on or not). Because all the tokens heard at test by the BothExposed group were of the type 'trained', this group could not be included in the analyses since it had only one level for the predictor Training. The BothExposed group accuracies on the targets are nevertheless presented in Figure 3 for completeness' sake. Our second predictor of interest 'Experimental Group' thus had two levels: the FullExposed and the RedExposed groups (1836 trials). Our third predictor of interest was 'Repetition Match' and indicated whether the target occurred in the same form as the prime (matching target) or not (mismatching target). Note that for an untrained target, a mismatch implied that this target was the first occurrence of the item the participants heard in the untrained form, while a match implied that it was the second occurrence of the same untrained form. Finally, since we wanted to distinguish between the cases in which the participants were already able to recognize the untrained form at prime from the cases where they could not, we also included the predictor of interest 'Accuracy on the prime'. The final statistical analysis is presented in Appendix 2 Table 7.

Our control predictors were Trial number and Distance between the prime and target and they were both significant with negative betas, indicating that the participants showed some fatigue effects (*i.e.*, participants' accuracy for the targets significantly decreased as the experiment unfolded), and participants made fewer errors the closer the target was to the prime in number of intervening trials. This latter effect shows that participants showed priming effects in the experiment. In the absence of any significant simple effect or interaction of Experimental Group, the RedExposed and FullExposed groups data were collapsed in Figure 3.

We found significant simple effects of the predictors Accuracy on the prime ($\beta = -0.79$, $S.E. = 0.19$, $z = -4.07$, $p < .001$), Training ($\beta = 2.05$, $S.E. = 0.19$, $z = 11.02$, $p < .001$), and Repetition Match ($\beta = 1.66$, $S.E. = 0.21$, $z = 7.86$, $p < .001$). The simple effects are modulated by two interactions: Repetition Match showed significant interactions with both Accuracy on the prime ($\beta = -1.89$, $S.E. = 0.27$, $z = -6.93$, $p < .001$) and with Training ($\beta = -1.24$, $S.E. = 0.27$, $z = -4.61$, $p < .001$). Both inter-

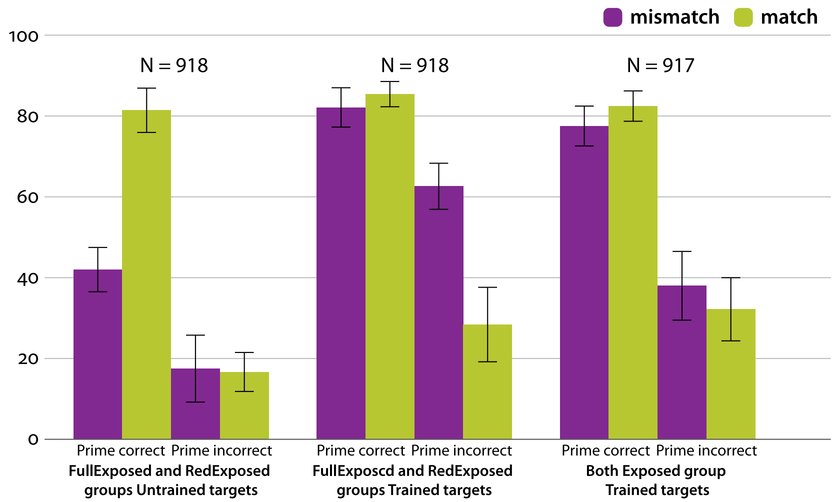

Figure 3. Accuracies to the Trained Schwas targets, in percentage of correct answers, split by Repetition match (target matching or mismatching the pronunciation of the prime) and by whether the prime had been answered to correctly or not. The four bars on the left show accuracies on the forms the FullExposed and RedExposed participants had not been trained on. The middle four bars show the accuracies on the forms these participants had been trained on. The right four bars show the accuracies for the BothExposed group. Error bars are 95% confidence intervals. We collapsed the data from the RedExposed and FullExposed groups because the statistical analyses showed no significant differences

actions have betas of similar magnitude but of opposite sign to the simple effect of Repetition match. Consequently, the simple effect of Repetition Match only holds for the case on the intercept: participants were only more accurate on targets matching the pronunciation of the primes when the primes were answered correctly (*i.e.*, accepted) and the target was in the untrained form.

In contrast, when the targets were trained and preceded by rejected primes, the simple effect of Repetition Match and its interactions with Accuracy on the Prime and Training show that Repetition match is significant with a negative beta (as shown when the trained targets preceded by rejected primes are on the intercept; Repetition Match: $\beta = -1.46$, $S.E. = 0.23$, $z = -6.45$, $p < 0.001$). In these trials, participants were less accurate in case of a match (28.18%) than in case of a mismatch (62.41%). When participants did not recognize the prime in the trained form (rejected prime, match), it is highly probable that they did not remember the item in the trained form and were consequently again unable to recognize the target word in the same form, while when the participants did not recognize the prime in the untrained form (rejected prime, mismatch), it is still possible that they knew the item in its trained form and recognized it at target.

In the two remaining cases, that is when an untrained target was preceded by a rejected prime or when a trained target was preceded by an accepted prime, the combination of the simple effect of Repetition Match with either of the interactions suggests that there was no significant effect of Repetition. This is also shown when putting on the intercept the untrained targets with rejected primes (Repetition Match: $\beta = 0.23$, $S.E. = 0.24$, $z = 0.96$, $p = .34$; compare the third and fourth bars of the left graph of Figure 3) or the trained targets with accepted primes (Repetition Match: $\beta = -0.42$, $S.E. = 0.23$, $z = -1.82$, $p > .05$).

General discussion

We investigated the effect of exposure on the recognition of mildly reduced word forms by beginner L2 learners. We trained three groups of Dutch learners of French on either both the full and the reduced forms (BothExposed group) of French schwa words (Trained Schwas) new to all the participants or on one form only (FullExposed and RedExposed groups). We then tested the participants using an auditory lexical decision task in which the Trained Schwas were repeated either twice in the same form (*i.e.*, the primes and targets were either both reduced or full), or in a different form (*i.e.*, reduced prime and full target, or the reverse).

To assess whether recognition accuracy of a form is proportional to the exposure received to that form and to the same extent for reduced and full forms (RQ1a), we analysed participants' accuracy to the Trained Schwa primes. Our first main finding was that the BothExposed group was not significantly more accurate on the full than on the reduced forms. Contrary to the more advanced learners in Brand & Ernestus (2018), Matter (1986), and Nouveau (2012), the beginner learners of our study thus did not have more problems recognizing the reduced than the full forms. This result suggests that L2 learners' problems with reduced forms is mostly due to a lack of exposure to these forms in the classroom environment. We also did not find that the FullExposed group significantly outperformed the RedExposed group on the trained forms, nor significantly underperformed compared to the RedExposed group on the untrained forms, which strongly suggest that exposure determines how easily a learner comprehends a form.

We thus did not find evidence for an advantage of the full over the reduced forms contrary to what has been reported in previous literature, as evidenced by faster and/or more accurate recognition of the full form than the reduced one(s) by both native listeners (e.g., Pitt, 2009; Racine & Grosjean, 2000; Ranbom & Connine, 2007) and non-native listeners (e.g., Brand & Ernestus, 2018; Matter, 1986; Nouveau, 2012). Our results are, however, in line with more recent work indicating that once the frequencies of occurrences of both the full and the reduced forms have been taken into account, the two forms are recognized equally fast by native (Bürki et al., 2018) and non-native listeners (Brand & Ernestus, 2018).

One possible reason for these diverging findings is the role of orthography. While previous studies tested learners who knew the words' spellings, this was not the case in the present study. As previously mentioned, mental representations based on orthography can be used for speech comprehension (e.g., Rastle et al., 2011; Ziegler & Ferrand, 1998). Because orthography generally matches the full form, exposure to the orthographic form is in fact additional exposure to the full form. In previous studies (e.g., Brand & Ernestus, 2018; Matter, 1986; Nouveau, 2012), learners thus probably had more exposure to full forms (through orthography) than to reduced forms. In the absence of orthographic input, as for pre-readers (Racine et al., 2014) and for the beginner L2 learners in our study, auditory exposure is the only type of input that the listener received. Our study shows that in this condition, training on only the reduced form results in reduced forms being recognized more accurately than the full forms. Future studies could evaluate how much exposure to the reduced forms is necessary to reach equal recognition accuracy for reduced and full forms when learners also have access to the word's spelling.

To assess the impact of exposure to a single token of the trained and untrained forms (RQ1b), we analysed the FullExposed and RedExposed participants' accuracy to the target Trained Schwas. Concerning the untrained targets, we found that participants were consistent in accepting targets in the untrained form when they had accepted the same forms at prime, while, when the participants had rejected the untrained forms at prime, hearing an additional untrained token did not help the participants accept the untrained items as a word. This absence of a beneficial effect from hearing one extra untrained token does not align well with theories of speech perception which assume that every heard token is stored and used for speech perception (e.g., Goldinger, 1996; Pitt et al., 2011; Ranbom & Connine, 2007). Our results could nevertheless be reconciled with exemplar theory if we consider that the nature of the task could also have prevented lexical storage. Since participants hear words and non-words during a lexical decision task, we speculate that they may not have deemed unknown words worth to be stored as they categorized them as non-words. It could also be that a night of sleep is necessary for the word form to become lexicalized (Dumay et al., 2004).

Concerning the trained targets, we found that, when participants accepted the primes, they also recognized the trained targets, independently of whether the prime word was in the trained or untrained form. The accepted untrained prime thus primed the trained form just as well as the accepted trained prime. We also found that when the prime was not recognized, either in the trained or the untrained form, the trained target was also poorly recognized. It may be surprising that the recognition of the untrained prime predicts the recognition of the trained target. It could be that hearing the item in the untrained form at prime destabilized the participants at target, or that participants were better able to comprehend the untrained form (at prime) when they remembered well the trained form (as indicated by the accuracy at target). Both explanations point to a weak encoding of the trained form in the first place despite the participants' average accuracy of 72% on the trained primes.

Concerning our second research question (RQ2): 'Can L2 learners use reconstruction processes in order to recognize reduced forms?', we found mixed evidence. On the one hand, the RedExposed group was not significantly more accurate on the untrained forms than the FullExposed group. Our beginner L2 learners in the RedExposed group were thus not able to make use of illegal onset clusters to help them in the recognition of full words to the same extent as the native listeners tested by Ernestus (2009) and Spinelli and Gros-Balthazar (2007). On the other hand, we also found a significantly larger accuracy difference between the trained and untrained forms for the FullExposed than for the RedExposed group.

While the recognition of the untrained forms by the RedExposed group can be explained by reconstruction processes, the FullExposed group is unlikely to have recognized the reduced forms by means of schwa deletion, given beginner L2 learners' problems with recognizing reduced forms while they can recognize the corresponding full forms (e.g., Brown & Hilferty 1986; Ernestus et al., 2017). More plausibly, the RedExposed and FullExposed groups may have perceived the non-trained forms simply as free variation rather than the product of a regular alternation. Contrary to the BothExposed group, they were not taught that each target word has two frequently occurring pronunciation variants, neither by being presented with the other form or by seeing its orthographic transcription.

Since the FullExposed and the ReducedExposed groups may not have been aware of the systematicity in the variation, they may have been using a goodness of fit mechanism to recognize the untrained form. The goodness of fit mechanism holds that a form can be recognized given a sufficiently close similarity with a stored form, similar to the interlanguage comprehension process (or receptive multilingualism) of speakers of closely related languages (e.g., Blees et al., 2014). Future research could test to which extent L2 listeners apply a goodness of fit mechanism by replacing the untrained form with stimuli that vary in a non-systematic way from the trained forms.

While previous literature has reported positive effects of explicit instruction on the comprehension of reduced forms (e.g., Ahmadian & Matour, 2014; Brown & Hilferty, 1986; Kennedy & Blanchett, 2014), to the best of our knowledge, our study is the first one that reports a significant positive effect of implicit instruction (*i.e.* exposure only). Note however, that although we did not make use of explicit instruction, our participants could focus all their attention on learning new words and their pronunciation in line with the principles of the Focus on Form approach (Long & Robinson, 1998).

Furthermore, recognition of a form (assessed in our study with a lexical decision task) does not necessarily equal word comprehension in context. Further studies should replicate our findings using exposure in context, for example using online comprehension exercises. It could be that L2 listeners are too focused on meaning when listening to speech in context to pay attention to the form and consequently, more exposure, or even explicit instruction in order to focus L2 listeners' attention to the form, could be necessary. Nevertheless, our finding that exposure to only five tokens largely improves recognition of difficult reduced forms for L2 listeners is particularly promising for online teaching implementations.

In sum, we found that beginner learners' exposure to a relatively limited number of tokens (five) is sufficient to learn mildly and regularly reduced word forms, and L2 learners' problems with these forms can easily be addressed by including repetition of reduced forms in (online) teaching materials (RQ1). We did not find clear evidence for a special status of the full (*i.e.*, canonical) form in comparison with the reduced from (RQ1a), probably because of a lack of influence of orthography in our study. We also found that beginner L2 listeners were able to recognize the untrained form (full or reduced) using a goodness of fit mechanism rather than by applying a deletion or insertion rule (RQ2). Finally, hearing an additional single token during a lexical decision task (RQ1b) was not beneficial for the recognition of the trained nor the untrained form indicating that our participants were not able to store a token of the untrained form in their mental lexicon when performing a lexical decision task. Exposure is crucial in recognizing reduced forms in L2 as it seems that in order to recognize a word form in L2, listeners use both retrieval from storage and goodness of fit (including reconstruction) mechanisms, in the same way for reduced as for full forms.

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Data availability

The materials and processed data that support the findings of this study are openly available on the Radboud Repository at https://doi.org/10.34973/565g-y832

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Appendix 1

Stimuli (words and correspondingly derived pseudowords) presented in the experiment

Trained Schwas (TS)	Transltation	Pseudowords	Non-Trained Schwa (NTS)	Translation	Pseudowords
la cerise	the cherry	la sequette	*la chemise*	the shirt	la chenette
le chemin	the way	le chelon	*le demain*	the tomorrow	le degnon
le chenil	the kennel	la chelure	*la demande*	the request	la devaine
le devis	the price estimate	le deneau	*le devoir*	the homework	la denaille
la gelée	the jelly	le genain	*la fenêtre*	the window	le feriple
le levier	the lever	la lecière	*le genou*	the knee	le gemier
la levure	the yeast	la lerette	*la leçon*	the lesson	le leveux
la menotte	the hancuf	la merelle	*le melon*	the melon	le meret
la mesure	the measure	la merole	*le menu*	the menu	le merot
la pelote	the wollenball	la petaine	*le monsieur*	the sir	le meniant
la pelouse	the grass	la petèque	*la recette*	the recipe	la recousse
la peluche	the teddy bear	la petode	*le record*	the record	la regeotte
le rebord	the sil	la relèse	*le refrain*	the chorus	le replot
le reflet	the reflection	le rebli	*le regard*	the gaze	le revage
le refuge	the refuge	la repine	*le registre*	the register	la retoufle
la remise	the discount	la relanque	*la remarque*	the remark	le recombre
la remorque	the trailer	le relecte	*le repas*	the meal	le rechon
le repère	the axes	la renelle	*la ressource*	the ressource	la regorne
le ressort	the spring	la relice	*le retard*	the delay	la renache
la retraite	the retirement	le reblage	*le retour*	the return	le remage
le revers	the backhand	la relège	*la revanche*	the revenge	la renite
la semoule	the semolina	la serelle	*le secret*	the secret	le semier
la seringue	the seringe	la semide	*la semaine*	the week	le sereuil
le velours	the velvet	le venal	*le semestre*	the semester	le segastre

Non-Trained Non-Schwas (NTNS)	**Translation**	**Pseudowords**	**Trained Non-Schwas (TNS)**	**Translation**	**Pseudowords**
la baguette	the baguette	la bagnotte	*le bateau*	the boat	le bacheux
le bureau	the desk	le bulain	*le bébé*	the baby	le bégeon
le café	the coffee	le cabi	*le bus*	the bus	la bigne
le chat	the cat	le chon	*le cadeau*	the present	le casin
le chien	the dog	le choui	*le collège*	the secondary school	la caussade
le citron	the lemon	le civlain	*le concert*	the concert	la condive
la classe	the class	la claise	*la fleur*	the flower	le flar
le cours	the course	la conce*	*la forêt*	the forest	le fonar
la crêpe	the pancake	la crine	*la fraise*	the strawberry	le frage
la famille	the family	la fanure	*la glace*	the ice cream	la glette
le film	the film	le fougre	*le groupe*	the band	le grane
le garage	the garage	la ganère	*la tomate*	the tomato	le toleur
le garçon	the boy	le garget	*la lettre*	the letter	la landre
le jour	the day	le give	*la montagne*	the mountain	le monceuil
le livre	the book	la linfle	*la musique*	the music	la muquette
le lundi	the Monday	le linton	*la neige*	the snow	le node
la maison	the house	le maipi	*le papier*	the paper	le pamion
le mardi	the Tuesday	le marfant	*la piscine*	the swimming pool	la pitude
la mère	the mother	la migne	*la plage*	the beach	la plesse
le père	the father	le pache	*la pomme*	the appel	la pugne
la photo	the photo	le fozi	*le poulet*	the chicken	le pouson
la route	the road	le ril	*la rose*	the rose	la rigue
la salade	the salad	la sagogne	*le train*	the train	la tru
la soupe	the soup	la save	*la ville*	the city	le vade

Words (and their translation) and *pseudowords for the practice trials: *la *chenure*, *la cuisine* (the kitchen), *la *falège, la gare* (the station), *la *gonde, la *merafe, la *mulade, la *toilade*, *le *corbage*, *le dîner* (the dinner), *le *flon, le journal* (the newspaper), *le travail* (the work), *le vin* (the wine).

Appendix 2

Generalized linear mixed effects models modeling the participants' accuracy to the filler primes. Standard error is indicated by *S.E.* and standard deviation is indicated by *SD*. R2m = R squared marginal. R^2c = R squared conditional. The coefficients of R squared marginal (R^2m) and R squared conditional (R^2c) were estimated using the piecewiseSEM package.

Table 1. Statistical glmer model fitting the probability of a correct response to a Pseudoword prime (11488 trials). The intercept represents the logistic probability of producing a correct response for a pseudoword prime by participants of all three groups. $R^2m = 0.003$. $R^2c = 0.21$. We removed Group as a predictor from this analysis because, no matter which level of Group was on the intercept, the p value of Group was never below 0.87

Fixed effects		*ß*	*S.E.*	*z*	*p*
(intercept)		1.83	0.15	12.50	<.001*
Trial number		0.21	0.04	5.05	<.001*
Random effects			*Variance*	*SD*	
Item	Intercept		0.63	0.80	
Participant	Intercept		1.26	1.12	

Table 2. Statistical glmer model fitting the probability of a correct response to a Non-Trained Filler prime (2872 trials). The intercept represents the logistic probability of producing a correct response for a Non-Trained Filler word prime by participants of all three groups. $R^2m = 0.005$. $R^2c = 0.31$. We removed Group as a predictor from this analysis because, no matter which level of Group was on the intercept, the p value of Group was never below 0.10

Fixed effects		*ß*	*S.E.*	*z*	*p*
(intercept)		2.85	0.36	7.97	<.001*
Trial number		−0.31	0.09	−3.59	.001*
Random effects			*Variance*	*SD*	
Item	Intercept		2.30	1.52	
Participant	Intercept		0.84	0.92	

Table 3. Statistical glmer model fitting the probability of a correct response to a Trained Filler prime (2878 trials). The intercept represents the logistic probability of producing a correct response for a Trained Filler word prime by participants of all three groups. $R^2m = 0.002$. $R^2c = 0.08$. We removed Group as a predictor from this analysis because, no matter which level of Group was on the intercept, the p value of Group was never below 0.56

Fixed effects		*ß*	*S.E.*	*z*	*p*
(intercept)		5.24	0.47	11.22	<.001*
Trial number		−0.36	0.17	−2.09	.04*
Random effects			*Variance*	*SD*	
Item	Intercept		1.61	1.27	
Participant	Intercept		1.32	1.15	

Table 4. Statistical glmer model fitting the probability of a correct response to a Non-Trained Schwa Filler prime (2866 trials). The intercept represents the logistic probability of producing a correct response for a reduced Non-Trained Schwa Filler word prime in its reduced form by participants of the RedExposed group. $R^2m = 0.09$. $R^2c = 0.51$

Fixed effects		*ß*	*S.E.*	*z*	*p*
(intercept)		−1.10	0.28	−3.89	<.001*
Trial number		−0.30	0.07	−4.06	<.001*
Experimental Group:	BothExposed	0.57	0.28	2.04	.04*
	FullExposed	0.64	0.28	2.30	.02*
Reduction:	Full	2.45	0.26	9.34	<.001*
Group * Reduction:	BothExposed * Full	−1.19	0.24	−5.00	<.001*
	FullExposed * Full	−1.52	0.24	−6.42	<.001*
Random effects			*Variance*	*SD*	*Correlation*
Item	Intercept		0.63	0.79	
	Reduction: Full		0.83	0.91	0.37
Participant	Intercept		1.00	1.00	

Table 5. Statistical lmer model fitting the probability of a correct response to a Trained Schwa prime (2748 trials). The intercept represents the logistic probability of producing a correct response for a reduced Trained Schwa prime by the participants of the BothExposed group. Experimental Group was not statistically and thus does not appear in the table. $R^2m = 0.14$. $R^2c = 0.38$

Fixed effects		*ß*	*S.E.*	*z*	*p*
(intercept)		1.07	0.28	3.75	< .001*
Reduction	Full form	0.34	0.21	1.61	.11
Group	FullExposed	−1.81	0.27	−6.73	< .001*
	RedExposed	0.43	0.27	1.60	.11
Trial number		−0.22	0.08	−2.80	.005*
Reduction * Group	Full form * FullExposed	2.18	0.14	9.11	< .001*
	Full form * RedExposed	−2.14	0.23	−9.21	< .001*
Random effects			*Variance*	*SD*	**Correlation**
Item	Intercept		0.83	0.91	
	Reduction: Full form		0.41	0.64	−0.65
Participant	Intercept		0.89	0.94	

Table 6. Statistical lmer model fitting the probability of a correct response to a Trained Schwa prime for the RedExposed and FullExposed groups only (1833 trials). The intercept represents the logistic probability of producing a correct response for a reduced Trained Schwa prime by the participants of the FullExposed group. $R^2m = 0.17$. $R^2c = 0.48$

Fixed effects		*ß*	*S.E.*	*z*	*p*
(intercept)		1.68	0.31	5.44	< .001*
Training	Untrained	−1.81	0.24	−7.65	< .001*
Group	RedExposed	0.35	0.36	0.98	.33
Trial number		−0.36	0.10	−3.68	< .001*
Training * Group	Untrained * RedExposed	−0.82	0.40	−2.06	.04*

Random effects		*Variance*	*SD*	*Correlation*		
Item	Intercept	0.95	0.98			
	Training: Untrained	0.61	0.78	−0.82		
	Group: RedExposed	1.09	1.04	−0.55	0.65	
	Training * Group: Untrained*RedExposed	2.15	1.47	0.72	−0.90	−0.87
Participant	Intercept	0.88	0.94			

Table 7. Statistical logistic regression model estimating the probability of a correct response to a target for the RedExposed and FullExposed groups (1836 trials). The intercept represents the logistic probability of a correct response (by participants of both the FullExposed and the RedExposed groups) to a mismatching target in an untrained form whose prime had been answered to correctly. Experimental Group was not statistically significant and thus does not appear in the table. $R^2m = 0.27$. $R^2c = 0.39$

Fixed effects		*ß*	*S.E.*	*z*	*p*
(intercept)		2.21	0.29	0.72	.47
Repetition match	Match	1.66	0.21	7.86	<.001*
Accuracy on the prime	Incorrect	−0.79	0.19	−4.07	<.001*
Training	Trained	2.05	0.19	11.02	<.001*
Scaled Distance prime target		−0.62	0.32	−1.95	.05*
Scaled Trial number		−0.20	0.10	−2.02	.04*
Repetition match * Accuracy on the prime	Match * Incorrect	−1.89	0.27	−6.93	<.001*
Repetition match * Training	Match * Trained	−1.24	0.27	−4.61	<.001*
Random effects			*Variance*	*SD*	
Item	Intercept		0.20	0.44	
Participant	Intercept		0.60	0.78	

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