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Phonologically Driven Variability: The Case of Determiners

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Speakers usually produce words in connected speech. In such contexts, the form in which many words are uttered is influenced by the phonological properties of neighboring words. The current article examines the representations and processes underlying the production of phonologically constrained word form variations. For this purpose, we consider determiners whose form is sensitive to phonological context (e.g., in English: ***a*** *car* vs. ***an*** *animal*; in French: ***le*** *chien* 'the dog' vs. ***l'***âne 'the donkey'). Two hypotheses have been proposed regarding how these words are processed. Determiners either are thought to have different representations for each of their surface forms, or they are thought to have only 1 representation while other forms are generated online after selection through a rule-based process. We tested the predictions derived from these 2 views in 3 picture naming experiments. Participants named pictures using determiner–adjective–noun phrases (e.g., *la nouvelle table* 'the new table'). Phonologically consistent or inconsistent conditions were contrasted, based on the phonological onsets of the adjective and the noun. Results revealed shorter naming latencies for consistent than for inconsistent sequences (i.e., a phonological consistency effect) for all the determiner types tested. Our interpretation of these findings converges on the assumption that determiners with varying surface forms are represented in memory with multiple phonological-lexical representations. This conclusion is discussed in relation to models of determiner processing and models of lexical variability.

Keywords: language production, variation, lexical representations, speech

Words are not always uttered in the way they are described in a standard dictionary. For instance, in English, the word *camera* is often realized without its second vowel ([kæmrə]), the word *plain* is likely to be realized with [m] rather than [n] in some contexts (e.g., "a plain bun"), and the words *a* and *the* are often produced as [ə] and [ði:] when preceding a vowel. Similarly, in French, the adjectives *beau* [bo] 'nice', *vieux* [vjø] 'old', and *grand* [gʀã] 'big' are realized [bɛl], [vjɛj], and [gʀãt], respectively, before vowel-initial nouns. The form of those words surrounding the varying word (i.e., the phonological context) plays a major role in determining the occurrence of many of these variations (e.g., Gaskell, Cox, Foley, Grieve, & O'Brien, 2003; Gaskell, Hare, & Marslen-Wilson, 1995).

In this research, we examine the representations and processes underlying the production of phonologically constrained variations. Dependencies (i.e., fact that the form or the pronunciation of a word depends on another word in the sentence) have been studied extensively at the syntactic level (e.g., Eberhard, Cutting, & Bock, 2005; Franck, Vigliocco, Antón-Méndez, Collina, & Frauenfelder, 2008; Haskell, Thornton, & MacDonald, 2010; Mirković & MacDonald, 2013). By contrast, much less is known of phonological dependencies because significantly less psycholinguistic research has been devoted to this issue, be it in auditory and visual language perception (e.g., DeLong, Urbach, & Kutas, 2005; Gaskell & Marslen-Wilson, 1996, 2001) or in speech production (Alario & Caramazza, 2002; Miozzo & Caramazza, 1999; Spalek, Bock, & Schriefers, 2010).

Determiners provide an interesting test ground for understanding phonologically driven variability. In many languages, determiner form depends on diverse properties of the surrounding words, which frequently include the phonological context (see Table 1). Whereas this fact has been acknowledged in previous

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Table 1
Examples of Constraints on Singular Determiner Form Production in Different Languages

Language and determiner type	Grammatical constraint (noun gender)	Phonological constraint (next word onset)	Determiner form
English indefinite determiner		Consonant	a
		Vowel	an
French definite determiner	Masculine	Consonant	le
		Vowel	l’
	Feminine	Consonant	la
		Vowel	l’
French possessive determiner	Masculine	Consonant	mon
		Vowel	mon with liaison
	Feminine	Consonant	ma
		Vowel	mon with liaison
German definite determiner	Feminine	Any	die
	Masculine	Any	der
	Neuter	Any	das

research (Caramazza, Miozzo, Costa, Schiller, & Alario, 2001; Foucart, Branigan, & Bard, 2010; Garrett, 1975; Spalek et al., 2010), the conclusions reached in these studies are not consensual. Here we will reconsider this research and provide new evidence to clarify the representations and processes involved in determiner form variation. In our interpretation of the findings, we will focus specifically on connecting linguistic and psycholinguistic frameworks.

Nonlexical Determiner Representations

In early psycholinguistic accounts of determiner processing (Garrett, 1975, 1984, 1988), determiners have no corresponding phonological representation in the mental lexicon. Unlike content words, they are not lexical entities. This *nonlexical hypothesis* was proposed to account for error patterns in natural speech corpora. Especially relevant were the observations that phonological errors rarely involve function words and that word exchange errors involve stems but not their inflections (e.g., *“*she’s already trunked two packs*”; Berndt, 2001). In Garrett’s model, function words and inflections share a number of properties. The generation of a sentence starts with the assembly of a planning frame that specifies the location of the content words (see also Bock, 1987). These content words are activated and selected, and their phonological forms are inserted into this frame. In contrast, function words, as well as inflections, are part of the planning frame. Their production is automatic and results from the processing of the sentence frame. Their phonological makeup is determined once that of the content words has been defined (see Dell, 1990, for an alternative view). According to Garrett (1980), local accommodation processes adjust the determiner form to the phonological context (e.g., *a money’s aunt* for *an aunt’s money* in Garrett, 1984). Consequently, the phonological shapes of these morphemes are not “tied to particular lexical entries” (Garrett, 1980, p. 187).

A Lexicalist View of Determiner Representation

In a seminal study Schriefers (1993) initiated the investigation of determiner production with chronometric paradigms. He introduced the manipulation of grammatical gender as the distractor in the picture-word interference paradigm (Lupker, 1979). Dutch native participants were asked to name pictures with determiner + noun phrases. When the distractor and the name of the picture had different genders, naming latencies were longer than when they had the same gender. This so-called gender congruency effect was replicated several times, in Dutch and other Germanic languages (i.e., La Heij, Mak, Sander, & Willeboordse, 1998; Schiller & Caramazza, 2003; van Berkum, 1997) and has been interpreted as reflecting a conflict between determiner form representations (e.g., Schiller & Caramazza, 2003; Schriefers, Jescheniak, & Hantsch, 2002, 2005; see also Schriefers, 1993, for an interpretation of the effect in terms of competition at the level of the words’ syntactic features). After Schriefers’ report, Garrett’s conception of determiners was more or less abandoned in favor of a lexicalist view of determiner processing and representation (as discussed in Alario, Ayora, Costa, & Melinger, 2008). According to this view, determiners are represented in the mental lexicon, and their production, like that of content words, results from an active, presumably attention demanding, selection mechanism (Ayora, Janssen, Dell’Acqua, & Alario, 2009). One of the reasons for this novel perspective may be the variety of constraints that govern determiner production across languages, particularly those described in the next section.

Constraints From the Phonological Context

In addition to grammatical gender, phonological context can be a major constraint on determiner forms, notably in Romance languages (e.g., Italian, French, Spanish, Catalan; see Table 1). The presence of this phonological constraint is associated with a systematic empirical pattern. When the gender congruency effect described in the previous paragraph was tested in these languages, it was never observed (for an overview, see Figure 1 in Costa, Alario, & Sebastián-Gallés, 2007).[1] The requirement to consider phonological context to select the appropriate determiner form is thought to delay determiner selection. For this reason, at the time of selection, the representations activated by the distractor word (e.g., its gender and associated determiner form) do not constitute

[1] With one notable exception described below (Foucart et al., 2010).

significant alternatives. This has been termed the *late selection hypothesis* and is thought to apply to all determiners within a given language (Caramazza et al., 2001; Miozzo & Caramazza, 1999). Although the timing aspects of this hypothesis are quite detailed, the representations over which selection processes operate were merely assumed to be lexical units. Determiner forms are produced via an activation/selection mechanism constrained, among others, by those properties of the local noun with which the determiner agrees.

Of interest, determiner retrieval performance is not influenced solely by the adjacent (local) phonological context (i.e., the context that is considered relevant for language usage); the context uttered beyond the local word can also affect performance. This was shown early on by Miozzo and Caramazza (1999). In Italian, the masculine definite singular determiner is realized as *l'* before vowels; *lo* before /S/; and "s" followed by a consonant, gn, and some affricates (/ts/ and /dz/). It is realized as *il* in all other cases. Miozzo and Caramazza (1999, Experiment 5) measured naming latencies for the production of *il* + *adjective* + *noun* sequences (e.g., *il grande treno* 'the big train') in a picture naming task. Naming latencies were longer for the adjective noun phrases (relative to the *il* + *noun* baseline; e.g., *il treno*, lo sgabello) when the adjective and the noun called for different determiner forms (i.e., inconsistent noun phrases; e.g., *il* vs. *lo* in *il grande sgabello* 'big stool') than when they called for the same form (i.e., consistent noun phrases; e.g., *il grande treno*). Alario and Caramazza (2002) reported a similar finding for the French determiners *ma* (*mon*) 'my' and *ce* (*cet*) 'this', with shorter naming latencies for consistent than for inconsistent noun phrases. These results were interpreted as reflecting the phonological activation of the (nonlocal) noun prior to response onset. This is consistent with a variety of findings suggesting that, in noun phrases such as those used in these studies, the phonological properties of the three words are activated prior to vocal response (at least, the onsets of all three words; e.g., Alario, Costa, & Caramazza, 2002; Costa & Caramazza, 2002; Damian & Dumay, 2009). The phonological activation of the third word to be uttered is thought to constrain the selection of determiner forms, although the mechanism involved is not specified beyond the hypothesis of late selection discussed in the previous paragraph. As was the case for Germanic languages, in this account determiners are thought to have several lexical representations from among which the appropriate one must be selected: "The proposal is that the noun's gender and number activate an allomorphic set of determiners (e.g., il/lo for singular masculine), but the selection of a specific determiner has to wait for the ordering and insertion of the phonological forms of the noun and adjectives into a phonological phrase" (Miozzo & Caramazza, 1999, p. 920).

Interpreting Phonological Constraints With Adjustment Processes

Two recent studies (Foucart et al., 2010; Spalek et al., 2010) have investigated in more detail how the phonological context constrains determiner form selection. The interpretation of their findings leads these authors to discuss explicitly the nature of determiner representations. Notably, in both studies, the discussions account for local context dependency by means of a conceptualization that borrows some aspects of the conceptualization originally proposed in Garrett's model (see references above); namely, a process of adjustment of determiner form.

In the first study, Foucart et al. (2010) focused on the alternation properties of the definite determiner ('the') in French (le_{masc} and la_{fem}, realized as [l] irrespective of gender before vowels; see Table 1). They observed the gender congruency effect that had only been observed in Germanic languages before (see above). A first aspect of their result is that they only observed the gender congruency effect when the distractor appeared after the picture onset (with a stimulus onset asynchrony, or SOA, of +200 ms), not when the picture and distractor were synchronous (SOA 0; note that Miozzo, Costa, & Caramazza, 2002, failed to observe the effect when they used a similar SOA manipulation in Spanish and Italian). The timing constraint on the occurrence of the effect is compatible with the core claim of the late selection hypothesis, if one assumes that the activation induced by a later distractor stands a greater chance of being influential when determiner selection occurs.

A second, more important, aspect on which Foucart et al. (2010) focused their interpretation concerns the specific properties of the determiner forms they tested. In their view, the form [l] produced before vowel-onset words results from a "late phonetic" adjustment.[2] The presence of a gender congruency effect at +200 SOA occurs because the adjustment process delays the selection of the determiner. In their own words, "*le/la* would always be selected by 'default' but could only be 'fully' selected once the post-selection rule had been checked with reference to the *local* [emphasis added] context" (Foucart et al. (2010), p. 1416). They do not discuss the production of larger sequences and the possible influence of nonadjacent words on determiner production. However, because the late phonetic process is triggered by the local context, determiner production should be blind to the phonological composition of words occurring later in the sequence.

In the second study, Spalek et al. (2010) investigated determiner phonological variation in English by using definite and indefinite determiners, both of which are constrained by the phonological context (i.e., [ə]/[ðə] before consonants and [ən]/[ðiː] before vowels; the alternation being less systematic for *the* and only found in some dialects of English; see, e.g., Raymond, Fisher, & Healy 2002). They measured naming latencies and errors for the production of noun phrases with determiners and adjectives (e.g., *a purple elephant*). Naming latencies were longer when the adjective and the noun called for different determiner forms (e.g., *a* versus *an* in *a purple elephant*, because the adjective and the noun start, respectively, with a consonant and a vowel) than when they called for the same form (e.g., *an*, as in *an orange elephant*, or *a*, as in *a purple giraffe*; 24 ms and 19 ms for *a–an* and *the–thee* respectively). As was the case in Italian and French (Alario & Caramazza, 2002; Miozzo & Caramazza, 1999), this effect of phonological consistency indicated that the production of a given determiner form is not the result of a local adjustment process. Spalek et al. took these findings to suggest that the two determiner

[2] The term *phonetic* is borrowed from Foucart et al. (2010). Note however that the adjustment rule described by these authors cannot take place after the phonological encoding process has been completed, given its impact on the selection of the determiner's phonological representation. If such a rule does apply, it must be phonological (rather than phonetic) in nature.

forms (e.g., *a* vs. *an*) compete at the phonological level. In their proposal, these determiner forms are both derived from a single underlying representation, or one form is directly retrieved from the lexicon while the other one is derived from the former.

To summarize, according to Foucart et al. (2010), definite determiner form selection on the basis of gender is followed by an optional adaptation of determiner form constrained by the local phonological context. In Spalek et al. (2010), in contrast, definite and indefinite determiner forms are first derived from an underlying form and then compete with one another for selection. Irrespective of the order in which form derivation and selection operate, these two accounts contrast with the assumption made in previous research that determiners have stable (i.e., nonadjustable) lexical representations and that all determiners are processed by the same mechanisms within a given language (Caramazza et al., 2001).

The crucial differences noted between accounts regarding determiner form representation may be due to one or a combination of the following reasons. First, the studies investigated different languages, and hence differences in the conclusions may reflect cross-linguistic disparities in determiner representation. Second, determiner processing could differ depending on specific properties of the determiners examined, a point that is emphasized by Foucart et al. (2010). Third, differences in these accounts could be due to the fact that different experimental paradigms were used. Finally, because of some difficulties in each of the theoretical accounts (to be considered in more detail in the General Discussion), it is still possible that the determiner representations and production are in fact homogeneous within and across these (and possibly other) languages and that the findings are not as divergent as they seem.

Working Model and Hypothesis Tested

We now summarize the available theoretical proposals regarding the representation of phonologically constrained determiners. According to one view, varying surface forms enjoy alternative lexical representations, each of which is appropriate for a different type of phonological context (typically, in front of vowel vs. consonant onsets). We will refer to this view as the *alternating forms hypothesis.* A selection process isolates the form to be retrieved and selected. In principle, the selection processes could be *restricted* or *unrestricted.* A restricted selection process involves exclusively the information that is logically required to perform the selection (i.e., the information specified in language usage rules: the local phonological context). Alternatively, an unrestricted selection process would be more open and would involve any information that is active, even if it is not required according to language usage rules (e.g., the nonlocal phonological context).

According to the other view, a given determiner form is stored and then retrieved irrespective of the phonological context. When certain phonological constraints are met (e.g., if the following word starts with a vowel), an alternative form is derived. Such derivation is typically realized through local accommodation processes involving the adjacent word (usually at the phonological level). By "typically" we refer to the fact that the definition of such constraints in Garrett's classic model or in linguistic accounts involves only adjacent words. For example, Selkirk and Vergnaud (1973) reviewed several simple phonological rules of this kind. The following rule accounts for the alternation between *le/la* and *l* in French: V→∅/___#V ("the vowel of the definite determiner deletes before a vowel-initial word but not before a consonant-initial one"; Selkirk & Vergnaud, 1973, p. 250). For these reasons, we shall consider that deriving alternative forms is a process that can only be governed by the local context (although see Spalek et al., 2010; we come back to this point in the General Discussion). We will refer to this view as the *accommodation hypothesis.*

Within this working model, testing for the presence of nonlocal phonological constraints on determiner retrieval performance provides a discriminative test between the alternating forms and the accommodation hypothesis. Observing an effect of nonlocal constraints would provide evidence against the accommodation hypothesis but would be consistent with the alternating forms hypothesis, inasmuch as it involves an unrestricted selection process. Alternatively, if the effect of nonlocal constraints is absent (in a reliable and interpretable manner), this would be most consistent with the accommodation hypothesis, or with the alternating forms hypothesis, but only with a restricted selection process.

Although the research described in the previous section has involved many languages (e.g., English, Italian, French), the experiments we report here were all conducted in French. This language allows the conditions needed for testing the alternative hypotheses to be constructed. Moreover, whereas previous studies resorted to different paradigms (picture word interference vs. noun phrase production), we used the same paradigm for all the determiners we examine (i.e., the experimental paradigm used in Spalek et al., 2010; see also Alario and Caramazza, 2002). Native speakers were asked to name pictures using determiner + adjective + noun sequences, while phonologically consistent and inconsistent conditions were contrasted (i.e., where the prenominal adjective and noun require the same vs. different determiner forms).

The alternative forms and accommodation hypotheses were tested with different types of determiners. First, we performed a conceptual (i.e., not literal) replication of Alario and Caramazza's (2002) Experiment 3. We tested determiners whose alternation is typically described as allomorphic (mon/ma). This alternation is not expected to rely on accommodation processes. Thus it is expected to be sensitive to nonlocal constraints (as reported in Alario & Caramazza, 2002). Then we tested the definite determiners *le* (*l'*) and *la* (*l'*), whose alternation is thought to involve accommodation processes (e.g., Foucart et al., 2010). These should not be sensitive to nonadjacent words. In light of the findings, we will reconsider the evidence available in French and other languages.

Experiment 1

In French, the singular possessive determiner takes the gender of the object possessed (and not that of the possessor, as is for instance the case in English). Moreover, the feminine determiner is realized as [ma] before consonants (e.g., *ma chaise*$_{fem}$ 'my chair') and as [mɔ̃n] before vowel-initial words (*mon armoire*$_{fem}$ 'my cupboard'). Alario and Caramazza (2002) reported that the production of noun phrases starting with the French singular feminine possessive determiner is delayed (+34 ms) when followed by an adjective and noun that require different determiner forms (phonological inconsistent condition; e.g., *mon ancienne table* 'my old

table'). This suggests that the production of this determiner does not involve the application of a local rule to a single underlying representation. Our first step was to perform a replication of Alario and Caramazza's Experiment 3, albeit with different materials and different participants. This was intended to ensure that, with our set of stimuli, it is possible to observe an effect of phonological consistency.

Method

Participants. Eighteen native French speakers, all university students, took part in this experiment. They were given course credit for their participation.

Material. Following Alario and Caramazza (2002), we selected two adjectives that are frequently found in prenominal position in French. One adjective started with a vowel (*ancienne* 'old'), and the other started with a consonant (*nouvelle* 'new'). The vowel-initial adjective requires gender agreement (ancienne$_{fem}$ vs. ancien$_{masc}$). The consonant-initial adjective also requires gender agreement (nouvelle$_{fem}$ vs. nouveau$_{masc}$); in addition, the masculine form of the adjective varies with the phonology of the next word (nouveau$_{masc}$ before consonant and nouvel$_{masc}$ before vowel). To simplify the interpretation of the contrasts devised below, involving manipulations of noun phonology in relation to determiner selection, the experimental targets were all feminine nouns. We selected 40 pictures representing feminine nouns (see Appendix A for the complete list of stimuli). Half of these corresponded to vowel-initial nouns (e.g., *armoire* 'cupboard'), and the other half corresponded to consonant-initial nouns (e.g., *table* 'table'). In addition, 10 filler items were added, all of which were masculine.

In order to elicit the production of these two adjectives with each noun, we used two versions of each picture. For the adjective *nouvelle*, we used the original solid line black drawings. For the adjective *ancienne*, these original pictures were slightly blurred with the software Adobe Photoshop 5.5 (see Figure 4 in Alario & Caramazza, 2002, for an example). Although this blurring may have an effect on visual performance, the theoretical argument hinges on the interaction between adjective and noun properties.

Procedure. The experimental software DMDX (Forster & Forster, 2003) was used to control stimulus presentation, timing, and data collection for all experiments. The experiment started with a familiarization phase. During this phase, participants were presented with all the pictures and their corresponding nouns. They were then asked to name each picture preceded by the singular possessive determiner and the relevant adjective. For experimental (feminine) items, these were *ma nouvelle* 'my new' and *mon ancienne* 'my old', depending on the picture format (e.g., *ma nouvelle table* 'my new table'). For the masculine fillers, these could be /mɔ̃nuvo/, /mɔ̃nuvɛl/, /mɔ̃nɑ̃sjɛ̃/ or /mɔ̃nɑ̃sjɛn/. The 100 different adjective–noun combinations were presented twice, in two consecutive blocks. Each block started with two warm-up trials. The items were randomized such that no more than three consecutive trials requiring the same determiner–adjective pairs were presented. Each trial had the following structure: an empty screen for 300 ms, followed by a fixation cross shown at the center of the screen for 500 ms, followed by the presentation of the picture. The picture remained on the screen until the participant responded or a maximum duration of 2,000 ms had elapsed. After a 1,000-ms blank screen interval, the participant pressed a key to start the next trial.

Data analyses. In all experiments, we analyzed participants' responses and latencies by means of (generalized) mixed-effects regression models (e.g., Baayen, Davidson, & Bates, 2008; Goldstein, 1987) using the statistical software R (R Development Core Team, 2007–2013). The random part of the model included random intercepts for participant and item, and random slopes allowing for the effects of the predictors to differ across participants or items for all between-unit predictors (see, e.g., Baayen & Milin, 2010; Barr, Levy, Scheepers, & Tily, 2013). All the results we report stem from models with the maximal random effects structure. Moreover, a sequential analysis of variance (Baayen, 2008) was conducted to ensure that, for the fixed part of the model, each predictor or interaction contributed significantly to explaining the variance in the dependent variable.

In the presentation of the results, we report the estimates and t values of the model with the maximal random effect structure. Estimations of p values made use of the posterior probabilities of a Markov chain Monte Carlo simulation with 10,000 runs. As the function to obtain p values from posterior probabilities of Markov chain Monte Carlo simulations is not yet implemented in R for models with random slopes, the p values were estimated from the corresponding models with random intercept for participant and item only. In all the statistical models, we took the inverse of the production latencies as our dependent variable, as indicated by the Box–Cox test (Box & Cox, 1964). These values are provided for information only. Significance was assessed using two criteria: a t value above 1.96 for the estimate and the p value from the sequential F tests (see Baayen, 2008).

The fixed part of the model initially included phonological consistency, adjective onset (whether a vowel or a consonant), and several variables capturing diverse properties of the nouns and pictures (age of acquisition, number of syllables, name agreement, lexical frequency, visual complexity, image variability). In Experiment 3, the predictor "grammatical gender" was also included. Notably, in the literature, phonological consistency effects are reported with two different analyses: in terms of an interaction between the onset of the adjective and that of the noun (Spalek et al., 2010) or by grouping and comparing trials as a function of the consistency of their onsets (Alario & Caramazza, 2002). The main advantage of the latter analysis is the possible inclusion in the model of the effect of adjective (or noun) onset and its interaction with phonological consistency. For this reason, we opted for an analysis in terms of consistency effects.

The models we present contain only those fixed effects that reached significance or that were involved in a significant interaction (alpha level = 0.05). Following Baayen (2008), residuals larger than 2.5 times the standard deviation were considered outliers and were removed from all models. This procedure ensured that the results were not driven by a small number of atypical data points.

Results and Discussion

All responses were checked for accuracy, and errors were removed prior to any statistical analysis. There were 212 errors (7%), most of them due to dysfluencies (53% of errors). Of the remaining errors, 14% involved the noun, 20% the adjective, and

12% the determiner; 1% were no responses. Nine additional data points were removed due to voice key malfunctioning. The probability of producing an error was not influenced by the phonological consistency between onsets ($p > .1$).

Visual examination of the distribution by means of a quantile-quantile plot led us to disregard the 8 data points above 1,500 ms (0.4% of data). Whenever a response for a given noun was missing, the corresponding trial with the other adjective was excluded from the data set (183 data points, 7% of correct responses). The mean latency of the 2,468 remaining correct responses was 662 ms (confidence interval = ±6 ms). Mean latencies broken down by adjective and noun onset (consonant initial vs. vowel initial) are summarized in Appendix B. Figure 1 (left panel) shows the mean production latencies as a function of the phonological consistency between onsets.

Results revealed a main effect of phonological consistency with longer latencies for inconsistent adjective–noun combinations (i.e., different onset for adjective and noun) than for consistent sequences (i.e., same onset for adjective and noun, $\beta = 4.10\ 10^{-5}$, $t = 3.13$, $p < .0001$).[3] In addition, they revealed a main effect of adjective onset, with longer response latencies for sequences whose adjective starts with a vowel ($\beta = 3.99\ 10^{-5}$, $t = 2.09$, $p < .0001$). Response latencies were also longer for late than for early acquired words ($\beta = 7.47\ 10^{-5}$, $t = 4.24$, $p < .0001$) and for sequences with more syllables ($\beta = 7.66\ 10^{-5}$, $t = 2.90$, $p < .01$). The apparent difference in the phonological consistency effect across adjective (or noun) onsets was not significant (i.e., the interaction between the onset of the adjective and the consistency between onsets is not significant, $t = 0.91$).

These results provide a conceptual replication of the observations made by Alario and Caramazza (2002) with a different set of stimuli and a different statistical analysis. The consistency effect confirms that the alternation between *ma* and *mon* in feminine noun phrases is not the result of a strictly local process.

Experiment 2

We are now in a position to use the paradigm to test the production of the French definite singular feminine determiner, realized [la] before consonant-initial words and [l] before vowel-initial words. In Experiment 2, we examine whether this determiner also shows a phonological consistency effect; that is, shorter response latencies for sequences in which the adjective and noun call for the same determiner form (e.g., *la nouvelle table* 'the new table', *l'ancienne armoire* 'the old cupboard') than for sequences in which the adjective and the noun call for different determiner forms (e.g., *l'ancienne table* 'the old table', *la nouvelle armoire* 'the new cupboard'). Within the accommodation hypothesis of our working model, the only information that is relevant for the production of the reduced form [l] is the onset of the word that immediately follows the determiner. This view predicts no difference between consistent and inconsistent sequences. By contrast the alternative forms hypothesis with unrestricted selection predicts an advantage for consistent sequences.

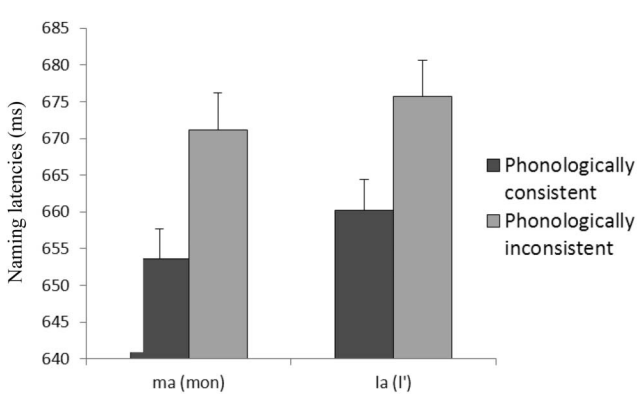

Figure 1. Mean production latencies (raw data) as a function of the phonological consistency between the adjective and the noun in Experiments 1 (determiner ma, left panel) and Experiment 2 (determiner la, right panel). The bars represent the standard errors of the means.

Method

Participants. A total of 18 native French speakers from the same pool as in Experiment 1 participated in the study. They had not participated in Experiment 1. They were given course credit for their participation.

Material, design, and procedure. The materials, design, and procedure were identical to those of Experiment 2, except that participants were instructed to use the definite singular determiner *la* (*l'*) or *le* (*l'*).

Results and Discussion

All responses were checked for accuracy, and errors were removed prior to any statistical analysis. There were 198 errors (7%), most which were due to dysfluencies (51% of errors). Of the remaining errors, 14% involved the noun, 27% the adjective, and 4% the determiner; 4% were no responses. Twenty-one additional data points were removed due to voice key malfunctioning. The probability of producing an error was not influenced by the phonological consistency between onsets ($p > .1$).

Visual examination of the distribution by means of a quantile-quantile plot led us to disregard the 20 data point above 1,500 ms (0.8% of data). In addition, whenever a response for a given noun was missing, the corresponding trial with the other adjective was excluded from the dataset (184 data points, 7% of the correct responses). The mean latency of the remaining 2,461 correct responses was 662 ms (confidence interval = ±10). Mean latencies broken down by adjective and noun onset (consonant initial vs. vowel initial) are summarized in Appendix B. The mean production latencies as a function of the phonological consistency between onsets are shown in Figure 1 (right panel).

Results revealed an effect of phonological consistency, with inconsistent sequences being produced with longer latencies than consistent sequences ($\beta = 3.56\ 10^{-5}$, $t = 3.4$, $p < .001$). Production latencies were also influenced by the age of acquisition of the noun ($\beta = 6.74\ 10^{-5}$, $t = 4.91$, $p < .0001$) and its number of syllables ($\beta = 5.42\ 10^{-5}$, $t = 2.57$, $p < .01$). There was no effect

[3] In this and subsequent experiments, we also carried out an analysis in which we removed the predictor "phonological consistency" and introduced instead the interaction between adjective and noun onset (as was done in previous studies; i.e., Spalek et al., 2010). In all experiments, this interaction is significant.

of adjective onset ($t = 0.47$) and no interaction between adjective onset and phonological consistency ($t = -0.43$). The fact that production latencies are influenced by the phonological properties of the two content words of the noun phrase is consistent with the alternative forms hypothesis with unrestricted selection.

Experiment 3

In Experiment 3, we test the generalizability of the results of Experiments 1 and 2 to other contexts (i.e., other adjectives and nouns) and to the definite masculine French determiner *le*. Foucart et al. (2010) proposed that the use of the reduced variants in front of vowels for the French definite singular determiner *le* and *la* results from the application of a phonetic adaptation rule.

Foucart et al. (2010) did not provide results for each grammatical gender separately; thus, in theory, it is possible that the gender congruency effect they reported is mostly driven by the masculine determiner. *Le* differs from *la* (and from *ma*) in an important way. The phonological constraints governing the realization of *le* are not systematic. Whereas the same variant (l') is invariably used in front of vowels, both determiner forms are used in front of consonants (see, e.g., Côté and Morrison, 2007). In fact, the use of the reduced from *l'* before consonant-initial words might be even more frequent than the nonreduced form *le* in some contexts. For instance, in a sentence like *Prends le paquet de mouchoirs* [Take the pack of tissues], the masculine definite determiner is more likely to be realized [l] than [lə]. Because both variants of the determiner can be used in the same context, it is possible that the onset of the nonlocal noun has a reduced impact on the naming latencies for the whole sequence.

In Experiment 3, we use the same paradigm as in Experiments 1 and 2 to examine whether a phonological consistency is also found when the masculine and feminine forms *le* and *la* are considered within the same experiment and whether this effect differs across genders.

Method

Participants. Eighteen native French speakers, all university students between 18 and 35 years of age, took part in the experiment. They had not participated in the previous study. They were paid for their participation.

Materials. We selected 60 pictures representing masculine nouns and 60 pictures representing feminine nouns. In each group, there were 30 vowel-initial and 30 consonant-initial nouns (see Appendix C). Four adjectives were also selected. As in Experiments 1 and 2, we used the adjectives *ancien/ancienne* and *nouveau/nouvelle*. As mentioned above, the masculine forms of these two adjectives alternate with the phonology of the next word (e.g., $\text{nouveau}_{\text{masc}}$ before consonant and $\text{nouvel}_{\text{masc}}$ before vowel), which introduces a potential additional difficulty for the speaker. Thus, in our statistical analyses, we considered only the feminine noun phrases for these two adjectives ($N = 30$). We selected an additional adjective pair that we could use for both the feminine and masculine nouns. One adjective started with a vowel (*immense* 'huge') and the other started with a consonant (*demi* 'half'). Each noun was associated with one adjective pair (either demi/immense or nouveau/ancien). Given that the adjectives *nouveau–nouvelle* and *ancien–ancienne* were to be elicited in the context of *demi* and *immense*, we modified the representation of these adjectives so as to maximize the contrast between the four adjectives. For the adjective *ancien–ancienne*, the original pictures were blurred and colored to resemble the sepia style of old pictures. For the adjective *nouveau–nouvelle*, we added alternating black and white lines around the original black outline pictures to mimic the shining aspect of a new object. In order to elicit the adjective *demi*, we applied a semi-opaque white mask to the right-hand half of the original black outline pictures. This way, the whole picture was still visible but the right-hand part was much less clear. In order to elicit the adjective *immense*, the pictures were enlarged so as to touch the black square. Examples of the pictures used in Experiment 3 are presented in Figure 2.

In order to maximize the distance between trials involving the same target noun, we constructed two lists. Each noun appeared once with a different adjective in each list. Lists were balanced in terms of adjective type, grammatical gender, and consistent versus inconsistent sequences. The lists were presented one after the other, and their order was counterbalanced across participants. Given the higher number of sequences (240) involved in this experiment, each adjective–noun combination was presented once only.

Procedure. In this experiment, in addition to being familiarized with the pictures and their corresponding nouns (as in all other experiments), participants were familiarized and trained with the adjectives. Training with the adjectives was progressive and involved four steps. Participants were first presented with four versions of the same object, each representing one of the four adjectives to be used in the experiment. The name of the adjective appeared next to the picture, and the participants were told to memorize the association between the visual display and the adjective. The four pictures and their corresponding adjective were presented twice. During the second step, participants were presented with the same pictures and had to produce the adjective in

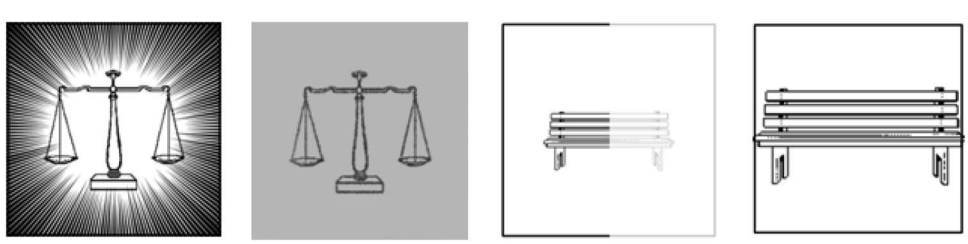

Figure 2. Examples of pictures used in Experiment 3 to elicit the production of the adjectives *nouvelle* 'new', *ancienne* 'old', *demi* 'half', and *immense* 'huge' (from left to right).

isolation. A novel object, with, again, four different versions, was then introduced, and participants had to name the adjective in isolation. Feedback was provided by the experimenter. During the third step, participants had to name the object using the determiner, the adjective, and the noun, in blocks of four trials. In each block, the object remained the same but the visual display was varied. During the last step, they performed the same task as in the experiment, and the object varied from trial to trial. This progressive training was introduced to compensate for the increased difficulty of the task. Whereas in Experiments 1 and 2, participants had to select one among two antagonist adjectives, in Experiment 3, they had to select among four adjectives, and three of them were not antagonist to one another.

During the experiment, a fixation cross first appeared on the screen and stayed there for 800 ms, followed by a 200-ms blank screen interval. The picture then appeared on the screen and remained there for 4,000 ms or until a response was given. A 1,000-ms blank screen interval separated trials.

Results and Discussion

All responses were checked for accuracy, and errors were removed prior to any statistical analysis. There were 659 errors (20%), most being due to dysfluencies (71% of errors). Of the remaining errors, 15% involved the noun, 3% the adjective, and 5% the determiner; 5% were no responses. A further 1% of the data was removed due to difficulty in setting the response onset. The probability of producing an error was not influenced by the phonological consistency between onsets ($p = .5$) or by gender ($p = .9$), and there was no interaction between gender and phonological consistency ($p = .5$).

Automatically generated response latencies were adjusted whenever necessary with the CheckVocal software (Protopapas, 2007). Visual examination of the distribution by means of a quantile-quantile plot led us to disregard the 38 data points above 2,200 ms and the one data point below 500 ms (2% of data). Whenever a response for a given noun was missing, the corresponding trial with the other adjective was excluded from the data set (228 data points, 9% of correct responses). The mean latency for the 2,312 remaining data points was 966 ms (confidence interval = ±12 ms). Mean latencies for target and filler sequences, broken down by adjective and noun onset (consonant initial vs. vowel initial) and gender, are summarized in Appendix D.

Mean production latencies for phonologically consistent and inconsistent sequences as a function of grammatical gender are shown in Figure 3. Mean response times for fillers were 1,030 ms for consistent sequences and 1,060 ms for inconsistent sequences. The analysis (target words) revealed a main effect of phonological consistency ($\beta = 4.10\ 10^{-05}$, $t = 3.68$, $p < .0001$), with shorter naming latencies for consistent than for inconsistent sequences. In addition, naming latencies were shorter for sequences whose adjectives started with a consonant ($\beta = 5.26\ 10^{-05}$, $t = 3.73$, $p < .0001$) for early than for late acquired words ($\beta = 6.80\ 10^{-05}$, $t = 5.32$, $p < .0001$) and for masculine than feminine sequences ($\beta = 5.27\ 10^{-05}$, $t = 2.98$, $p < .001$). Crucially, there was no interaction between gender and phonological consistency ($t = 1.4$). Moreover, the apparent difference in the phonological consistency effect across adjective (or noun) onsets was not significant (i.e., the interaction between the onset of the adjective and the consistency

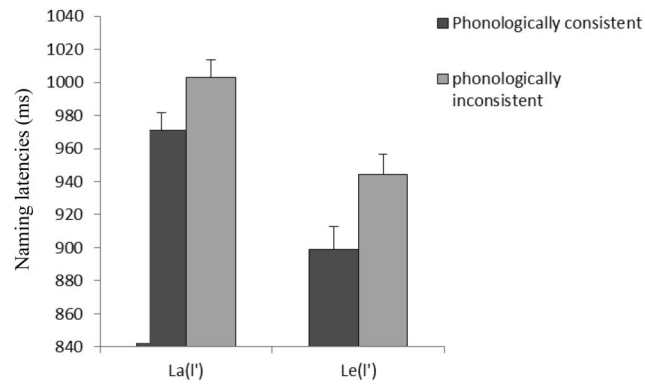

Figure 3. Mean production latencies (raw data) as a function of phonological consistency, broken down by gender, in Experiment 3. The bars represent the standard errors of the means.

between onsets was not significant, $t = 1.7$). There was no three-way interaction among gender, adjective onset, and phonological consistency ($t = 0.13$).

These results extend the findings of Experiment 2. They show that the phonological consistency effect for the French singular definite determiner is not restricted to the feminine nouns or feminine determiner forms and that it can be elicited with a variety of adjectives and stimulus displays. This conclusion, in turn, strengthens the view that the production of [l] before vowel-initial masculine and feminine words is not the result of a late local accommodation process. Results of Experiments 1 to 3 rather favor a view in which alternating forms enjoy alternative lexical representations, whose selection is influenced by both adjacent and nonadjacent words.

Note that in the present research we discuss mostly the possibility that determiners whose pronunciation varies with phonological context have two phonological representations, typically, one for the form used before consonants and one for the form used before vowels (see, however, the discussion of /le/ in the motivations of Experiment 3). Some determiners have more than two pronunciation variants. For instance, the English indefinite determiner form *an* can be realized /ən/ or /æn/ before vowels, and the form *a* can be realized /ə/ or /æ/. An interesting goal for future research will be to examine the representation of determiners with more than one pronunciation in a given phonological context.

General Discussion

Our goal in the present work was to examine the mechanisms and representations underlying the production of words whose form varies with the phonological context. To this end, we focused on French determiners, because many of them are constrained by the phonological context.

Summary of the Evidence

In three experiments, participants named pictures with determiner + adjective + noun phrases. Phonologically consistent or inconsistent conditions were contrasted, based on the phonological onsets of the adjective and noun. The accommodation hypothesis predicted no difference between conditions, whereas the alterna-

tive forms hypothesis with unrestricted selection predicted shorter latencies for consistent than for inconsistent sequences (i.e., a phonological consistency effect). Experiments 1 to 3 showed a reliable phonological consistency effect for the possessive determiners *ma* [ma] (realized [mɔ̃n] before vowel-initial words (e.g., *mon armoire* 'my cupboard') and for the feminine (la) and masculine (le) definite determiners (realized [l] before vowels; e.g., *l'armoire* 'the cupboard'). Within the working model developed in the introduction, these data stand in contrast to the accommodation hypothesis but are consistent with the alternative forms view with an unrestricted selection process. In the remainder of the General Discussion, we reconsider the definitions used in our working model and attempt to provide an integrative view of determiner representation and retrieval.

On the Phonological Representation of Determiners

Our working model stands at the crossroads of linguistic and psycholinguistic research, directly inspired from previous proposals made in those contexts. In linguistic and psycholinguistic studies two views can be found, which correspond roughly to the distinction we made between the alternative forms and the accommodation hypotheses.

According to the first linguistic view, phonologically constrained determiners have an underlying representation ("allomorph" in linguistic terms) for each pronunciation variant. Accounts of this kind have, for instance, been proposed to describe the alternation between the forms *a* and *an* of the English indefinite determiner (see Zwicky, 1986 or Nevins, 2011). Similarly, Raymond et al. (2002) discussed their corpus data on the English definite and indefinite determiners in terms of multiple representations (see also Neu, 1980, for a similar discussion for the English function word *and*).

According to a second view, phonologically constrained determiners have a single underlying representation, the other surface form being derived via a phonological rule. In Selkirk and Vergnaud (1973), several simple phonological rules of this kind are reviewed. For instance, the following rule accounts for the alternation between *le/la* and *l* in French: V→∅/___#V ("the vowel of the definite determiner is deleted before a consonant-initial word but not before a vowel-initial one"; Selkirk & Vergnaud, 1973, p. 250). Crucially, the latter view involves the local context (i.e., the word that is directly adjacent to the phonologically constrained word). In these linguistic accounts, rules indeed operate locally.

In psycholinguistic research, determiners, like content words, are most often thought to have phonological representations, roughly equivalent to the lexeme representations that have been posited for nouns.[4] In this context, the production of context-dependent determiners has been suggested to rely on an active selection mechanism operating on multiple phonological representations (Miozzo & Caramazza, 1999). This fits with the alternative forms hypothesis of the working model. Alternatively, the stored form that is retrieved is thought to be adjustable to its context, for example, through phonological rule based processes (Foucart et al., 2010; Spalek et al., 2010). This is in line with the accommodation hypothesis of the working model (although Spalek et al. suggested that accommodation may occur nonlocally; see below).

In particular, Foucart et al. (2010) suggested that *le* and *la* would be good candidates for a local ("phonetic") adjustment process applied to an underlying representation, given the close phonological relationship between the variants (i.e., the presence/absence of one phoneme) and given that the reduced form of both genders corresponds to the same pronunciation. To these arguments, we could add that vowel elision is not specific to these two words but occurs in a variety of contexts (e.g., pronouns, *j'aime* 'I like', *ils m'ont appelé* 'they called me'; nouns, *ch'val* 'horse'; adverbs, *il n'a pas* 'he doesn't have') and could, therefore, be easily accounted for in terms of a general phonological rule. In contrast to what we would normally expect, our results show that the alternation between *le* (or *la*) and the reduced form *l'* is subject to nonlocal constraints. A strictly local process applied to an underlying phonological representation cannot account for these results.

To account for our results, one option is to abandon the idea that an accommodation process is responsible for the alternation between forms and to adopt the alternative forms hypothesis in which determiner forms are retrieved but not adjusted. In this view, the three forms *le*/*la*/*l'* are stored as such and are discriminated one from another through a selection process that is sensitive to the broad phonological context. This option has the advantage of parsimony. It allows dispensing with what was essentially, in Foucart et al.'s proposal, a double selection process: "*le/la* would always be selected 'by default' but could only be 'fully' selected once the post-selection rule had been checked with reference to the local context" (Foucart et al., 2010, p. 1416). This option also allows preserving the hypothesis that all determiners within a language are retrieved through a similar process (Caramazza et al., 2001) and accounts for phenomena occurring in other Romance languages. For example, Miozzo and Caramazza's (1999) Experiment 5 shows a phonological consistency effect in Italian for the masculine definite determiner il/lo.

An alternative option, which would be along the lines of Spalek et al.'s (2010) account, is to abandon the idea that accommodation should only be local. Spalek et al. reported phonological consistency effects in English, thus showing that this phenomenon can be observed in the absence of the grammatical gender constraint. According to one of their accounts, the alternative forms of a given determiner (e.g., *the* and *thee*, or *a* and *an*) are generated by assimilation processes. In Spalek et al.'s account, the representation on which assimilation operates is not specified. One option is that determiners are represented in the phonological lexicon with a single phonological representation, which is to be used with every noun. This stored phonological representation is likely to correspond to either one of the surface forms. This predicts that the consistency effect should be asymmetrical (i.e., not present for the stored form, which is readily retrieved as needed for production). Our data allow us to reject this possibility, at least for French, as the consistency effect did not interact with the adjective phonology factor (i.e., the consistency effect was not weaker for the citation form).

Finally, along the lines of another of Spalek et al.'s (2010) proposals, nouns may be linked to their "default" determiner form (e.g., *a* or *the* for consonant-initial nouns, *an* or *thee* for vowel-initial nouns). The phonological consistency effect would arise

[4] In addition, they may also have lemma representations that do not comprise phonological information, but this issue is beyond our discussion of phonological representations.

because, in inconsistent sequences, the default determiner form retrieved by the noun competes with an alternative form prompted by the adjective. In this view, there are representations for all of the forms (e.g., *a* and *an*) of phonologically constrained determiners (e.g., indefinite). Therefore, this account is essentially similar to the alternative forms hypothesis with unrestricted selection. The main difference lies in the process prompted by the adjective: nonlocal assimilation, in Spalek et al.'s account, and activation, in our account (see also Alario & Caramazza, 2002). Determining whether this secondary distinction between the accounts leads to discriminating predictions is not straightforward, and the issue is left for future research. Such research should primarily address how adjectives prompt determiner forms and identify boundary conditions for the activation of determiners by nonadjacent words; for example, by manipulating adjective–noun order (pre- vs. postnominal), the number of adjectives, or their relative availability (e.g., lexical frequency as in Alario et al., 2002). The issue should be addressed in the light of previous studies of the dynamics of lexical activation and the scope of phonological planning that precedes vocal onset. Across various languages and noun phrase structures, there is evidence of phonological activation of both noun and adjective before vocal onset (Costa & Caramazza, 2002), with the noun being possibly more activated than the adjective (Damian & Dumay, 2009).

In summary, the account that seems to be the most compatible with the data, and the most parsimonious, is one in which the phonological variants of a determiner are represented. These forms are retrieved at the moment of production, and a selection process chooses from among the alternatives those forms that are (at least partially) compatible with the context of occurrence.

Toward a General Model of Determiner Processing

The proposal that varying determiners are stored in memory with multiple phonological representations is not novel. Most studies in the psycholinguistic literature have implicitly assumed multiple representations for determiners with multiple pronunciations. To our knowledge, however, this specific assumption has never been explicitly tested. Our interpretation leads us to argue that, pending further evidence, this assumption applies to many determiners. This conclusion is not at all trivial, as it allows for apprehending determiner selection in general terms.

In this context, we can propose the following mechanism of determiner processing, which integrates the present research's findings as well as previous findings in the literature, in Romance or Germanic languages. In this model all determiner forms are represented similarly, irrespective of the language. Determiners whose pronunciation depends on the phonological context have a representation for each pronunciation (or surface form).[5] During the production of a noun phrase involving a determiner, the lemma of the determiner is selected based on the noun's gender and conceptual information (e.g., whether the referent is indefinite or definite). This lemma, in turn, activates its corresponding lexeme(s). In a model without lemmas, the same may occur with lexemes being tied to grammatical gender.

In line with the late selection hypothesis, our model of determiner processing assumes different dynamic parameters of lexeme selection in Germanic versus Romance languages. In Germanic languages, the determiner lexeme is activated and can be selected as soon as the corresponding lemma has been selected. In languages in which the determiner form is dictated by the onset of the following word(s), the phonological form of the noun is selected first. The noun's lexeme then activates the corresponding determiner lexeme. In the presence of a prenominal adjective (e.g., *l'immense chien* 'the huge dog'), the adjective form also receives activation from the noun's lemma (and possibly from its lexeme, at least when the adjective form depends on the noun's phonological properties). Once selected, the noun and adjective forms send activation to the determiner form(s). This proposal, then, does not include nonlocal adaptation processes. Therefore, when both the adjective and noun call for the same determiner form, only this form will receive some activation. In contrast, when the two words each call for a different form, the two forms will receive some activation. The production of the latter sequences will be delayed in time, either because the activation level required for production is reached later or because of a competition mechanism in which both determiner forms receive activation and, thus, compete (for discussions related to the competitive versus noncompetitive nature of determiner selection, see Janssen, Schiller, & Alario, 2012; Jescheniak, Schriefers, & Lemhöfer, 2012). Alternatively, a graded value of activation could be computed on the basis of the phonological content of the noun phrase, and this value would then be sent to the determiner form (see Eberhard et al., 2005 for a mechanism of this kind in the context of the influence of local noun on noun–verb agreement).

In the same vein, the presentation of two nouns with different genders (as in, for instance, the picture word naming paradigm) will activate the determiner forms that correspond to both genders. This again results in a delay. This delay is the source of gender congruency effects in Germanic or Romance languages. The fact that the gender congruency effect occurs at a later SOA in French (Foucart et al., 2010; but see Miozzo et al., 2002) than in German or Dutch can be interpreted within the same framework and in accordance with the late selection hypothesis (Caramazza et al., 2001; Miozzo & Caramazza, 1999). In order for a distractor word to generate a gender congruency effect, it has to be presented at the time window within which the target word's determiner form(s) becomes activated. In languages with phonologically constrained determiners, the production of noun phrases with determiners requires that the noun's phonological properties be accessed before the activation of the relevant determiner forms. Determiner form selection is thus delayed in these languages, in contrast to languages in which determiner form does not depend on phonological constraints.

[5] We adopt the view of traditional abstractionist models of word production on lexical representations and phonological encoding processes. In these models, the words' acoustic forms are represented in the mental lexicon under the form of sets of abstract units (or lexemes). During the production process, these lexemes are activated by the corresponding lemmas. Once selected, a lexeme is phonological encoded; that is, its phonemes are ordered and inserted in the metrical structure. We do not consider the possibility that acoustic forms of words are stored in acoustically detailed exemplars (see Pierrehumbert, 2001, for convincing arguments against purely exemplarist accounts of speech production).

Phonological Representations of Alternating Words Across Word Classes

The present research adds to the more general debate on the representation and processes underlying words with pronunciation variants. The realization of many content words, like that of determiners, depends on the surrounding context. For instance, in British English, words ending with an /r/ are pronounced without their last phoneme when followed by a consonant or produced in isolation (e.g., *car* [kɑː]; Levelt, 1989) and with the /r/ when preceding a vowel (e.g., in *the car is running*). Similarly, in French, the adjective *beau* 'nice' is realized [bo] with a masculine noun when followed by a consonant-initial word (e.g., *beau bureau* 'nice desk') and [bɛ1] with the same gender but a vowel-initial word (*bel arbre* 'nice tree'). In this same language, it is also often the case that, as the result of the well-known liaison process, adjectives are realized with an additional final consonant when followed by a vowel-initial noun (e.g., *grand chien* 'big dog' vs. *grand* [t]ami 'great friend').

Other alternations are less systematic. For instance, words with a schwa in their initial syllable (e.g., *semaine* 'week') are more likely to be produced without the schwa if preceded by a vowel than if preceded by one or two consonants, but the two pronunciations can nevertheless be found in all contexts. In English, coronal-final phonemes tend to be realized as labial or velar if followed respectively by a labial (e.g., *plain bun* [pleɪmbʌn]) or a velar phoneme (e.g., *plain game* [pleɪŋgeɪm]).

Current psycholinguistic word production models assume that content words have a single underlying representation each. Until recently, this assumption had not been examined with chronometric evidence. Several studies have examined this assumption for content words with two pronunciation variants, a schwa and a non-schwa variant. Results converged to suggest that, as long as the pronunciation variants differ categorically, the two forms are lexically represented (Bürki, Alario, & Frauenfelder, 2011; Bürki & Gaskell, 2012). Notably, several studies in corpus linguistics also point to multiple representations for words with several pronunciation variants (e.g., Hanique, Ernestus, & Schuppler, 2013). For instance, the influence of the words' properties (e.g., lexical frequency) on the distribution and acoustic realization of the variants is often taken to suggest that these variants are lexically represented (Bybee, 2001; Hooper, 1976, see also Pierrehumbert, 2001). Taken together, the available evidence thus suggests that the way pronunciation variants are represented and processed could be relatively similar for content and function words.

Conclusion

The present study provides evidence in favor of the view that determiners with more than one pronunciation variant have several corresponding phonological forms in the mental lexicon, presumably lexemes. Moreover, whereas previous studies pointed to important differences among determiners and languages, our account highlights the similarities in processing and representation present across languages and determiner types.

In our view, then, phonological dependencies affecting determiner forms are likely handled through multiple representations, as has been previously posited for nouns. Language production models should be enriched in their representational structure and their dynamics to account for these phenomena.

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Appendix A

Materials Used in Experiments 1 and 2

Target words	Target words
Allumette (match)	Épée (sword)
Ambulance (ambulance)	Épingle (pin)
Ampoule (lightbulb)	Éprouvette (test tube)
Ancre (anchor)	Équerre (set square)
Antenne (aerial)	Étoile (star)
Assiette (plate)	Fleur (flower)
Balance (scale)	Guitare (guitar)
Balançoire (swing)	Hélice (propeller)
Bassine (basin)	Horloge (clock)
Bougie (candle)	Lampe (lamp)
Bouteille (bottle)	Maison (house)
Casserole (pan)	Oreille (ear)
Ceinture (belt)	Poignée (doorknob)
Chemise (shirt)	Poubelle (bin)
Couronne (crown)	Pyramide (pyramid)
Écharpe (scarf)	Seringue (syringe)
Échelle (ladder)	Tortue (turtle)
Église (church)	Toupie (spinning top)
Enclume (anvil)	Usine (factory)
Enveloppe (envelope)	Valise (suitcase)

Appendix B

Mean Latencies (With Standard Deviations in Parentheses) Broken Down by Adjective and Noun Onset for Noun Phrases Produced With the Possessive Feminine Determiner Ma (Mon) in Experiment 1 and With the Definite Feminine Determiner La (L') in Experiment 2

	Noun onset		
Adjective onset	Consonant	Vowel	*M*
Experiment 1 (ma/mon)			
Consonant	632 (137)	678 (157)	655 (149)
Vowel	664 (139)	676 (148)	670 (143)
M	648 (139)	677 (153)	662 (146)
Experiment 2 (la/l')			
Consonant	650 (175)	685 (211)	667 (194)
Vowel	667 (187)	672 (197)	669 (192)
M	658 (181)	678 (204)	668 (193)

(*Appendices continue*)

Appendix C

Materials Used in Experiment 3

Masculine words			Feminine words		
Noun	Adjective pair	Stimulus type	Noun	Adjective pair	Stimulus type
Agenda (diary)	ancien/nouveau	Filler	Affiche (poster)	ancien/nouveau	Target
Agneau (lamb)	ancien/nouveau	Filler	Agrafeuse (stapler)	ancien/nouveau	Target
Aigle (eagle)	ancien/nouveau	Filler	Ambulance (ambulance)	ancien/nouveau	Target
Arbre (tree)	ancien/nouveau	Filler	Ampoule (lightbulb)	ancien/nouveau	Target
Archet (bow)	ancien/nouveau	Filler	Ancre (anchor)	ancien/nouveau	Target
Bureau (desk)	ancien/nouveau	Filler	Antenne (aerial)	ancien/nouveau	Target
Camion (truck)	ancien/nouveau	Filler	Arche (arch)	ancien/nouveau	Target
Casque (helmet)	ancien/nouveau	Filler	Assiette (plate)	ancien/nouveau	Target
Crayon (pencil)	ancien/nouveau	Filler	Balance (scale)	ancien/nouveau	Target
Éclair (lightning)	ancien/nouveau	Filler	Balançoire (swing)	ancien/nouveau	Target
Écran (screen)	ancien/nouveau	Filler	Cloche (bell)	ancien/nouveau	Target
Écrou (nut)	ancien/nouveau	Filler	Couronne (crown)	ancien/nouveau	Target
Éléphant (elephant)	ancien/nouveau	Filler	Cravate (tie)	ancien/nouveau	Target
Éventail (fan)	ancien/nouveau	Filler	Échelle (ladder)	ancien/nouveau	Target
Évier (sink)	ancien/nouveau	Filler	École (school)	ancien/nouveau	Target
Indien (Indian)	ancien/nouveau	Filler	Église (church)	ancien/nouveau	Target
Journal (newspaper)	ancien/nouveau	Filler	Enveloppe (envelope)	ancien/nouveau	Target
Lit (bed)	ancien/nouveau	Filler	Épée (sword)	ancien/nouveau	Target
Manteau (coat)	ancien/nouveau	Filler	Étoile (star)	ancien/nouveau	Target
Microscope (microscope)	ancien/nouveau	Filler	Guitare (guitar)	ancien/nouveau	Target
Miroir (mirror)	ancien/nouveau	Filler	Maison (house)	ancien/nouveau	Target
Moulin (mill)	ancien/nouveau	Filler	Médaille (medal)	ancien/nouveau	Target
Œil (eye)	ancien/nouveau	Filler	Moto (motorbike)	ancien/nouveau	Target
Oiseau (bird)	ancien/nouveau	Filler	Poupée (doll)	ancien/nouveau	Target
Oreiller (pillow)	ancien/nouveau	Filler	Pyramide (pyramid)	ancien/nouveau	Target
Panier (basket)	ancien/nouveau	Filler	Table (table)	ancien/nouveau	Target
Robot (robot)	ancien/nouveau	Filler	Trompette (trumpet)	ancien/nouveau	Target
Saxophone (saxophone)	ancien/nouveau	Filler	Usine (factory)	ancien/nouveau	Target
Tambour (drum)	ancien/nouveau	Filler	Valise (suitcase)	ancien/nouveau	Target
Violon (violin)	ancien/nouveau	Filler	Voiture (car)	ancien/nouveau	Target
Aimant (magnet)	immense/demi	Target	Aiguille (needle)	immense/demi	Target
Ananas (pineapple)	immense/demi	Target	Aile (wing)	immense/demi	Target
Arc (bow)	immense/demi	Target	Allumette (match)	immense/demi	Target
Arrosoir (watering can)	immense/demi	Target	Anse (handle)	immense/demi	Target
Avion (airplane)	immense/demi	Target	Araignée (spider)	immense/demi	Target
Avocat (avocado)	immense/demi	Target	Asperge (asparagus)	immense/demi	Target
Banc (bench)	immense/demi	Target	Aubergine (eggplant)	immense/demi	Target
Bol (bowl)	immense/demi	Target	Baignoire (bathtube)	immense/demi	Target
Cactus (cactus)	immense/demi	Target	Bibliothèque (bookcase)	immense/demi	Target
Canapé (coach)	immense/demi	Target	Casquette (cap)	immense/demi	Target
Cendrier (ashtray)	immense/demi	Target	Catapulte (catapult)	immense/demi	Target
Champ (field)	immense/demi	Target	Chaise (chair)	immense/demi	Target
Champignon (mushroom)	immense/demi	Target	Cigarette (cigarette)	immense/demi	Target
Chapeau (hat)	immense/demi	Target	Empreinte (fingerprint)	immense/demi	Target
Citron (lemon)	immense/demi	Target	Éprouvette (test tube)	immense/demi	Target
Clown (clown)	immense/demi	Target	Étiquette (label)	immense/demi	Target
Entonnoir (funnel)	immense/demi	Target	Fusée (rocket)	immense/demi	Target
Épi (ear)	immense/demi	Target	Girouette (weathercock)	immense/demi	Target
Escalier (stairs)	immense/demi	Target	Oie (goose)	immense/demi	Target
Igloo (igloo)	immense/demi	Target	Olive (olive)	immense/demi	Target
Œuf (egg)	immense/demi	Target	Orange (orange)	immense/demi	Target
Oignon (onion)	immense/demi	Target	Oreille (ear)	immense/demi	Target
Ongle (nail)	immense/demi	Target	Partition (music sheet)	immense/demi	Target
Orgue (organ)	immense/demi	Target	Pelle (shovel)	immense/demi	Target
Os (bone)	immense/demi	Target	Pomme (apple)	immense/demi	Target
Pantalon (pants)	immense/demi	Target	Roue (wheel)	immense/demi	Target
Parapluie (umbrella)	immense/demi	Target	Tasse (cup)	immense/demi	Target
Peigne (comb)	immense/demi	Target	Tomate (tomato)	immense/demi	Target
Poivron (pepper)	immense/demi	Target	Toupie (spinning top)	immense/demi	Target
Sifflet (whistle)	immense/demi	Target	Urne (box)	immense/demi	Target

(*Appendices continue*)

Appendix D

Mean Latencies Broken Down by Adjective and Noun Onset for Targets (Table D1) and Fillers (Table D2) in Experiment 3

Table D1
Mean Latencies (With Standard Deviations) Broken Down by Adjective and Noun Onset for Sequences Produced With the Definite Determiner La (L') and Le (L') in Experiment 3

	Noun onset						
	La			Le			
Adjective onset	Consonant	Vowel	*M*	Consonant	Vowel	*M*	*M*
Consonant	927 (281)	1,004 (301)	965 (293)	848 (234)	943 (234)	895 (239)	942 (278)
Vowel	1,002 (301)	1,027 (299)	1,014 (300)	945 (247)	969 (281)	956 (263)	996 (290)
M	962 (293)	1,015 (300)	987 (297)	891 (244)	954 (255)	922 (251)	966 (285)

Table D2
Mean Latencies Broken Down by Adjective and Noun Onset for Fillers in Experiment 3

	Noun onset		
Adjective onset	Consonant	Vowel	*M*
Consonant	1,023 (288)	999 (307)	1,011 (298)
Vowel	1,133 (343)	1,037 (297)	1,084 (324)
M	1,074 (319)	1,017 (303)	1,045 (312)