The consonant bias in word learning is not determined by position within the word: Evidence from vowel-initial words

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Acknowledgments

The present study was supported by an ANR research grant to TN (ANR-16-FRAL-0007) and a NSERC Discovery grant to LP (OPG105397). We would like to thank Mélanie Havy, Marina Dallongeville and Solange Akochi-Saye for help in setting up and running the experiment, and the infants and their parents for their participation.

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Keywords: consonant bias; word learning; phonology/lexicon interface; infancy; French.

Highlights

- The consonant bias in early lexical processing is extended to Canadian French

- The consonant bias in early lexical processing cannot be reduced to a positional effect

- Canadian French-learning 20-month-old children can learn vowel-initial words

- Canadian French-learning 20-month-old children can segment vowel-initial wordsAbstract

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Abstract

The present study used an object manipulation task to explore whether infants rely more on consonant than vowel information when learning new words, even when the words start with a vowel. Canadian French-learning 20-month-olds, who were taught pairs of new vowel-initial words contrasted either on their initial vowel (*opsi*/*eupsi*) or following consonant (*oupsa*/*outsa*), were found to have learned the words only in the consonant condition, and performed significantly better on the consonant versus vowel condition. These results extend to Canadian French-learning infants the consonant bias in word learning previously found in French-learning infants from France and, crucially, shows that vocalic information has less weight than consonant information in new word learning even when it is the initial sound of the target words, confirming the consonant bias at the lexical level postulated by Nespor et al. (2003). The present findings also suggest that French-learning infants are able to segment vowel-initial words as early as 20 months of age.

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The question of the phonetic specificity of early lexical processing has been a focus of interest for decades, showing that from the moment infants' start encoding words or word forms, these word forms are at least partly specified (Jusczyk & Aslin, 1995; Stager & Werker, 1997; Bortfeld et al., 2005; Hallé & de Boysson-Bardies, 1996; Bouchon et al., 2015). More recently, based on various phonological considerations (e.g., consonant inventories tending to be larger than vocalic ones across languages; consonants being perceived more categorically than vowels; consonants tending to disharmonize within words while many languages instantiate vowel harmony at the lexical level…), Nespor et al. (2003) have proposed that consonants are more important than vowels for lexical processing. This has led to an increase in studies directly comparing the use of consonant and vowel information in early lexical processing. The evidence supporting Nespor et al. (2003)'s view comes in particular from studies looking at the acquisition of pairs of words differing by one phoneme/phonetic feature which show that the trajectory of acquisition of the consonant bias varies crosslinguistically (for a review, Nazzi, Poltrock & Von Holzen, 2016). However, in all studies so far, vowels were tested in word-medial but never in word-initial position, a particularly salient processing position according to some models of lexical access (e.g., Cohort, Marslen-Wilson & Welsh, 1978). Importantly, prior work also suggests that vowel-initial words are more difficult to process than consonant-initial words (English: Mattys & Jusczyk, 2001; Nazzi et al., 2005; French: Babineau & Shi, 2014). The present study compared French-learning 20-month-olds' acquisition of vowel-initial words having a VC.CV structure, and differing in either their initial vowel or following consonant. To our knowledge, this is the first study to explore on-line acquisition of vowel-initial words in French.

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Consonants and vowels have different acoustic properties. Compared to consonants, vowels usually correspond to more stable spectral information than consonants, and are processed less categorically. Nespor et al. (2003) proposed that these processing differences result in consonants and vowels having different functions in language processing, which might facilitate language acquisition. More specifically, vowels play a more important role than consonants in marking prosodic and (morpho)syntactic regularities, while consonants play a more important role for lexically-related processes. This proposal is supported by adult data from lexical reconstructions tasks in which participants have to change a pseudoword into a word (English and Spanish: Cutler et al., 2000; for Dutch: van Ooijen, 1996), as well as lexical priming tasks (French: New et al., 2008; New & Nazzi, 2014; delle Luche et al., 2014; Spanish: Carreiras et al., 2009; English: delle Luche et al., 2014) and artificial language segmentation tasks (Bonatti et al., 2005; Toro et al., 2008).

Taken together, the above studies support the existence of a consonantal bias in both oral and written adult lexical processing in several languages (Dutch, English, French, Italian and Spanish). These results raise the issue of the emergence of this bias in development, since Nespor et al. (2003) proposed that this functional asymmetry would help language acquisition. This issue has been explored in many studies investigating the existence of a consonant bias in lexical acquisition in French-learning infants. The present study further contributes to this line of research.

In these word learning studies, infants are taught a pair of words that differ only by a consonant or a vowel, and then are asked to select one of the two objects at test (for example, by requesting the object by its name). First, exploring French-learning infants using this object manipulation task, many studies found an asymmetry in processing to the advantage of consonants between 16 months and 3 years. Both 16- and 20-month-olds can simultaneously

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learn two new words contrasting by a consonantal feature (place: e.g., /gul/-/dul/ or voicing: e.g., /paʃ/-/baʃ/), but fail when the words contrast by a vocalic feature (place: e.g., /ʃyl/-/ʃul/ or height: e.g., /pœs/-/pos/; Havy & Nazzi, 2009; Nazzi, 2005). Infants' use of minimal vocalic contrasts in this kind of task is found starting at 30 months (Nazzi et al., 2009). However in spite of this improvement in vowel processing, the consonant/vowel asymmetry remains present from 16 months all the way to adulthood (Nazzi et al., 2009; Havy et al., 2011, 2014) in French-learning participants.

These findings led to the question of the generality of this consonant bias. From a crosslinguistic point of view, this bias appears to be modulated by the language infants are acquiring: while a bias was found in Italian-learning 12-month-olds (Hochman et al., 2011), no bias could be found in 16-to-23-month-old English-learning infants (Floccia et al., 2014), a vocalic bias was found in 20-month-old Danish-learning infants (Højen & Nazzi, 2016) and possibly in 24-month-old Mandarin-learning toddlers (Wewalaarachchi, Wong & Singh, 2017). From a developmental point of view, the consonant bias was found to emerge developmentally from an initial vocalic bias, between 6 (Bouchon et al., 2105; Nishibayashi & Nazzi, 2016) and 8 months (Nishibayashi & Nazzi, 2016; Poltrock & Nazzi, 2015; Zesiger & Johr, 2011) in French, between 6 (Benavides-Varela et al., 2012; Hochman et al., 2017) and 12 months (Hochman et al., 2011) in Italian, and between 23 (Floccia et al., 2014) and 30 months (Nazzi et al., 2009) in English. It has been proposed that these crosslinguistic differences in the developmental trajectory of the consonant bias stem from differences in the phonological and/or lexical properties of the different languages tested. For example, Danish has a larger vocalic than consonantal inventory (contrary to French, Italian and English) and also has several phenomena that lead to the under-articulation of consonants. Both of these

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factors are likely to increase the informativeness of vowels relative to consonants at the lexical level in Danish.

Importantly, other studies are exploring the scope of the consonant bias, focusing on French since the consonant bias is found pervasively in this language. These studies have mostly explored this issue by focusing on word learning in the second year. One line of research found that the consonant advantage found for stop consonants (Nazzi, 2005) extends to other kinds of consonants (fricatives, liquids and nasals, Nazzi & New, 2007). This brings support to an interpretation in terms of a consonant versus vowel dichotomy, rather than graded sensitivity based on the sonority hierarchy. Moreover, several phonological features were tested (consonants: place, voicing; vowels: place, height, roundness), all leading to an advantage of consonant over vocalic features (e.g., Havy & Nazzi, 2009).

A second line of research explored the possible role of the relative position of consonants and vowels within lexical and syllabic structures. Indeed, in most word-learning studies conducted, the critical consonants were located at syllable onsets, and often even in word-initial positions, while the critical vowels often followed the consonants. Therefore, the consonant bias might derive from positional differences: in word-learning situations, consonants at the onset of words and/or syllables might be processed in more detail by young infants than phonemes in other lexical/syllabic positions. That these factors could have contributed to the better processing of consonants is suggested by models of lexical access giving more weight to elements that come earlier in the signal (e.g., Marslen-Wilson & Welsh, 1978), and by some studies reporting better processing of onset compared to coda consonants (e.g., Swingley, 2005, though not Swingley, 2009). To address this concern, several word-learning studies explored the processing of consonants in syllable onset positions but not in word-initial positions (Nazzi, 2005), or of consonants in syllable coda

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positions (Nazzi & Bertoncini, 2009; Havy et al., 2011, 2014). Overall, the findings establish that in French, from 16 months onward, the consonant bias is not an artifact of relative consonant/vowel position, showing overall higher performance with both onset and coda consonants over vowels. Only one study (Havy et al., 2014) found a position effect when adult participants had to neglect either a consonant or a vocalic change, with an advantage for phonemes appearing first in the word; however, this effect was not found in 3- to 5-year-old children.

While the above findings support the claim that the consonant bias in word learning cannot be reduced to a positional effect (for convergent findings obtained in the first year of life, testing word form segmentation, see Nishibayashi & Nazzi, 2016; Von Holzen, Nishibayashi & Nazzi, 2018), one crucial test has not yet been conducted: that of vowels in word-initial positions. Indeed, in models of lexical access like Cohort (Marslen-Wilson & Welsh, 1978), the initial phoneme of a word plays a crucial role in lexical access, more than the following phonemes. Therefore, vocalic processing might be better in word-initial positions, allowing us to observe above chance level performance in tasks in which infants have to learn two words differing only in their word-initial vowel, compared to non-word-initial vowels for which above chance level performance emerges between 20 and 30 months (Nazzi, 2005; Nazzi et al., 2009). Accordingly, we tested French-learning 20-month-olds' ability to process vocalic information when learning pairs of vowel-initial words differing on their initial vowel. We used the simplified word learning task set up by Havy and Nazzi (2009), which might facilitate learning compared to the name-based categorization task previously used at that age (e.g., Nazzi, 2005). In this procedure, infants are presented with various trials in which three different objects are presented. Two of the objects are labeled with two different names (e.g., *opsi/eupsi*). The experimenter then takes the third object,

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labels it with one of the previous names (e.g., *opsi*), puts it in a cup and asks the infant to put the other *opsi* in the cup. Previous research found that infants succeed in this task at 16 months with consonant-initial words contrasted on their initial consonant, but fail at that same age with consonant-initial words contrasted on their following vowel (Havy & Nazzi, 2009).

Lastly, because vowel-initial words are more difficult to process in infancy (up until about 13 months in English, Mattys & Jusczyk, 2001, Nazzi et al., 2005; up until 20 to 24 months in French, Babineau & Shi, 2014), infants were tested on their ability to use consonant contrasts in vowel-initial words with the exact same phonetic/lexical structures: VC.CV. Therefore, infants were presented with 2 types of trials, differing on how the words to-be-learned were contrasted: on their initial vowel (e.g., *opsi/eupsi*), or on the following coda consonant (e.g., *oupsa/outsa*). The consonant bias predicts that performance on the consonant-contrasted trials should be higher than performance on the vowel-contrasted trials.

Experiment

Methods

Participants

The participants were 24 infants (mean age = 20 months, 11 days, range = 19;24 – 20;25; 12 boys, 12 girls) from monolingual French-speaking families growing up in the Montreal area. To assess infant language experience, parents completed a language questionnaire which provided detailed information on the caregivers, family and others who interact with the child on a regular basis, how much time they spend in a typical week, and what language(s) they speak when doing so. The data was used to compute the percent of each language present in the child's overall language input. We included infants who had 95 to 100% of their input as Canadian French. Sample size was decided on the basis of previous

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studies (eg, Havy & Nazzi, 2009; Nazzi & Bertoncini, 2009), which used similar procedure, age group and number of conditions. Eight additional infants failed to complete the session, and all their data was discarded.

Stimuli

The stimuli used consisted of unfamiliar objects and pseudowords. We used eight triads of very distinct novel objects for which infants had no names, and eight pairs of VC.CV pseudowords differing only by one phonological feature to name the objects. Four pairs differed by a vowel (1-feature place changes: /ɔpsi/-/œpsi/, /ykta/-/ukta/; 1-feature rounding changes: /ɛpto/-/œpto/, /irge/-/urge/) while the other 4 differed by a consonant (1-feature place changes: /yste/-/yʃte/, /upsa/-/utsa/, 1-feature manner changes: /ɔpti/-/ɔfti/, /aldo/-/azdo/). Note that this VC.CV structure is legal in French, but rather infrequent: in the CDI version we used, only 4 such forms are present (argent /ar.ʒã/, acheter /aʃ.te/, amener /am.ne/, enlever /ãl.ve/).

All pseudowords were embedded in the same French carrier sentences: Regarde! Un *opsi*. C'est un *opsi*. Tu veux jouer avec l'*opsi*. Oui, joue avec l'*opsi*. Tu vois cet *opsi*? Voila, on met cet *opsi* sur la table. [Look ! An *opsi*. This is an *opsi*. Do you want to play with the *opsi*? Yes, play with the *opsi*. See this *opsi*. All right, let's put the *opsi* on the table.]

Procedure

Infants were tested in a quiet room, sitting on a parent's lap at a table facing a French-speaking female experimenter. The session started with two training trials in which the experimenter presented a pair of familiar objects for which infants were likely to have a name (car/ball and horse/spoon). Then, the experimenter took a second visually-different exemplar of one of the familiar objects, put it in a cup and asked the infant to put the other one in the cup.

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The goal of these two training trials was to familiarize the infants with the experimental set-up and procedure, which was very similar in training and test, with the major difference that, during training, infants were presented with familiar objects, while in the test itself, they were presented with unfamiliar objects and pseudowords and had to learn new words.

Each of the 8 test trials were composed of two phases. First, one at a time, two objects were presented and named 6 times with different pseudowords, e.g., *opsi/eupsi*, before being placed on the table. Second, the experimenter tested word learning by presenting a third object, naming it, e.g., a *opsi*, putting it in a cup and asking the infant to put the other *opsi* in the cup (Figure 1). The left/right position of the target object on the table was counterbalanced within participants. Which of the two pseudowords of a pair was used as target was counterbalanced between participants. After the test session, parents completed the Canadian French adaptation of the MCDI: words and sentences (Frank, Poulin-Dubois & Trudeau, 1997) in order to evaluate the size of the infant's productive vocabulary.

Results

For each trial, infants were given a score of 1 when they chose the object with the correct name. Total scores were calculated for each contrast condition (consonant versus vowel) and then converted into percentages, chance being 50% (Figure 2).

For the consonant trials, infants chose the correct object 59.38% (SD = 18.47) of the time, above chance level, $t(23) = 2.38$, $p = .026$, 2-tailed, $d = .51$, medium effect. For the vowel trials, infants chose the correct object 48.96% of the time (SD = 19.36), at chance level, $t(23) = -.25$, $p = .80$, 2-tailed, $d = .05$. Infants' performance was significantly higher for the consonant than the vowel trials, $t(23) = 1.93$, $p = .033$, 1-tailed (given our oriented

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prediction), d = .40, small effect. Moreover, performance on consonant and vowel trials was not correlated, r = .10, p = .65, suggesting that processing of the two types of phonemes was not linked. Lastly, number of words produced (as indexed by MCDI scores) did not correlate with performance on either the consonant (r = .21, p = .32) or the vowel (r = -.10, p = .63) trials.

Discussion

The main goal of the present study was to determine whether French-learning infants rely more on consonants than vowels in word learning, that is, whether they have a consonant bias, even in a situation in which vowels are positioned at word onsets, which are crucial positions for lexical access according to models of lexical access such as Cohort (Marslen-Wilson & Welsch, 1978). Our findings reveal that even though vowels appeared in word initial-positions, and were positioned earlier (VC.CV) in the target words than the consonants (VC.CV), infants performed above chance level for the consonants but not the vowels, and consonant performance was higher than vowel performance. This extends to Canadian French-learning infants the consonant bias previously found at this age in Parisian French-learning infants. Performance on consonant and vowel trials was not correlated, which suggests that overall performance was not determined by levels of word learning or general phonetic processing, but rather that consonant and vowel processing was not linked. Figure 2 shows that within both the consonant and the vowel contrasts, performance was variable. Given this non-explained variability, we recommend that when evaluating infants' differential processing of consonants and vowels, it is important to use as many different pairs of words as possible by given the experimental procedure used. Lastly, we also found that, as in many word-learning studies on this issue with infants aged 17 months and beyond, performance was

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not correlated with parent-reported vocabulary levels (Floccia et al., 2014; Havy & Nazzi, 2009; Nazzi, 2005; Nazzi & New, 2007; Werker, Fennell, Corcoran & Stager, 2002). This suggests that there is no effect of vocabulary size on the use of phonological information at the lexical level at this age (although an effect was found by Werker et al., 2002, for English-learning 14-month-olds).

More crucially, since consonant-initial words have been used in all previous developmental studies on this issue, the present study is the first to establish a consonant bias in infancy when using vowel-initial words, extending related findings found for adults (New et al., 2008; New & Nazzi, 2014; delle Luche et al., 2014). Hence, although word-initial phonemes are granted a privileged role in some models of lexical access, placing vowels in word-initial positions did not favor their processing in the present task. Our results are consistent with previous findings on French-learning infants and toddlers showing that a consonant advantage can be found for both onset and coda consonant positions. This was found for word learning from 20 months to 5 years of age (Nazzi & Bertoncini, 2009; Havy et al., 2014) and for detection of mispronunciations in word form segmentation tasks at 8 months (Nishibayashi & Nazzi, 2016; Von Holzen et al., 2018). Our findings thus support the notion that the consonant bias cannot be reduced to an artifact of relative position.

The present data on French further confirm that more weight is given to consonantal over vocalic information, as proposed by Nespor et al. (2003), and are consistent with their proposal of a functional dissociation between consonants and vowels, consonants being more important than vowels for lexical processing. The fact that performance for consonant and vowel contrasts did not correlate might further support this dissociation (although lack of power might also be responsible for this null result). Given that the present findings were obtained for French, a language in which a pervasive consonant bias is found from 8 months

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onwards, and since crosslinguistic differences were found in the developmental trajectory of this bias (see Nazzi et al., 2016, for a review), it will be important in the future to explore whether the (relatively) position-independent consonant bias found for French extends to other languages, or whether some crosslinguistic modulations are also found at this level. This would allow us to further understand the links between the processing of phonological and lexical properties in development. Note that we find a consonant bias for an infrequent VC.CV lexical structure for which it is unlikely that infants would have minimal pairs (only four such words appear in the French CDI). This suggests that the consonant bias is acquired as a general property of the native language rather than a surface structure-specific pattern.

A second important finding is that, as revealed by performance in the consonant condition, 20-month-old French-learning infants are able to learn vowel-initial words. Moreover, because our task involved processing words produced in sentence context, these results nevertheless indirectly show that our toddlers were able to correctly segment the vowel-initial words. This is because although the sentences used allowed resyllabification based on liaison (the contexts that would have blocked resyllabification being too restricted to use here), we had chosen different liaison contexts, so that a word like *opsi* would have resyllabified as *nopsi* twice, *topsi* twice, and *lopsi* twice. To perform above chance level, it is thus likely that our infants were able to undo this liaison to retrieve the vowel-initial form of the word. This result is important given that vowel-initial words had been found to be more difficult to segment than consonant-initial words, both in English up until 13 months (Mattys & Jusczyk, 2001; Nazzi et al., 2005) and in French up until 24 months (Babineau & Shi, 2014). Our study thus reveals vowel-initial segmentation earlier than Babineau and Shi (2014), as they found no vowel-initial word segmentation at 20 months, and ambiguous segmentation at 24 months in Canadian French infants. Several difference in methods and

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tasks used could account for this difference. First, our use of shorter sentences that contained many frequent words probably known to the infants may have facilitated segmentation. Second, our task was clearly referential, contrary to the purely auditory task used in Babineau and Shi (2014), which could have facilitated word segmentation (as it facilitates early word learning, e.g., Fennell & Waxman, 2010). Nevertheless, our findings do not necessarily mean that vowel-initial words are no longer more difficult to process than consonant-initial words at 20 months. This is indirectly supported by the fact that while mean performance for trials with consonant contrasts was about 59% in the present study (medium effect), Havy and Nazzi (2009) had found that, 4 months earlier in development, French-learning 16-month-olds tested in the exact same task, but on consonants located in word initial position, had a performance level of 69% (SD = 11.05, Cohen d = 1.74, large effect). Hence, there appears to remain a cost for processing vowel-initial words compared to consonant-initial words at 20 months of age, which is compatible with the segmentation findings of Babineau and Shi (2014).

In conclusion, the present study is the first to establish the possibility of learning vowel-initial words by 20 months of age, and that even for such words, consonants are given more weight than vowels in this acquisition process. It contributes to establishing that the consonant bias found in early word-learning in French-learning infants is independent of the relative position of consonants and vowels within words (by showing that the word-onset position is not necessarily the position best processed), thus providing unambiguous support for a non-positional interpretation of the functional specialization of consonants and vowels proposed by Nespor et al. (2003). Future research will have to explore these positional issues in other languages.

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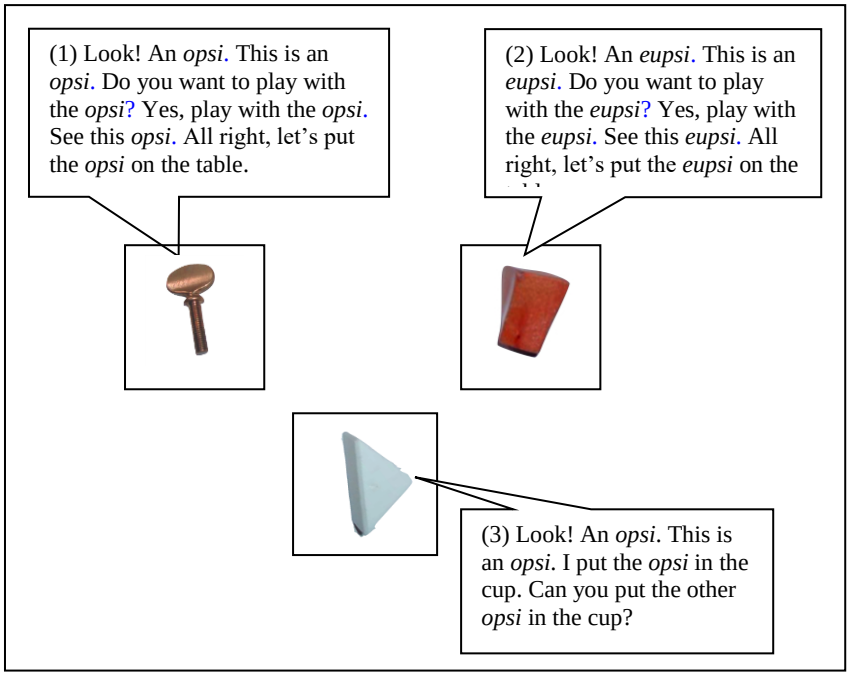

Figure 1: Illustration of the procedure for one of the 8 triads of objects used in the present study (the two objects used in the presentation phase, and which of these two objects related to the object used in the test phase were counterbalanced between participants)

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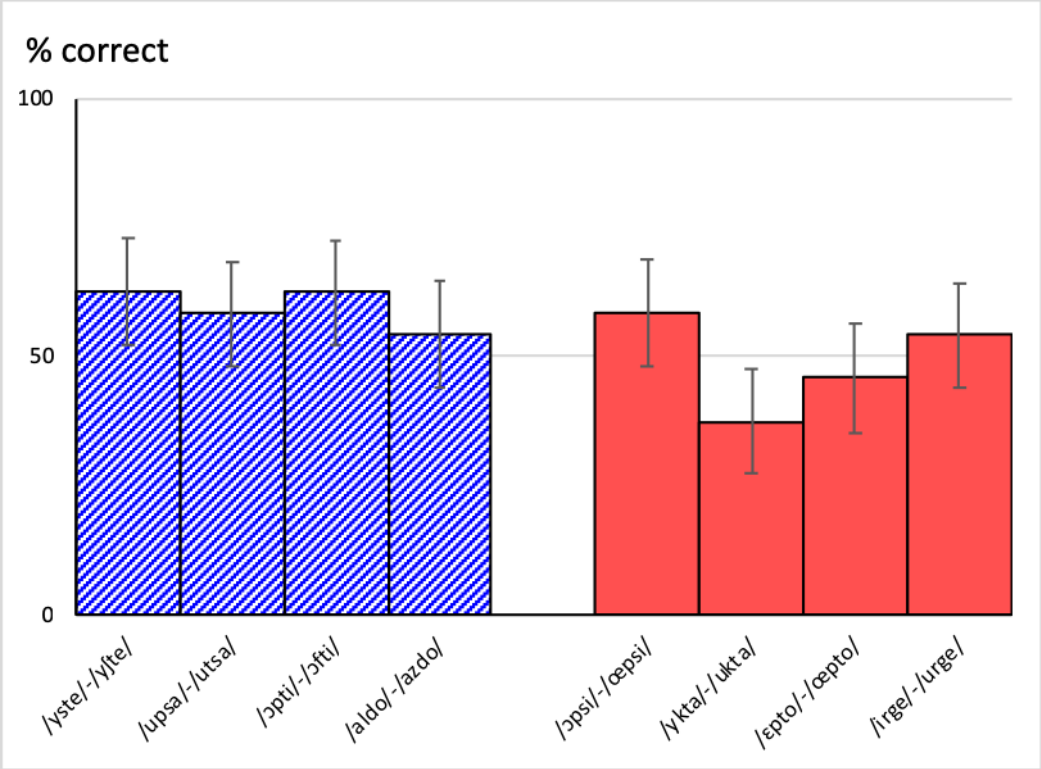

Figure 2: Mean correct responses in percentage for the 4 consonant trials (in blue; 2 place followed by 2 manner contrasts) and the 4 vowel trials (2 place followed by 2 rounding contrasts). Error bars denote standard error (SE).

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