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Observations on the phonetic realization of opaque schwa in Southern French*

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Eychenne, Julien. 2015. Observations on the phonetic realization of opaque schwa in Southern French. *Studies in Phonetics, Phonology and Morphology* 21.3. 457-494. This paper discusses a little-known case of opacity found in some southern varieties of French, where the vowel /ə/, which is footed in the dependent syllable of a trochee, is usually realized as [ø], like the full vowel /Œ/. This case of opacity is particularly noteworthy because the opaque generalization is suprasegmental, not segmental. I show that, depending on how the phenomenon is analyzed derivationally, it simultaneously displays symptoms of counterbleeding and counterfeeding opacity. A phonetic analysis of data from one representative speaker is carried out, and it is shown that the neutralization between /ə/ and /Œ/ is complete in this idiolect. Implications for the structure of lexical representations and for models of phonology are discussed in light of these results. **(Hankuk University of Foreign Studies)**

Keywords: schwa, Southern French, opacity

1. Introduction

Opacity is one of the most fundamental issues in generative phonological theory. The traditional view of opacity, due to Kiparsky (1971, 1973) and framed within the derivational framework of *The Sound Pattern of English* (henceforth SPE, Chomsky and Halle 1968), goes as follows:

(1) Opacity (Kiparsky 1973: 79)
A phonological rule P of the form $A \rightarrow B \ / \ C\_\_D$ is opaque if there are

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surface structures with either of the following characteristics:

a. instances of *A* in the environment *C__D*.
b. instances of *B* derived by *P* that occur in environments other than *C__D*.

Using McCarthy's (1999) later terminology, rule *P* in (1a) seems to have *underapplied*, since the surface string *CAD* contradicts the generalization that *CAD* should be rewritten as *CBD* (in that case, *P* is *non-surface-true*), whereas in (1b) rule *P* seems to have *overapplied*, since the environment that made its application possible in the first place is not visible on the surface (*P* is *non-surface-apparent*). Kiparsky associated the symptoms (1a) and (1b) with two types of rule interaction: (1a) is understood to be the result of a *counterfeeding* relation, whereby the generalization *P* would have been fed by another rule *Q* if *Q* had applied before *P*; in other words, *Q* could have created more opportunities for *P* to apply (a relation known as *feeding*), but *Q* was ordered too late in the derivation. On the other hand, (1b) is symptomatic of a *counterbleeding* relation; *P* could have been prevented from applying by *Q* (a relation known as *bleeding*) if *Q* had applied before *P*, but *Q* was ordered too late in the derivation for that to happen. According to Kiparsky, counterfeeding and counterbleeding are *opaque* rule orderings, whereas feeding and bleeding are *transparent*. Kiparsky further claimed that opaque rule orderings were more difficult to learn, and that sound change tended to shift phonological grammars towards transparent rule ordering.

A number of works have questioned the extent to which opaque generalizations can be said to be truly opaque. As a reaction to the excessive abstractness of underlying representation in SPE, the framework of Natural Generative Phonology set stringent restrictions on phonological rules via the True Generalization Condition, which claims 'that the rules speakers formulate are based directly on surface forms and that these rules relate one surface form to another, rather than relating underlying to surface forms' (Hooper 1976: 13), which had the effect of banning opaque analyses of phonological phenomena. More recently, in the context of Optimality Theory (OT, Prince and Smolensky 1993 and subsequent work), the issue of opacity has come under intense scrutiny since standard OT is not able to model most cases of opacity, as they crucially rely on the existence of an intermediate form between the input and output (Baković 2007). A number of scholars have argued that OT's approach is in fact fundamentally correct, and that problems are due to how opacity itself is conceptualized. For instance, Sanders (2002) reanalyzed the interaction

between /ɔ/ raising before a word-final voiced consonant and final devoicing of obstruents in Polish, two processes which are traditionally assumed to interact opaquely (e.g. /grɔb/ → [grup] 'grave', /grɔb+i̵/ → [grɔbi̵] 'graves'). The author presents evidence from loanword adaptation and from a nonce word experiment that together suggest that /ɔ/ raising may not be a synchronically active process. In a similar vein, Mielke et al. (2003) discuss two types of opacity, that they dub allophonic opacity and lexicalized opacity, which, at least in some cases, may be amenable to a transparent reanalysis. The interaction between raising and flapping in Canadian English is an illustration of the former type; the diphthongs /ɑw/ and /ɑj/ rise to [ʌw] and [ʌj] respectively before a voiceless obstruent (compare *house* (verb) [hɑwz] and *house* (noun) [hʌws]). This generalization is rendered opaque by /t/ flapping in forms such as *writer* [ɹʌjɾɚ] (from /ɹɑjt+əɹ/), as opposed to forms in which the diphthong is followed by a voiced consonant in the underlying form (cf. *rider* /ɹɑjd+əɹ/ → [ɹɑjɾɚ]). On the basis of surface minimal pairs such as *writer* [ɹʌjɾɚ] vs *rider* [ɹɑjɾɚ], the authors reanalyze the diphthongs /ɑj/ and /ʌj/ (as well as /ɑw/ and /ʌw/) as being 'contrastive, though predictable in one context' (Mielke et al. 2003: 131). The other important class of apparently opaque generalizations discussed by these authors (lexicalized opacity) can be illustrated with data from Barrow Inupiaq; in this language, suffix-initial alveolars are palatalized after some roots with /i/ (e.g. [iki] 'wound' → [ikiʎu] 'wound+and'), but some roots fail to trigger palatalization (e.g. [ini] 'place' → [inilu] 'place+and'). Traditional analyses of this phenomenon postulate a vowel /i̵/ in the second type of stem, which is always realized as [i] on the surface. This situation somewhat mirrors the diachronic situation of this language, since the postulated /i̵/ appears to be the reflex of a former */ə/. However, since there is no independent evidence motivating the existence of /i̵/ synchronically, Mielke and colleagues argue that there is now only one vowel /i/ and that there are two types of stem: those that trigger palatalization, and those that do not (see also Green 2004 for a reanalysis of opacity in Tiberian Hebrew along the same line of thinking).

Without discussing the merits of each analysis, it seems reasonable to accept that, at least for some phonological phenomena, an alternative transparent analysis is available that may be superior to an opaque analysis. Nevertheless, as pointed out by McCarthy (2007: 12), the fact that there have been dubious analyses relying on overly abstract representations that introduced unwarranted opaque rule interaction does not entail that there are no synchronically active opaque generalizations in any

language. To take one of McCarthy's examples, the very general process of /t/ deletion after nasals, present in many dialects of American English, interacts opaquely with schwa epenthesis between /t/ or /d/ and the past morpheme /d/ in regular past tense forms, since /t/ deletion can destroy the context that made epenthesis applicable in the first place, as seen in *planned* /plæn+d/ → [plænd] vs *planted* /plænt+d/ → [plænəd]; McCarthy 2007: 2-3, see also his discussion of Bedouin Arabic pp. 177 ff). It thus seems justified to keep investigating the nature of phonological opacity. As a matter of fact, research over the past decade (Baković 2007, 2011) has overhauled our understanding of this issue. Baković showed that the traditional view, according to which counterfeeding opacity results in underapplication of a rule, whereas counterbleeding results in overapplication, was in fact incorrect, or at least incomplete. For instance, he identified a new type of rule interaction, *self-destructive feeding*[1], where a specific type of feeding interaction, which should be transparent according to the traditional interpretation of feeding, in fact results in overapplication opacity. For example, in Turkish, the mapping /bebek+n/ → [bebein] 'your baby' is mediated by the intermediate form [bebekin], with epenthesis of /i/ between two word-final consonants, which subsequently undergoes the deletion of morpheme-final /k/ between vowels. Crucially here, vowel epenthesis feeds /k/ deletion, but /k/ deletion destroys the context that made its application possible, resulting in the overapplication of vowel epenthesis. Baković's work is important because it shows that opacity is more complex than originally envisioned, which is probably due in part to the fact that most discussions have relied on relatively simple, pairwise rule interactions. As Baković points out, "most if not all definitions of pairwise ordered rule relations provided in textbooks and in the scholarly literature are insufficiently precise about situations involving more than two rules (Baković 2011: 42)".

The above remarks show that much work remains to be done in the area of opacity, and that it is crucial to broaden the empirical base on which discussions of this issue are based if we are to gain a fuller understanding of the range of opaque generalizations that natural languages allow. This paper is intended to be a contribution to this effort. I discuss a little-known case of opacity found in varieties

[1] A rule *P* feeds another rule *Q* which destroys part of the environment that made it possible for *P* to apply.

of French spoken in the southern part of France (henceforth, Southern French)[2], which involves an interesting interaction between segmental and suprasegmental phenomena. Specifically, the vowel /ə/ (schwa) is most often realized as the full vowel [ø] on the surface in non-final position (a phenomenon we shall henceforth refer to as 'schwa coloring'), although it behaves prosodically as a degenerate vowel. While most cases of opacity discussed in the phonological literature rely on impressionistic data, this study provides a detailed phonetic investigation of the idiolect of one speaker in order to assess the extent to which schwa can be said to be opaque within a given a grammar. To the best of my knowledge, this study is the first attempt to study this phenomenon experimentally.

I first provide an overview of this pattern, showing its implications for the learnability of lexical representations (§2). Next, I report on a phonetic case study involving the speech one 64-year-old subject, representative of the variety of French discussed in this paper (§3). The results of this case study are consistent with previous phonological descriptions of the phenomenon, suggesting that, at least for the idiolect considered the phonetic neutralization between schwa and the front rounded vowel is complete. The significance of these results is discussed in §4.

2. Opaque schwa in Southern French

2.1 Schwa in Parisian French

This subsection provides some background information on the behavior of schwa in Parisian French. Readers familiar with French phonology might want to skip this section.

Contemporary Parisian French, which is usually regarded as the reference variety as far as the phonology of (European) French is concerned, possesses 10 oral vowels, namely /i y u e ø o ɛ œ ɔ a/, as well as the 3 nasal vowels /ɛ̃ ɔ̃ ɑ̃/. In addition, traditional descriptions report the existence of a low back /ɑ/, which has now merged with /a/ for most speakers, as well as an additional nasal vowel, /œ̃/, which has been undergoing a merger with its unrounded counterpart /ɛ̃/ (see Tranel 1987a, Walker

[2] Southern French does not represent an entirely cohesive system, as there are important areas of variation in several aspects of its phonology. The variety described in this paper by and large corresponds to the variety described in Durand et al. (1987) and shares what Armstrong and Pooley (2010: 188 ff.) refer to as the 'Dominant Southern Pattern' (see §2.2 below).

2001 and Gess et al. 2012b and the references they provide for a more detailed discussion of the vowel system of 'standard' French).

In addition to these stable vowels, the vowel inventory of French includes a schwa, generally noted /ə/ at the phonological level, which has been the focus on intense scrutiny[3]. Although the exact nature of this vowel is not uncontroversial, Gess et al. (2012b: 5) identify three properties which are widely agreed upon: (i) it alternates with zero; (ii) it is usually realized as [ø] or (more commonly) [œ]; (iii) it usually corresponds to an *e* in the spelling, unless this *e* is part of a digraph (e.g. *eu* which corresponds to stable /ø/ or /œ/) or is followed by a consonant within the same graphical syllable, in which case it normally corresponds to /e/ or /ɛ/ (e.g. *fer* [fɛʁ] 'iron'). Consider the examples in (1), which represent typical realizations of the verb *demander* 'to ask' in different segmental contexts[4]:

(2)	a. *Il faut d<u>e</u>mander*	[ilfodmɑ̃de]	'one must ask'
	b. *Il faut même d<u>e</u>mander*	[ilfomɛmdœmɑ̃de]	'one must even ask'

The vowel corresponding to the first *e* in *d<u>e</u>mander* is usually deleted in (2a) since its deletion does not raise any issue with regard to the syllabification of /d/ and /m/; in (2b), however, the vowel is realized since its absence would yield the triconsonantal cluster *[mdm], which violates the phonotactics of French (see Côté 2000: 120). Because of this lexically specified vowel/zero alternation, schwa needs to be encoded in lexical representations, at least in morpheme internal position[5]. Thus, the word *demander* is assumed to have the representation /dəmɑ̃d+e/.

The use of the symbol /ə/ to denote this vowel should not be interpreted as necessarily representing a genuine central vowel in the sense of the International Phonetic Alphabet (see Pullum and Ladusaw 1996: 48-49); although, from a

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[3] It is not possible to do justice to the enormous amount of literature on this topic, but see Dell (1985 [1973]), Côté (2000), Andreassen (2013), partly translated into English as Morin (1978), Dell (1980), Tranel (1981, 1987b), Eychenne (2006), Pustka (2007), as well as the contributions to the following volumes: Verluyten (1988), Durand et al. (2009), Gess et al. (2012a) for an overview of the core facts and conceptual issues surrounding French schwa.

[4] Throughout the paper, underlining in orthographic forms represents the position where the target segment appears.

[5] A well-known pair is the verbs *skier* /ski+e/ 'to ski' and *secouer* /səku+e/ 'to shake'. While schwa may appear between /s/ and /k/ in *secouer*, it can never do so in *skier* (*[səkije]).

diachronic perspective, this vowel derives from a (most likely) central unstressed vowel, which subsequently merged with /œ/ phonetically (see Morin 1978), this symbol is usually understood as a convenient short-hand to denote this unstable vowel. This fact is explicitly acknowledged by Dell (1985) in his landmark derivational analysis:

> [W]e are not in a position to define precisely the feature matrix represented by the symbol ə. We will simply admit that it is a [+syll, −cons] vowel, and that this vowel is distinct from all other vowels that appear in derivations […] From this point of view, quality differences in the pronunciation of ə that can be found across speakers are a superficial phenomenon. They fall under very late phonological rules. (Dell 1985: 197, translation mine)

Although its exact phonological representation is still a matter of debate, and is influenced in no small part by the theoretical framework that is adopted, this vowel clearly displays properties usually associated with schwa-like vowels (van Oostendorp 2003, Silverman 2011): it is generally stressless[6]; there are strong restrictions on schwa-headed syllables (i.e. they must have an onset and cannot have a coda); it can appear as an epenthetic vowel to break up illicit consonant clusters that would result from external sandhi (e.g. *parc naturel* [paʁkœnatyʁɛl] 'nature park').

Regarding the last point, it is important to emphasize that Parisian French no longer distinguishes words ending with an *e* in the spelling, which used to have a word-final schwa, and words ending with a pronounced consonant. For example, the words *net* 'neat.MASC' and *nette* 'neat.FEM' are now homophonous and are both realized as [nɛt]. The occurrence of schwa word-finally in surface representations is driven by phonotactic and/or prosodic constraints, irrespective of the etymology. Nonetheless, the status of word-final schwas in Northern French is still a hotly debated issue, which has far-reaching consequences for the analysis of the morpho-phonology of the language (see Schane 1966). Tranel (1981) provides a number of arguments against the postulation of abstract schwas in word-final position, as in Schane's (1968) and Dell's (1985) analyses. These claims appear to be supported by

[6] There are a number of apparent exceptions such as stressed clitics in imperative forms, e.g. *Prends-l̲e̲ !* [pʁɑ̃lœ] 'Take it!'. See Morin (1978: 98) for more examples.

corpus research that compared the two word classes and showed that they behaved identically with respect to the realization of schwa (e.g. Durand and Eychenne 2004).

Having presented the most salient characteristics of schwa in Parisian French, we now turn our attention to Southern French.

2.2 Schwa in Southern French

The behavior of schwa in Southern French is markedly different from that of Parisian French. First, Southern French possesses four distinct 'nasal vowels', which are typically realized as an oral vowel followed by a nasal appendage, usually homorganic with the following consonant or velar (/ɛ̃ œ̃ ɔ̃ ɑ̃/; Durand 1988, Coquillon and Turcsan 2012: §3.2.2). Second, and more crucially in the context of this paper, it displays no contrast between mid high and mid low vowels; instead, it possesses three mid vowels (often noted as /E Œ O/) which are realized as mid high or mid low according to a pattern known as the *loi de position* (henceforth LDP, see Rochet 1980, Moreux 1985, Durand 1995, Watbled 1995, Eychenne 2014), stated as follows:

(3) The loi de position
A mid vowel is:
a. mid close in an open syllable
b. mid open in a closed syllable or in an open syllable followed by a schwa-headed syllable

Examples in (4) illustrate this pattern for the three vowels in the three relevant environments. As the examples in (4c) show, and contrary to Parisian French, Southern French displays a word final schwa that corresponds to a graphical *e*. Many minimal pairs can be distinguished by the presence/absence of a word-final schwa (e.g. *golf* [gɔlf] 'golf' vs *golfe* [ˈgɔlfə] 'gulf'). It also plays an important role in verbal morphology (e.g. *casser* [kaˈse] 'to break' vs *(je) casse* [ˈkasə] '(I) break') and corresponds to the realization of the feminine marker, as seen in the pair *seul* vs *seule* in (4).

(4) Illustration of the loi de position (Eychenne 2014: 225)
a. *sait* [se] 'knows'

	ceux	[sø]	'those (pron.)'
	sceau	[so]	'bucket'
b.	*sel*	[sɛl]	'salt'
	seul	[sœl]	'alone (masc.)'
	sol	[sɔl]	'ground'
c.	*selle*	[ˈsɛ.lə]	'saddle'
	seule	[ˈsœ.lə]	'alone (fem.)'
	sole	[ˈsɔ.lə]	'sole (fish)'

The first multilinear analysis of the LDP is, to the best of my knowledge, Durand (1976). According to his analysis, framed in Dependency Phonology, all full vowels project a foot, whereas a schwa-headed syllable is adjoined to the preceding syllable to form a trochee. In order to unify the disjunctive context (3b), he further proposed that a mid vowel is realized as mid low if it has a right-hand side dependent, either directly, as in Figure 1, or indirectly, as in Figure 2[7]. A similar approach to foot formation was independently put forward by Selkirk (1978) for the analysis of standard French[8], albeit using a more familiar notation for syllables and feet.

As we alluded to earlier, the behavior of schwa in Southern French does not follow the same pattern as in Parisian French. Durand (1995) identifies four criteria, summarized in (5), that can be used to determine whether a vowel is a schwa.

(5) Schwa in southern French (adapted from Durand 1995: 40-42)

a. deletion condition: schwa is deleted before a vowel.

b. stresslessness condition: schwa is stressless.

c. realization condition: schwa is phonetically variable.

d. mid-vowel lowering condition: schwa triggers the lowering of a preceding mid vowel within its domain.

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[7] In later work, Durand (1986, 1995) offers slightly different formalizations that treat the onset of the schwa-headed syllable as ambisyllabic. Such aspects are not essential for our discussion.

[8] Selkirk's analysis relies on the postulation of abstract schwas in standard French, as in Dell's (1985 [1973]) and Schane's (1968) analyses. See the remarks at the end of §2.1 above.

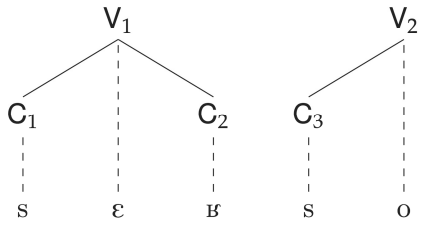

Figure 1. Dependency representation of *cerceau* 'hoop' (after Durand 1976)

The deletion condition applies categorically at the end of a morpheme (*bêtise* /bEtə+izə/ → [betizə] 'stupidity', cf. *bête* [bɛtə] 'stupid') or a word (*bête et méchant* [bɛteme$\int$a$^{\tilde{\text{ŋ}}}$] 'stupid and nasty'). Note however that, in the accent described here, schwa cannot be deleted in other contexts, such as (2a) above in Parisian French. The stresslessness of the vowel is most apparent in word-final positions (i.e. in a stressed trochee), as in *facile* [faˈsilə] 'easy', but it has been argued to play a role with schwas footed in the dependent position of a word-internal trochee, in which case it is reported to display a secondary stress (*bêtement* [ˌbɛtəˈma$^{\tilde{\text{ŋ}}}$] 'stupidly'). The realization condition refers to the fact that the exact quality of this vowel in word-final position is variable across speakers and/or dialectal areas (Durand 1995 reports qualities such as [ə], [ø], [œ], [ʌ], see also Taylor 1996, Eychenne 2014). Finally, the mid-vowel lowering condition is nothing but the effect of the LDP mentioned in (3). For instance, in the word *heure* [ˈœʁə] 'hour', the first vowel is mid low because the following vowel is a schwa, whereas in *heureux* [øˈʁø] 'happy.MASC', it is mid high since the final vowel is a full vowel.

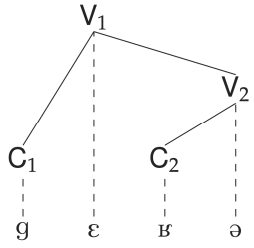

Figure 2. Dependency representation of *guerre* 'war' (after Durand 1976)

The domain of application of the LDP is the prosodic word (Durand 1990, Eychenne 2014), which corresponds either to a base and its suffixes, or to a prefix. For example, in the words *bêtise* [betizə] and *bêtement* [bɛtəmaⁿ] mentioned above (both composed of a base and a suffix), we see that /E/ is mid high in the former because it is in an open syllable followed by /i/ (see (3a)), whereas it is mid low in the latter because it is followed by a schwa, as predicted by (3b). An important cue about the behavior of prefixes with respect to the LDP is provided by the syllabification of /sC/ clusters. Durand (1990: 26-27) observes that the consonants in such clusters are heterosyllabic; the /s/ is usually syllabified as the coda of the previous syllable, which has the effect of lowering that syllable's nucleus if it is a mid vowel according to (3b), as in *hospitalité* [ɔs.pi.ta.li.te] 'hospitality'. However, this lowering effect is blocked if the vowel is located at the right edge of a prefix and the /s/ is aligned with the left edge of a base. Thus, in the word *préscolaire* /pʁE+skOlEʁə/ 'preschool', the preceding mid vowel /E/ is realized as a mid high vowel, yielding [pʁ̥eskolɛʁə] in lieu of *[pʁ̥ɛskolɛʁə]. The asymmetry between prefixes and suffixes regarding prosodic affiliation is a robust generalization in the morpho-phonology of French, which is supported by independent evidence such as the behavior of glides (Hannahs 1995: §3.2).

I will not have much to say about (5c) in the rest of this paper, but I shall treat conditions (5a), (5b) and (5d) as sufficient conditions, whenever they can apply, for diagnosing the presence of a schwa.

2.3 Schwa coloring in Southern French

So far, we have assumed that Southern French schwa is always realized as [ə] on the surface. While this is indeed a common realization, at least in word-final position, this is not always the case.

First, when schwa appears in monosyllabic clitics such as *je* /ʒə/ 'I', *me* /mə/ 'me', *le* /lə/ 'it/him', the vowel is systematically realized as [ø], as in *je le veux* [ʒøløvø] 'I want it'. There are several phonological arguments supporting the fact that this vowel is a schwa. For example, contrary to stable vowels, it obeys the deletion condition in (5a), as in *j'y vais* [ʒive] 'I am going there'. In addition, when the clitic is realized as an enclitic in interrogative constructions, it is an unstressed vowel (cf. (5b)) that triggers mid vowel lowering as expected from (5d), for instance *serait-ce* [søˈʁɛsə]

'would it be', vais-je [ˈvɛʒə] 'am I going', *devrais-je* [døˈvʁɛʒə], *pourrais-je* [puˈʁɛʒə] 'may I' (see Durand 1995: 42).

Second, the vowel that corresponds to Parisian French schwa in a word-initial syllable is always realized as a stable [ø]. For example, there is no difference between *br<u>e</u>vet* [bʁøve] 'certificate' and *br<u>eu</u>vage* [bʁøvaʒə] 'beverage'. Temporarily leaving aside the question of morpho-phonological alternations, which will be discussed in §2.4, it appears that, although they are spelled differently, there is no phonological argument to distinguish the vowels in *br<u>e</u>vet* and *br<u>eu</u>vage*. Durand et al. (1987: 993) argue that in such cases, the non-alternating vowel in a word such as *br<u>e</u>vet* has been reanalyzed as a stable /Œ/.

Third, it has been observed that schwa is often realized as [ø] in word-internal position as well (Rochet 1980: 92). Consider the adverb *nettement* 'neatly', a typical realization of which is [nɛtømaⁿ̃]. It is derived from the feminine adjective *nette* /nEt+ə/ 'neat+fem', for which we know unambiguously that there is a schwa since it is usually pronounced as [ˈnɛtə], where the final vowel is the realization of the feminine morpheme and satisfies both the stresslessness (5b) and mid vowel lowering (5d) conditions. In the derived adverb [nɛtømaⁿ̃], however, we see that schwa appears to trigger the lowering of the preceding mid vowel even though it is not realized as a central vowel on the surface.

As we shall see, the precise nature of this opaque schwa 'coloring' depends on how the problem is framed in derivational terms. Let us first assume that feet are built according to Selkirk's (1978) treatment. According to this view, all syllables (including schwa) project a foot (a rule called SIMPLE-FOOT by Selkirk), and a subsequent rule merges two feet into one trochee if the second one is headed by a schwa, which, following Selkirk, we shall call a DERIVED-FOOT. The grammar must also include a rule turning a schwa into [ø], which will be referred to as SCHWA-COL (schwa coloring), as well as a process of mid vowel adjustment (informally referred to as MV-ADJ), which adjusts the quality of mid vowels according to the LDP (see Durand 1990: 165-168, for one possible formalization in terms of underspecification). A derivation that yields the expected output is given in (6). Parentheses are used to indicate prosodic constituents, σ denotes a syllable and Σ denotes a foot; UR and SR refer to the underlying and surface representations respectively.

(6) Derivation of *bêtement* with opaque schwa

UR	/##bEtə+ma^{ŋ}##/
SYLLABIFICATION	(bE)$_{σ}$ (tə)$_{σ}$ (ma^{ŋ})$_{σ}$
SIMPLE-FOOT	((bE)$_{σ}$)$_{Σ}$ ((tə)$_{σ}$)$_{Σ}$ ((ma^{ŋ})$_{σ}$)$_{Σ}$
DERIVED-FOOT	((bE)$_{σ}$ (tə)$_{σ}$)$_{Σ}$ ((ma^{ŋ})$_{σ}$)$_{Σ}$
SCHWA-COL	((bE)$_{σ}$ (tŒ)$_{σ}$)$_{Σ}$ ((ma^{ŋ})$_{σ}$)$_{Σ}$
MV-ADJ	((bɛ)$_{σ}$ (tø)$_{σ}$)$_{Σ}$ ((ma^{ŋ})$_{σ}$)$_{Σ}$
SR	[bɛtøma^{ŋ}]

To understand why the realization of schwa is opaque, consider the counterfactual derivation (7). Crucially, if SCHWA-COL is ordered before DERIVED-FOOT, the former bleeds the latter since the second syllable is no longer headed by a schwa and DERIVED-FOOT's structural description is no longer satisfied. Thus, we can conclude that SCHWA-COL counterbleeds DERIVED-FOOT in (6).

(7) Counterfactual derivation of *bêtement*

UR	##bEtə+ma^{ŋ}##
SYLLABIFICATION	(bE)$_{σ}$ (tə)$_{σ}$ (ma^{ŋ})$_{σ}$
SIMPLE-FOOT	((bE)$_{σ}$)$_{Σ}$ ((tə)$_{σ}$)$_{Σ}$ ((ma^{ŋ})$_{σ}$)$_{Σ}$
SCHWA-COL	((bE)$_{σ}$)$_{Σ}$ ((tŒ)$_{σ}$)$_{Σ}$ ((ma^{ŋ})$_{σ}$)$_{Σ}$
DERIVED-FOOT	----------
MV-ADJ	((bɐ)$_{σ}$)$_{Σ}$ ((tø)$_{σ}$)$_{Σ}$ ((ma^{ŋ})$_{σ}$)$_{Σ}$
SR	*[betøma^{ŋ}]

The construction of prosodic structure in this approach is a *structure-changing* operation, in that it builds feet that are later destroyed if they are headed by a schwa. But this is not the only possible solution. In fact, a more stringent theory would most likely require prosodification to be a *structure-building* operation. This is in essence the approach advocated by Durand (1986) in Dependency Phonology. Framed in more familiar terms, the grammar could require all full vowels to project a foot (let us call this rule SIMPLE-FOOT'), and a subsequent rule would adjoin unfooted syllables to the preceding foot (let us call it DERIVED-FOOT' for the sake of symmetry). The corresponding derivation is given in (8). Note that in this case prosodic structure is built monotonically; although the foot at the left edge of the word is expanded into a trochee, there is no destructive operation as in (6).

(8) Monotonic derivation of *bêtement* with opaque schwa

UR	##bEtə+ma^{ŋ}##
SYLLABIFICATION	$(bE)_{σ}$ $(tə)_{σ}$ $(ma^{ŋ})_{σ}$
SIMPLE-FOOT'	$((bE)_{σ})_{Σ}$ $(tə)_{σ}$ $((ma^{ŋ})_{σ})_{Σ}$
DERIVED-FOOT'	$((bE)_{σ}$ $(tə)_{σ})_{Σ}$ $((ma^{ŋ})_{σ})_{Σ}$
SCHWA-COL	$((bE)_{σ}$ $(tŒ)_{σ})_{Σ}$ $((ma^{ŋ})_{σ})_{Σ}$
MV-ADJ	$((bɛ)_{σ}$ $(tø)_{σ})_{Σ}$ $((ma^{ŋ})_{σ})_{Σ}$
SR	[bɛtøma^{ŋ}]

Consider now the counterfactual derivation in (9). In this case, SCHWA-COL crucially feeds SIMPLE-FOOT' since it creates an additional context, namely the syllable $(tø)_{σ}$, for this rule to apply. As a result, DERIVED-FOOT' is bled, as in (7) before, since no trochee can be created. The important point is that, for SCHWA-COL to bleed DERIVED-FOOT', it must first feed SIMPLE-FOOT'. Consequently, in (8), SCHWA-COL counterfeeds SIMPLE-FOOT' but also counterbleeds DERIVED-FOOT'. Indeed, it looks on the surface as if both SIMPLE-FOOT' has underapplied (a full vowel does not project a foot), and DERIVED-FOOT' has overapplied (the dependent syllable in the trochee is not headed by a schwa).

(9) Counterfactual derivation of *bêtement* (monotonic)

UR	##bEtə+ma^{ŋ}##
SYLLABIFICATION	$(bE)_{σ}$ $(tə)_{σ}$ $(ma^{ŋ})_{σ}$
SCHWA-COL	$(bE)_{σ}$ $(tŒ)_{σ}$ $(ma^{ŋ})_{σ}$
SIMPLE-FOOT'	$((bE)_{σ})_{Σ}$ $((tŒ)_{σ})_{Σ}$ $((ma^{ŋ})_{σ})_{Σ}$
DERIVED-FOOT'	----------
MV-ADJ	$((be)_{σ})_{Σ}$ $((tø)_{σ})_{Σ}$ $((ma^{ŋ})_{σ})_{Σ}$
SR	*[betøma^{ŋ}]

We see that the two analyses considered yield slightly different interpretations of the nature of opaque schwa; both recognize that it is a type of counterbleeding opacity, but according to the structure-building analysis, which many would consider as superior because it does not involve destructive operations[9], schwa coloring

[9] See for instance Coleman (1995), who rejects derivations altogether in favor of strictly monotonic operations.

simultaneously displays features of counterfeeding and counterbleeding opacity. This apparently paradoxical situation can be resolved as soon as one recognizes the nature of the generalizations involved. As pointed out in the introduction, opacity is most often discussed with reference to only two rules, and the opaque generalization is usually a segmental one. Foot formation, on the other hand, is a phenomenon that must generally be expressed by means of several rules[10]. Indeed, prosodic structure is an area where a non-derivational theory such as OT has shown some of its most meaningful achievements, since it allows prosodic structure to be built at once, by simultaneously applying a number of (possibly conflicting) structural constraints. (See in particular van Oostendorp 2000 for a reanalysis of Selkirk 1978 using constraints that connect segmental and suprasegmental information.) The key point here is that if foot formation were transparent, there should be a one-to-one mapping between full vowels and prosodic heads. Since, in derivational terms, schwa coloring can interact with two different rules that are part of foot formation, both effects (overapplication of trochee formation, underapplication of unary foot formation) are visible simultaneously.

2.4 Taxonomy of 'opaque' word-internal schwas

Having established the opaque nature of schwa, it is worth discussing its consequences for the learnability of the morpho-phonology of Southern French, especially in word-internal position where the presence of schwa can often only be inferred indirectly. In order to clearly distinguish schwas from stable /Œ/'s, I propose the following taxonomy:

Morphologically recoverable schwa. This type of vowel appears at the end of a base and can be motivated on morphological grounds. Consider for example the form *util<u>e</u>ment* [ytiløma$^{\eta}$] 'usefully'. As has been argued by Rochet (1980: 92) and Durand et al. (1987: 992), the surface [ø] can be unambiguously reconstructed as an underlying

[10] An anonymous reviewer suggests that an alternative analysis might be possible, where MV-ADJ would counterbleed SCHWA-COL, in which case this could be considered a strictly segmental phenomenon. The issue might depend on how MV-ADJ is ultimately formalized, since one might in fact need two different rules for mid high and mid low vowels. In any case, it seems clear that mid vowel adjustment is driven by foot structure (see Moreux 1985, Durand 1995, Watbled 1995, Eychenne 2014, for different proposals); as far as I can see, applying SCHWA-COL after MV-ADJ would result in a mid vowel unspecified for tenseness on the surface but SCHWA-COL would not be bled.

/ə/ since a schwa appears at the end of the base *utile* [yˈtilə] 'useful', where it satisfies the stresslessness condition (5b). Such forms are therefore not problematic.

Phonologically recoverable schwa. A schwa can be unambiguously recovered when a surface [ø] is preceded by a mid low vowel. Consider the monomorphemic word *céleri* 'celery'. Durand et al. (1987) report that this word (as well as a few others) has two pronunciations, one with a mid high (typically, [seløʁi]), and one with a mid low vowel (typically, [sɛløʁi]) in the first syllable. They argue (quite convincingly) that for speakers who display a mid low vowel, the medial vowel is a schwa (in accordance with the mid vowel lowering condition (5d)), and the underlying form of the word is /sElәʁi/, whereas for speakers with a mid high vowel, the medial vowel has been reinterpreted as a stable /Œ/ and the underlying form is in that case /sElŒʁi/. Note that in many cases a schwa may be recoverable both morphologically and phonologically. This is the case for instance in *nettété* [nɛtøte] 'neatness', where [ø] is preceded by a mid low vowel, but also corresponds to an unstressed schwa in the base *nette* [ˈnɛtə], which is itself derived from the masculine form *net* [nɛt] by adding the feminine morpheme /ə/.

Non-recoverable putative schwa. This category corresponds to a vowel written *e* that appears inside a morpheme (and cannot therefore be a morphologically recoverable schwa) and is not preceded by a mid vowel, in which case condition (5d) cannot be used as a diagnostic either (Durand et al. 1987: 992). Words belonging to this category include *allemand* [alømɑ̃] 'German' and *hameçon* [amøsɔ̃] 'fish hook', for example. On the surface, the vowel appears to be identical to a stable /Œ/, as found for instance in *pharmaceutique* /farmasŒtikə/ → [farmasøtikə]. In the absence of phonological or morphological cues to the contrary, it seems reasonable to assume that the vowel is reanalyzed as a stable /Œ/, and a word such as *allemand* would have the underlying form /alŒmɑ̃/. The difficulty, however, is that it is not clear in discussions in the literature whether the two vowels are strictly identical. It seems that although schwa *can* be realized as [ø], it may also be realized as a central vowel [ə], whereas /Œ/ *must* be realized as [ø] in open syllables (Eychenne 2014: 230). Unfortunately, available phonological descriptions are rather imprecise on this issue. It may well be the case that there are (possibly subtle) differences in the realizations of schwa and /Œ/, with respect to the phonetic quality and/or to suprasegmental parameters (pitch, loudness, duration) since a schwa is predicted to appear in the dependent position of a trochee whereas /Œ/ should be the head of a unary foot. If it can be established that there exist phonetic differences in the realization of the medial

vowel in, say, *ameuter* 'to gather (a pack of hounds)' and *hameçon* in a given idiolect, a learner should be able to infer that the vowel in the latter form is a bona fide schwa; if there is no difference, then it seems legitimate to assume that the vowel in *hameçon* was reanalyzed as /Œ/. It is possible that there are differences across sub-dialects of Southern French, and perhaps even across speakers. In the absence of reliable evidence, however, it is important to treat this class of vowels separately since their status cannot be trivially determined.

Alternating putative schwa. Another important class of potential schwas comes from vowels that alternate with [ɛ]. This is perhaps the most delicate type to analyze since it somewhat cuts across previous categories, and depends on one's view of the phonology/morphology interface. Consider forms such as *(j')amène* [aˈmɛnə] '(I) bring' vs *(vous) amenez* [amøˈne] '(you pl.) bring'. We see that when the vowel appears in the head position of a trochee, it is realized as [ɛ], whereas it is realized as [ø] if it is in an unstressed open syllable. In Parisian French, the vowel is clearly a schwa since it can be deleted ([amne] ~ [amœne]) and, because the 'stressed schwa' appears in a closed syllable rather than in a trochee ([amɛn] instead of [amɛnə]), the phenomenon is often called 'Closed Syllable Adjustment' (see Dell 1985, Tranel 1985, Morin 1988, Montreuil 2002, among others). Several scholars (e.g. Dell 1985, Montreuil 2002) view the schwa/ɛ alternation as a purely phonological phenomenon, whereby schwa gets realized as [ɛ] in relatively prominent positions, i.e. positions where it receives a primary or secondary (lexical) stress (see in particular Montreuil 2002). Morin (1988), on the other hand, makes a strong case against this strictly phonological analysis in "non-southern" varieties of French, and argues that the alternation involves suppletive allomorphs. He first points out that while some alternations do involve a schwa (e.g. *amène ~ amener*), others, such as the verb *peser* 'to weigh', involve a stable vowel, as in *pèse* [pɛz] ~ *peser* [pœze], but not *[pze] (recall that alternation with zero is a fundamental criterion in the identification of a schwa in Parisian French, as shown in (2)). Considered in isolation, this argument is perhaps not decisive because one could argue that the vowel in *peser* is a stabilized schwa, but a schwa nonetheless. However, Morin convincingly demonstrates that these alternations, which are manifested both in inflection and derivation, are not different from other alternations involving schwa in unstressed position, since schwa is the diachronical result of the weakening of stressed vowels in many contexts. According to Morin, an alternation such as *(vous) menez* [m(œ)ne] '(you pl.) lead' ~ *(ils) mènent* [mɛn] '(they) lead' is no different from *(vous) venez* [v(œ)ne] '(you pl.)

come' ~ (*ils) viennent* [vjɛn] '(they') come', which in this case involves an alternation between schwa and [jɛ], the reflex of a former diphthong. With respect to Southern French, Eychenne (2006: 219) reports that some speakers display inconsistent patterns and may show a schwa in *hôtel* [otɛl] ~ *hôtelier* [ɔtølje] (lowering of /O/, in accordance with (5d)), but a stable vowel in *vaisselle* [vesɛlə] 'dishes' ~ *vaisselier* [vesølje] 'dresser' (no lowering of /E/), a finding that is in line with Morin's analysis of "non-southern" French, and which suggests that a morphological solution is preferable since both schwa and /Œ/ can alternate with [ɛ]. In any case, one still faces the task of determining which vowel occurs in each form.

Stable /Œ/. For the sake of completeness, it is worth briefly mentioning the case of stable vowels. This type of vowel corresponds to *eu* in the spelling (e.g. *pharmaceutique* /farmasŒtikə/ → [farmasøtikə]) or to an *e* preceded by a mid high vowel, as in the case of *céleri* realized [seløʁi] that was mentioned earlier.

This taxonomy should not be understood as a hard-and-fast classification. It is simply meant to emphasize the cues that may be available (or not) to a learner trying to tell apart opaque schwas from stable /Œ/'s. But it is important to stress that this taxonomy is valid only insofar as the realization of schwa in medial position is genuinely opaque. Yet, it could be the case that the phonetic neutralization between schwa and /Œ/ is incomplete, as has been suggested for instance for final devoicing in Dutch, where an underlying voicing contrast word-finally can be indirectly manifested by vowel duration (Warner et al. 2004). However, to the best of my knowledge, this issue has not yet been investigated systematically. The case study reported in the next section will hopefully shed some light on this point.

3. Case study

All discussions of schwa coloring in Southern French that I am aware of have been expressed in terms of traditional phonological descriptions. Although they provide very valuable information, they may miss subtle phonetic differences that can only be probed using experimental techniques. In order to shed some light on the phonetic realization of opaque schwa, I conducted a pilot phonetic experiment involving one subject[11]. The procedure and results are reported in this section.

[11] Some readers might legitimately raise an eyebrow at the idea of studying only one speaker. As pointed out in the introduction, however, the focus of this study is on idiolectal grammars; inter-speaker variation, while interesting, lies beyond the scope of the present paper.

3.1 Method

The data were gathered in August 2015 in a low density rural area located 7 km away from Figeac, a small town (about 10,000 inhabitants) in the Midi-Pyrénées region (South West of France). The subject is a 64-year old middle-class male who was born in that region. He lived there until his early 20's, when he moved to the South East (near Marseilles) and lived there for about 25 years, after which he returned to the Midi-Pyrénées region, where he has been living since 1995.

The data were recorded in a quiet room in the subject's house, using an Olympus LS-5 PCM recorder (sampling rate = 22,050 Hz, bit depth = 16 bits), with all electronic appliances in the house turned off. The material recorded is a word list containing 260 items (including distractors) that was designed to investigate the behavior of schwa across a number of contexts (along with other phenomena, especially oral and nasal vowels). The word list was recorded 3 times (each time in a different, randomized order) with a short pause between each repetition. The recording device was held at a constant distance (about 40 cm) from the speaker's mouth throughout the recording.

The data were annotated in Praat (Boersma and Weenink 2015). EasyAlign (Goldman 2011) was used to obtain a preliminary phone alignment, which was corrected manually using cues from the waveform and a wide-band spectrogram. Regarding the segmentation of vowels, wherever possible (e.g. voiceless plosives), the start boundary was placed at the zero-crossing point at the beginning of the first unambiguous glottal cycle; the end boundary was placed using a combination of several factors, depending on the segmental context: abrupt drop in amplitude and/or simplification of periodicity of the waveform, corresponding to the attenuation of higher formants (F2/F3) for plosives, frication noise for fricatives, loss of energy due to anti-resonances in laterals and nasals. As expected, the most delicate aspect of the labeling was locating the end boundary of vowels in an open syllable at the end of a word. For the sake of consistency, the following strategy was adopted: whenever the offset of the vowel could be clearly identified (sudden drop in amplitude, with simplification of the periodicity pattern), this was used as the end boundary since it is generally agreed that the offset should not be treated as part of the vowel, especially

with respect to duration; in all other cases, I adopted an arbitrary intensity cut-off point (57 dB), which appeared appropriate for these data[12].

I then extracted 4 datasets from the corpus:

- Dataset I: all stressed vowels
- Dataset II: all word final schwas, along with the previous (stressed) vowel
- Dataset III: vowels corresponding to *e* and *eu* in word-initial position
- Dataset IV: vowels corresponding to *e* and *eu* in word-internal position

For each vowel, I extracted its duration, average intensity, average fundamental frequency (F0), and the first four formants (F1, F2, F3, F4) sampled every 5 ms throughout the vowel, using an LPC analysis, with Praat's settings set at 5 formants up to 5,000 Hz. In order to reduce the number of trivial formant tracking errors, a simple correction measure based on a three-point running average was applied to the raw formant measurements. For F1, F2, F3, at each time point *t*, the formant value F_{best} (among F1, F2, F3, F4) that is closest to the estimated value F' at time *t*-1. If none is available[13], F'_{t-1} is used as the estimate of F_{best}. Then, a three-point average is computed from F'_{t-2}, F'_{t-1} and F_{best}, which becomes the estimate for F'_t. The procedure is repeated until the end of the vowel is reached. Figure 3 illustrates the effect of the correction procedure on one vowel token (schwa).

The final formants (F1, F2, F3) were measured at the midpoint of the vowel, using a linear interpolation of the estimated formants. In addition, I applied a filter adapted from Gendrot and Adda-Decker (2005) in order to detect and eliminate nonsensical values.

For Dataset I, 795 vowels in the head position of a stressed trochee were extracted. Nine tokens (1.1%) were rejected, and the 84 nasal vowels were discarded. The final dataset contains 702 oral vowels. For Dataset II, 336 vowel/schwa pairs in the context C_0VC_1ə were extracted. Two pairs were excluded because the final schwa was voiceless; 13 vowels with possible problems were investigated, 9 of which were manually corrected. The final dataset contains 330 pairs (1.8% were rejected). Dataset III contains 66 tokens, none of which were discarded. Dataset IV contains 228 vowel/schwa (or vowel/*eu*) pairs, one of which was manually corrected.

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[12] This represents a half-amplitude loss from 60 dB.

[13] This happens for instance when Praat's estimate for F2 is between the previous values of F1 and F2, but closer to F1.

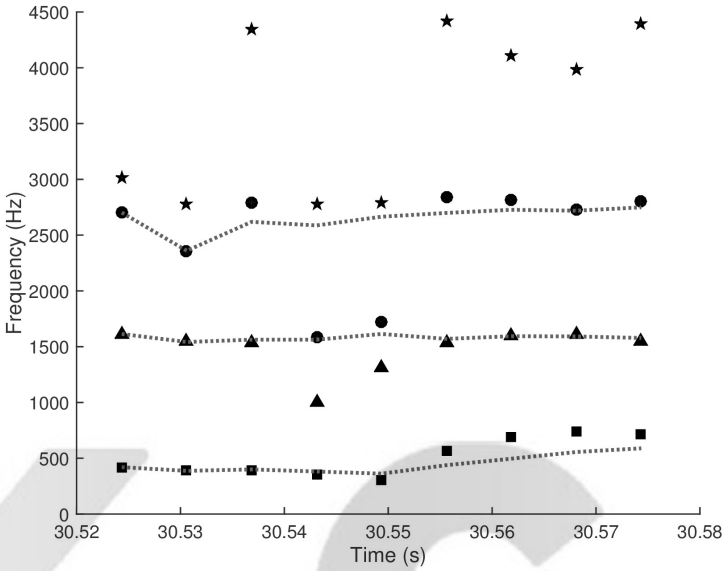

Figure 3. Smoothed formants for one schwa token

For all vowels in the final datasets, F0 was converted to semitones (with 100 Hz as a reference frequency) and F1, F2 and F3 were converted to the Equivalent Rectangular Bandwidth (ERB) auditory scale (Moore 2013: 76). The statistical analyses reported below were performed in MATLAB® 2014b (with the Statistics toolbox).

3.2 Results

3.2.1 Word-final position

In order to get a sense for the phonetic realization of word-final schwa, we will first compare its realization (obtained from Dataset II) to the quality of all stressed vowels. Table 1 reports average values of the first three formants for each vowel. (The value between parentheses represents the standard deviation.) A traditional F1/F2 formant chart is also provided for reference in Figure 4.

As can be seen, schwa's phonetic quality appears to be closest to [ø], although the low number of tokens of this vowel in stressed position ($N = 9$) makes it unreliable to probe whether the differences in mean formant values are statistically significant.

Table 1. Quality of all surface full vowels + schwa

	F1 (Hz)	F2 (Hz)	F3 (Hz)
i	339 (39)	2163 (103)	3060 (122)
y	352 (28)	1696 (128)	2259 (258)
u	352 (38)	816 (147)	2228 (340)
e	414 (29)	2027 (176)	2682 (132)
ø	**437** **(11)**	**1400** **(123)**	**2589** **(182)**
o	389 (55)	859 (74)	2535 (297)
ɛ	482 (34)	1766 (114)	2690 (74)
œ	471 (36)	1501 (52)	2520 (119)
ɔ	485 (22)	1036 (103)	2285 (194)
a	627 (36)	1414 (51)	2530 (128)
ə	**420** **(112)**	**1507** **(124)**	**2634** **(226)**

We now investigate the prosodic realization of schwas that appear in the dependent position of a word-final (i.e. stressed) trochee, as in *nette* [ˈnɛ.tə] 'neat+FEM' (Dataset II). Table 2 provides average values for suprasegmental parameters (duration, intensity, F0), for stressed vowels vs schwas. Fundamental frequency is indicated both in raw Hertz and semitones.

These figures show that there is a noticeable difference along the three dimensions; on average, a stressed vowel is longer, louder and realized with a higher pitch than an unstressed word-final schwa. To assess the statistical significance of these differences, I ran a generalized linear mixed-effects model, using a binomial

distribution for the outcome variable and the logit function as a link function, and fitted the model with maximum pseudo likelihood. We shall henceforth refer to this type of model as a logistic linear mixed-effects model, since it can be understood as a generalization of classical logistic regression, but allowing for the inclusion of random effects in addition to fixed effects. The vowel's STRESSEDNESS was modeled as a binary outcome variable (stressed vs unstressed schwa), the three suprasegmental parameters DURATION, INTENSITY and PITCH (in ST) as continuous fixed effects, and a random intercept for WORD[14] was included. The results for the model's intercept and fixed effects are reported in Table 3.

Table 2. Suprasegmental parameters in word-final trochees

duration		intensity		F0	
V	ə	V	ə	V	ə
145 ms (35)	77 ms (18)	75.5 dB (2.2)	68.2 dB (3.9)	141 Hz (6) 5.9 ST (0.7)	110 Hz (8) 1.5 ST (1.1)

Table 3. Model for stressedness in word-final position[15]

Name	Estimate	Std. Err.	*t*-stat.	*p*-value
Intercept	-51.36	13.07	-3.93	0.000 ***
Duration	0.10	0.022	4.37	0.000 ***
Intensity	0.48	0.16	2.97	0.003 **
F0 (ST)	1.44	0.26	5.49	0.000 ***

[14] Since each word is repeated 3 times in the corpus, I originally included a TRIAL random effect with 3 levels in several of the mixed-effects models. This factor was never significant and always degraded the model fit, as measured by both the Akaike Information Criterion and the Bayesian Information Criterion. As a result, it was discarded and will not be discussed.

[15] In all the models reported in this paper, the significance of the *p*-value is reported as follows: * for $p < 0.05$; ** for $p < 0.01$; *** for $p < 0.001$; *n.s.* for non-significant p-values.

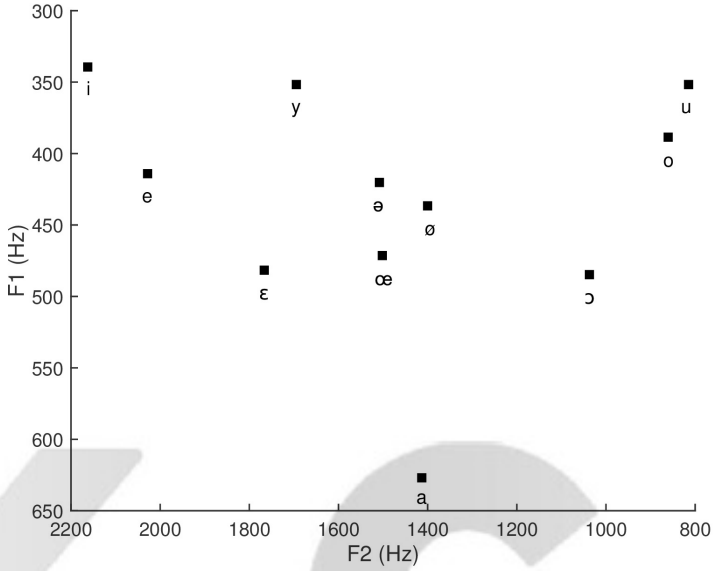

Figure 4. Formant chart of the speaker's oral vowels

Without surprise, all three parameters are predictive of the vowel's stressedness. The difference in pitch, though suggestive, must be interpreted cautiously since these data come from a read word list, which is characterized by a very specific type of intonational pattern (see Coquillon 2005: 261 ff, for a survey of the main tonal patterns associated with final schwas). The results for duration are consistent with previous research. Coquillon (2005) (see also Coquillon and Turcsan 2012) reports results from an investigation of vowel duration in trochees at the right edge of an intonational phrase in 2 groups of Southern French speakers, one from Toulouse in the South West, and one from Marseilles in the South East. (As mentioned in §3.1, these are in fact the two regions where the subject discussed in this paper has lived.) She found that schwa was shorter than the preceding stressed vowel in both groups, but was a little shorter in Marseilles, where it represented 38.1% of the cumulated length of the unstressed and stressed vowels, than in Toulouse, where it represented 46.3% (Coquillon 2005: 278). It is interesting to note that schwa's relative duration in our data is 34.7% (based on Table 2), which suggests that it could be a little

shorter than in Coquillon's data, although it is not possible to determine whether the difference is meaningful or is the consequence of different methodological choices.

3.2.2 Word-initial position

In word-initial position, the vowels written *e* ('schwa') and *eu* (stable /Œ/) are assumed to be phonetically identical (Durand et al. 1987). For example, *br<u>e</u>vet* [bʁøve] 'certificate' and *br<u>eu</u>vage* [bʁøvaʒə] 'beverage' are said to be realized with the same vowel [ø]. Table 4 provides the mean and standard deviation for duration, intensity, fundamental frequency and the first three formants in this position (Dataset III). Fundamental frequency and formant values are provided in raw Hertz and converted to an auditory scale (semitones and ERB units respectively).

The values on all the parameters measured are very similar, and the difference always lies within the standard deviation of either group, which strongly suggests that the vowels were not drawn from two different populations. To assess formally whether any of the acoustic parameters might be indicative of a vowel's belonging to either class (schwa or stable /Œ/), I ran a logistic linear mixed-effects model with the vowel's CLASS (schwa vs /Œ/) as the outcome variable, acoustic parameters (DURATION, INTENSITY, F0, F1, F2, F3, the latter four measured on an auditory scale), as the fixed effects, and a random intercept for WORD, as in the model for the word-final position. The results are reported in Table 5.

Table 4. e vs eu in word-initial position

	duration	intensity	F0	F1	F2	F3
eu	93 ms (21)	80.1 dB (1.0)	138 Hz (4) 5.6 ST (0.5)	416 Hz (17) 9.6 E (0.2)	1359 Hz (98) 18.0 E (0.6)	2468 Hz (111) 22.9 E (0.4)
e	82 ms (21)	79.7 dB (2.1)	140 Hz (5) 5.9 ST (0.6)	424 Hz (23) 9.7 E (0.3)	1339 Hz (117) 17.9 E (0.7)	2450 Hz (140) 22.9 (0.5)

Table 5. Model for *e* vs *eu* in word-initial position

Name	Estimate	Std. Err.	*t*-stat.	*p*-value
Intercept	-24.24	58.602	-0.41	0.68 (*n.s.*)
Intensity	0.43	0.476	0.90	0.37 (*n.s.*)
Duration	0.02	0.030	0.67	0.50 (*n.s.*)
F0 (ST)	-1.04	1.474	-0.71	0.48 (*n.s.*)
F1 (E)	-1.36	3.3223	-0.41	0.68 (*n.s.*)
F2 (E)	-0.12	1.2942	-0.10	0.92 (*n.s.*)
F3 (E)	0.37	1.2879	0.29	0.77 (*n.s.*)

As can be seen, none of the acoustic parameters are predictive of a vowel's membership to either class, and the estimates all have a large standard error. We can conclude that, for this speaker, vowels corresponding to *e* or *eu* in the orthography are all pronounced identically (as [ø]) in word-initial position.

3.2.3 Word-internal position

We finally turn our attention to the realization of schwa and /Œ/ in word-internal position (Dataset IV). To avoid problems with data sparsity, the 5 categories discussed in §2.4 were grouped into three categories: (morphologically or phonologically recoverable) schwas; (non-recoverable and alternating) putative schwas; stable /Œ/. Table 6 provides an overview of all the acoustic parameters measured for these categories. As before, F0, F1, F2 and F3 are indicated in raw Hertz and on an auditory scale.

Table 6. Schwa vs putative schwa vs /Œ/ in word-internal position

	duration	intensity	F0	F1	F2	F3
schwa	68 ms (15)	79.8 dB (1.4)	141 Hz (5) 5.9 ST (0.5)	427 Hz (21) 9.8 E (0.3)	1438 Hz (82) 18.4 E (0.5)	2470 Hz (175) 22.9 E (0.6)
putative ə	69 ms (13)	79.9 dB (1.4)	142 Hz (3) 6.1 ST (0.4)	430 Hz (22) 9.8 E (0.3)	1443 Hz (91) 18.5 E (0.5)	2535 Hz (164) 23.1 E (0.6)

stable Œ	74 ms (19)	80.3 dB (1.4)	141 Hz (5) 5.9 ST (0.6)	411 Hz (17) 9.6 E (0.2)	1483 Hz (61) 18.7 E (0.3)	2396 Hz (226) 22.6 E (0.8)

As in §3.2.2, values are very similar across the three categories for all parameters. The statistical significance of these results was evaluated by means of a multinomial mixed-effects model, with CLASS as an outcome variable (with the 3 categories mentioned above representing its 3 levels), DURATION, INTENSITY, F0 (in ST), F1, F2 and F3 (in ERB units) as fixed effects, and WORD as a random effect (random intercept). The results of the model are given in Table 7. None of these factors are significant predictors of a vowel's likelihood of belonging to any of the three classes. Thus it appears that for this speaker, there is no significant difference between genuine schwas, putative schwas and stable /Œ/'s with respect to phonetic quality and prosodic factors in word-internal position. All of these vowels are realized identically, i.e. as [ø].

To conclude this analysis of schwa, it is worth comparing its quality in word-final position to the quality of word-internal [ø]. The three categories (schwa, putative schwa and stable /Œ/) were pooled together, since there is no phonetic difference between them, and compared to final schwas. The average values are provided in Table 8, in raw Hertz and ERB units. A logistic mixed-effects model similar to the previous models was built to assess the significance of the differences. The outcome variable was set to the vowel's CLASS (word-internal [ø] vs word-final), F1, F2 and F3 (in ERB units) were used as fixed effects, and a random intercept for WORD was included. The results of the model are provided in Table 9.

Table 7. Model for schwa vs putative schwa vs /Œ/ in word-internal position

Name	Estimate	Std. Err.	*t*-stat.	*p*-value
Intercept	-25.51	33.83	-0.75	0.45 (*n.s.*)
Intensity	0.01	0.021	0.57	0.57 (*n.s.*)
Duration	0.06	0.28	0.21	0.83 (*n.s.*)
F0 (ST)	0.55	0.66	0.84	0.40 (*n.s.*)
F1 (E)	-0.29	1.21	-0.24	0.81 (*n.s.*)
F2 (E)	0.35	0.75	0.46	0.64 (*n.s.*)
F3 (E)	0.51	0.58	0.87	0.39 (*n.s.*)

Table 8. Final schwa vs word-internal [ø]

	F1	F2	F3
final schwa	420 Hz (112) 10.0 E (1.2)	1507 Hz (124) 18.7 E (1.9)	2634 Hz (226) 23.1 E (1.0)
word-internal [ø]	427 Hz (21) 9.8 E (0.3)	1442 Hz (84) 18.5 E (0.5)	2482 Hz (178) 23.0 E (0.6)

Table 9. Model for word-internal vs word-final positions

Name	Estimate	Std. Err.	*t*-stat.	*p*-value
Intercept	18.74	5.47	3.43	0.00 ***
F1 (E)	-0.49	0.19	-2.57	0.01 *
F2 (E)	-0.18	0.15	-1.19	0.23 (*n.s.*)
F3 (E)	-0.48	0.28	-1.68	0.09 (*n.s.*)

As we can see, only F1 contributes to differentiating the two classes. Under the usual assumptions that F1 is inversely related to vowel height, F2 is influenced by the size of the front cavity (which is related to vowel backness and, to a lesser extent, rounding), and F3 is correlated to lip protrusion, it appears that word-final schwa is slightly higher, but has a wider distribution (see the larger standard deviation), than (unstressed) [ø].

4. Discussion

Let us first summarize the main points of this paper. I have described a case of phonological opacity involving the surface neutralization of the contrast between /ə/ and /Œ/ (a mid front rounded vowel that can be realized as mid high or mid low) to [ø] in Southern French. In this variety of French, all vowels but schwa project a foot, whereas a schwa-headed syllable is adjoined to a preceding syllable to form a trochee, within a prosodic word. The effect of footing can be observed in the realization of the vowel preceding schwa if it is a mid vowel, since according to the LDP, a mid vowel is mid high in an open syllable and mid low in a closed syllable or in an open syllable followed by a schwa-headed syllable.

In order to shed some light on the type of opacity involved, two possible derivational analyses, one involving structure changing (schwa projects a foot, which is destroyed and merged with the preceding one) and one involving structure building (a schwa-headed syllable is left unfooted, and is later adjoined to the preceding foot) were discussed. Both analyses result in counter-bleeding opacity (overapplication of trochee formation, since the dependent vowel is not a schwa on the surface), but the structure building analysis also displays symptoms of counterfeeding opacity, i.e. underapplication of unary foot projection for the colored schwa. This multi-symptom case of opacity is the result of the fact that, contrary to most cases discussed in the literature, the opaque generalization involves suprasegmental structure which, when viewed derivationally, is usually constructed in several steps, i.e. by the sequential application of several rules. Crucially here, a later rule may interact *simultaneously* with several of the rules involved in prosodification. In order to try to disentangle the situation faced by a learner, I have put forward a (practical) taxonomy of the vowels realized as [ø] in word-medial position, showing that in some cases schwa is recoverable, but in some cases it is not.

In order to get a better understanding of the phonetic realization of opaque schwa, I have conducted a pilot study involving one speaker representative of the dialect analyzed in this paper. It was shown that, for this speaker, (i) the phonetic quality of schwa in word-final position is close to, but different from, [ø]; (ii) schwa is indistinguishable from [ø] in word-initial and word-medial position.

The results from this study call for several remarks. Since only one speaker was studied, the results obviously do not hold for 'Southern French' as a whole, but the fact that schwa is phonetically identical to /Œ/, and does not trigger any measurable prosodic difference in non-final position, suggests that this vowel is genuinely opaque in the subject's idiolect. Given that the material analyzed in this paper was a list of isolated words, if the effects of prosodic structure (e.g. *demeurez* [(dø)$_\Sigma$(mø)$_\Sigma$(ʁe)$_\Sigma$] '(you pl.) remain' vs *donnerez* [(dɔnø)$_\Sigma$(ʁe)$_\Sigma$] '(you pl.) will give') are not visible in this setting, it is extremely unlikely that one could detect any effect at all in connected speech in this type of idiolect, since potential cues to lexical metrical structure usually get weakened once words are integrated into larger prosodic units (as noted by Durand et al. 1987: 992 for Southern French). This strongly supports the view that the generalizations about footing and the LDP are limited to the lexicon. Durand (1986), for instance, clearly distinguishes between the *lexical foot*, as discussed in this paper, and the *sentence foot*, which can operate

across word boundaries. For the subject presented in this paper, the effects of lexical footing are not measurable in non-final position.

Given the genuinely opaque realization of schwa, it is worth revisiting the two cases of putative schwas mentioned in §2.4. The category labeled *non-recoverable putative schwa* corresponds to a vowel, spelled as *e*, which is realized as [ø] within a morpheme, as in *all̲emand*. Postulating an underlying schwa in this context would result in an instance of absolute neutralization (Kiparsky 1968) since the schwa in this morpheme would never surface as such. It is therefore reasonable to assume that in this dialect, the vowel in this context has been reanalyzed as /Œ/, so that the underlying form of *allemand* is /alŒmaᵑ/, not /aləmaᵑ/. The case of *alternating putative schwas* is much more complex. To illustrate the difficulties involved, consider the forms *(se) promener* 'to take a walk' and *(se) démener* 'to go out of one's way', both morphologically related to *mener* 'lead' which, as was mentioned in §2.4, displays a surface alternation between [ø] and [ɛ] (mener [møne] ~ mène [mɛnə]). Our speaker systematically pronounced the word *promener* as [pʁ̥ɔmøne] in the corpus, but he always pronounced *démener* as [demøne], with a mid high vowel. Mid vowel adjustment in [pʁ̥ɔmøne] suggests that the second vowel is a schwa and that the prefix and the base belong to the same prosodic word (see §2.2). A possible explanation for this apparently conflicting pattern (mid high vowel in *démener*, mid low vowel in *promener*) would go along the following lines: the stem *men(er)* has an underlying schwa /mən/, but the derived form *promen(er)*, which has drifted away from its etymological base and is semantically no longer compositional, has been reanalyzed as an autonomous form, making it possible for mid vowel lowering to apply in ⟨pʁOmən⟩⟨e⟩ → [pʁ̥ɔmøne][16]. This (non-productive) Latinate prefix *pro-*, as in English, is semantically non-transparent in most forms it appears in, as in *produire* 'produce', *proscrire* 'forbid', *proposer* 'propose', etc. It must be distinguished from the productive prefix *pro-* (opposite of *anti-*), which allows the creation of neologisms that are clearly compositional, such as *pro-Sarkozy* (former French president) and *pro-israëlien* (compare with *anti-Sarkozy, anti-israëlien*), and there is independent evidence that the two forms of *pro-* behave differently with respect to syllabification. While the form *proscrire* is usually realized as [pʁ̥ɔskʁ̥iʁə], which suggests that /s/ is parsed as the coda of the first syllable, Durand (1990: 26) gives the pronunciation [pʁ̥ostalinjɛᵑ] for *pro-stalinien*, which indicates that /O/ and /s/ are

[16] Angle brackets represent morphological domain boundaries.

heterosyllabic (see §2.2). The form *démen(er),* on the other hand, is most likely still compositional in this idiolect, preventing mid vowel lowering from applying across the stem's bounding domain, as in ⟨dE⟩ ⟨mən+e⟩ → [demøne], not *[dɛmøne]. This is also confirmed by forms such as *déstabiliser* [destabilize] with a mid high vowel (Moreux 1985: 62, Durand 1990: 26). Nevertheless, it is worth noting that there is a certain amount of variation in this area of the grammar, as was already pointed out in §2.4. Rochet (1980: 92-93) reports the pronunciation [pʁ̥omøne][17] in Bordeaux, suggesting that an etymological schwa may have been reanalyzed as /Œ/ in this case. This is a very plausible analysis, assuming that the base is indeed ⟨pʁOmən⟩, as for our speaker, but we cannot entirely rule out the possibility that this form is actually ⟨pʁO⟩⟨mən⟩. The presence of a mid high vowel at the end of a prefix and before an alternating putative schwa cannot be construed as a definite cue of the presence of a stable /Œ/ because the putative schwa could be at the left edge of its bounding domain, but the presence of a mid low vowel *is* a negative signal (*Grenzsignal*, Trubetzkoy 1938: 290 ff.) that there is no domain boundary after the mid vowel (and in this case, it also signals that the putative schwa *is* a schwa). As should by now be clear, it is not possible to provide a general answer regarding the nature of alternating putative schwas, and one would probably need to carry out an extensive morpho-phonological investigation of the paradigms in which the vowel appears to determine, in each case, whether it is a schwa or an /Œ/.

From a more theoretical perspective, our results put some constraints on the type of models compatible with the system illustrated by our subject. Specifically, counterbleeding opacity cannot be handled in standard OT, and some additional devices must be appealed to (see Baković 2007, McCarthy 2007: §2.3). One particularly problematic approach is Turbidity Theory (Goldrick 2001, see also McCarthy 2007: 31-33). This approach preserves the general parallel architecture of OT, but enriches phonological representations to allow for a different treatment of opaque and transparent segments. In this framework, association lines (represented as ↕) between segmental and suprasegmental structure are broken into two relations: *projection* (↑), which requires that a segment project some prosodic structure, and *pronunciation* (↓), which requires that a segment be pronounced (≈ licensed) by a prosodic constituent. Eychenne (2006: §6.3.1.3) builds upon this proposal to handle schwa coloring. An illustration of this approach for the form /bEtəmaŋ/ → [bɛtømaŋ]

[17] The transcription has been converted to IPA.

is given in Figure 5. One important difficulty with this approach is that one would expect the difference between a fully associated [ø] and a projected-only [ø] to be measurable in some way. For dialects in which the two vowels are phonetically different (if there is any such dialect), this type of approach could be justified, but it is clearly not tenable for the idiolect discussed in this paper, since the two vowels are identical. If one is allowed to enrich the theory at will without empirical consequences, it is hard to see how it can be falsified, and one can legitimately express doubts about its value as a scientific model of phonological competence. If, on the other hand, Turbidity Theory does predict that one should observe (possibly minute) phonetic differences between a transparent and an opaque structure, then the data presented in this paper offer a falsification of this approach since, in this particular idiolect, there is no difference between an [ø] derived from /Œ/ and one derived from /ə/. These data do not rule out all the variants of OT, however. Approaches such as Stratal OT (Bermúdez-Otero 2003) and Harmonic Serialism (McCarthy 2007, 2010), which both incorporate some form of derivation, albeit in different ways, are able to cope with this type opacity. Indeed, many cases of opacity have been major motivating examples in the development of these frameworks.

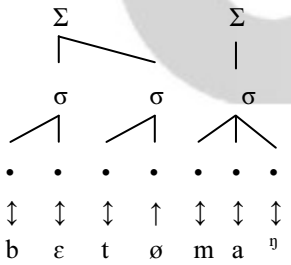

Figure 5. Turbid representation of *bêtement*

Finally, it must be emphasized once more that the results presented in this paper are not meant to be representative of Southern French as a whole. A key assumption of this work has been that the LDP is an exceptionless generalization. Although there are strong arguments for supposing that this is correct in this dialect, and notwithstanding a few principled exceptions (Rochet 1980, Eychenne 2014), it appears that the LDP is not as robust a generalization in some other Southern dialects. For example, in the variety described by Moreux (1985) and spoken in Béarn (South

West), open [ɔ] and [œ] are attested in open syllables, thus violating the LDP. In addition, some speakers display a contrast between /e/ and /ɛ/, as in Parisian French, as evidenced by minimal pairs such as *été* [ete] 'been' vs *étais* [etɛ] 'was' (see Moreux 1985: 65-66). In the South East, Nguyen and Fagyal (2008) showed that, in Aix-en-Provence (near Marseilles), the height of a mid vowel may be influenced to a certain extent by that of the following (stressed) vowel. For instance, /E/ might be lower in *dévote* [dɐ̣vɔtə] 'zealot+FEM', where it is influenced by the following mid low [ɔ], than in *dévot* [devo] 'zealot.MASC', where it is followed by a mid high [o]. This gradient vowel harmony does not appear to be phonologized, and they note that it is less frequent among Southern speakers than Northern speakers in their data, but it suggests that the LDP may not be absolute. Thomas (2006), who conducted a sociophonetic variationist study in another Southeastern dialect (in Nice, closer to the Italian border) argues that, although the LDP seems to be quite robust for the vowel /E/, it is less so for /O/ and /Œ/. All these facts show that, in some Southern varieties of French, the LDP may not be as reliable a cue as it is in varieties such as the one described by Durand et al. (1987) and here (Languedoc and surroundings). It remains to be seen to what extent the non-systematicity of the LDP might challenge the generalizations and results discussed hereinabove. Nevertheless, it is hoped that the data and analyses presented in this paper will provide some useful landmarks for further research on the nature of schwa in Southern French varieties.

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