

EXPLANATORY ADEQUACY IN PHONOLOGY: A DEDUCTIVE APPROACH TO /R/

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Abstract

This work reexamines phonological variation particular to the /R/ of convergent French, departing from the hypothesis that a deductive approach to this question can offer explanatory advantages. In contrast to data-driven approaches, the productive and receptive characteristics of /R/ constitute the foundation for explanation here. This approach is framed by a biomechanical conceptualization of effort and the general principle that, *mutatis mutandis*, effort should be reduced or avoided. Contextual oppositions underlie proposed effort-based taxonomies involving the relative effort implied by different outputs, themselves based on observations of the phonetic (productive and perceptual) quality of these surface segments. These oppositions are subsequently integrated in a productive phonological grammar following Optimality Theory (OT, Prince and Smolensky 1993), in which constraints are phonetically motivated. This grammar also highlights the minimal phonological representation characteristic of French /R/. It is posited that this phoneme is specified only for dorsality and continuance, excluding specification for manner (fricative, approximant) and voicing.

1. INTRODUCTION

This paper presents an analysis and explanation of rhotic variation in French, focusing on those varieties having a dorsal or back /R/.¹ Analysis of output or surface variation is undertaken deductively, deriving from phonetic principles and

¹For purposes of discussion and economy, all back /R/ are referred to as dorsal continuants throughout the present work; it should be noted that neither the IPA symbols nor segmental titles are meant to reflect an absolute or fixed articulation, but reflect observed tendencies among the larger, heteronymous group of speakers having back /R/. I specifically ignore French dialects having an apical /r/, including those having both apical and dorsal /r/ variants, as noted for example in Montreal (Charbonneau and Marchal 1976; Toussignant, Sankoff and Santerre 1989). While these variants are interesting, they have been excluded from the present discussion for qualitative reasons — namely the articulatory and acoustic differences distinguishing apical rhotics from dorsal ones — and due to empirical shortcomings — specifically the lack of available articulatory and acoustic data specific to such variants.

biomechanical observation. Categorized oppositions of more and less effort inducing gestural configurations are subsequently integrated within a broadly functionalist Optimality Theoretic (OT; Prince and Smolensky 1993) phonological model and the representation of /R/ is discussed, arguing for minimally specified input specification. Interest in French /R/ is twofold. Firstly, the French /R/ has not been adequately described or explained to date. By questioning the nature of this phoneme and its allophonic variation, greater insight is given into the phonological system of French. Secondly, this topic serves to demonstrate a potentially advantageous approach to phonology, one grounded in phonetic principles and founded upon a deductive methodology.

1.1. French /R/: An overview

Most phonetic and phonological literature acknowledges that the French /R/ is a variable sound, with little further precision as to surface form and distribution. Delattre (1971: 146) refers to /R/ as a "voiced constrictive" and presents x-ray tracings of one speaker's output, ignoring voicing and manner variability in his subsequent description. Tranel (1987: 142) notes that a this segment may be "'dorsal' ... 'velar' ... 'uvular' ... or pharyngeal" and that the "essential articulatory characteristic of the back *r* in standard French seems to be a pharyngeal constriction," which may be produced by at least two different tongue positions. Walker (2001) describes the segment as a uvular liquid, ignoring place and manner variation. Léon and Léon (1990: 23) make a distinction between two dorso-uvular rhotics, one which is "non-vibré" and the other which is rolled, specifying that the former "se répand le plus actuellement dans toute la francophonie," although they offer no explicit evidence for this claim. Russell Webb (2002) presents a close analysis of two metropolitan French speakers' rhotics, offering spectrographic evidence for place, manner (degree of constriction, voicing) variation according to positional and phonotactic considerations, but stops short of providing an explanation for these phenomena.

None of the above-mentioned sources posits a specific representation of /R/, nor do they propose an explanation accounting for variation, leaving the question unanswered as to why one or another output form surfaces. In many ways, these shortcomings are understandable; any account of /R/ phonology faces a relatively large idiosyncratic or speaker-specific variability not associated with geographic provenance or social network. French speakers of a common background might have different dorsal rhotics, variations of which might follow distinct patterns.

Boundaries distinguishing areas or social strata where one or another surface form of /R/ is normal are difficult, if not impossible to establish. Lacking such isoglosses, it is advantageous to distinguish between archetypal /R/ patterns. This classification construes speakers' habits in terms of systems: those having a velar or uvulo-velar /R/, where constriction in the oral cavity occurs between the tongue dorsum and the velum, involving secondary contact with the uvula; those having this as well as a uvular /R/, where the constriction occurs behind and not normal to the velum; and those having only a uvular /R/. Among such systems, the surface or

output form follows a regular pattern, e.g., voiceless variants occur in clusters involving a voiceless obstruent, voiced variants in those involving a voiced obstruent, and more- or less-constricted variants appear in pre- versus post-vocalic position. In several instances, such as simple onsets or word-final instantiations, variability in place and manner of articulation is also noted. The data in (1) provide examples of each type of tendency and exemplify typical outputs.

(1) a. *Velar or uvulo-velar /R/: V-system*

[ʋ]: *gras* 'fat'

[x]: *crasse* 'vulgar'

[ʁ]: *Arras-*, *garde* 'guard-3S'

[χ]: *harpe* 'harp', *âpre* 'sour'

[ʋ] or [x]: *rat-*

[ʁ] or [χ]: *par* 'by', *cadre* 'frame'

b. *Velar or uvulo-velar and uvular /R/: VU-system*

[ʀ]: *gras* 'fat'

[χ]: *crasse* 'vulgar'

[ʁ]: *Arras-*, *garde* 'guard-3S'

[χ]: *harpe* 'harp', *âpre* 'sour'

[ʀ] or [χ]: *rat-*

[ʁ] or [χ]: *par* 'by', *cadre* 'frame'

c. *Uvular /R/: U-system²*

[ʀ]: *gras* 'fat', *Arras-*, *garde* 'guard-3S'

[χ]: *crasse* 'vulgar', *harpe* 'harp', *âpre* 'sour',

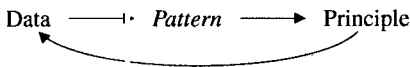
[ʀ] or [χ]: *rat-*, *par* 'by', *cadre* 'frame'

Of course, not all outputs conform to these relatively restricted archetypes; the majority of outputs, however, conform to the overall pattern established above (cf. Tranel 1987: 139–143; Russell Webb 2002: 33, 155–162; Ladefoged and Maddieson 1996: 225–226). The task of the present work is therefore not to account for every /R/ variant, but to propose an explanation for a broad distribution pattern.

1.2. Theoretical background

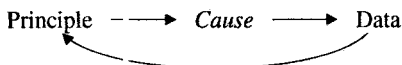
Traditionally, phonological analysis has proceeded from the description of a data set from one or more languages to the explanation of output and variation, based on principles induced from these data. A particular behaviour or pattern is isolated and formal rules or constraints are applied to an underlying or input representation, from which the surface form is generated; an illustration of inductive processing is provided in (2).

²Extrametrical /R/ elision (e.g., *quatre* 'four' [kat]) and the insertion of a paragogic vowel (e.g., *quatre* [katʁø]) are also common, especially in informal situations and/or rapid speech, as well as more systematically in some regional varieties. These questions are not taken up in the present work.

(2) *Inductive Explanatory Procedure:*

Despite the quantity and quality of phonological analyses founded on inductive logic and motivated by empirical observation, shortcomings of this approach are easily exemplified. One commonly used constraint is *CODA (“codas are not permitted”), based on the observation that languages tend to avoid syllabic structures having complex nuclei (e.g., Blevens 1995). While an inductively derived constraint such as this is descriptively useful, it is explanatorily weak, i.e., it makes no statement as to what characteristics of codas or of syllabic structure would cause codas be avoided. Such a constraint is also tautological in nature; inductively derived *CODA asserts that structure is avoided because structure is not present, i.e., “codas are avoided because many languages avoid codas.”

The shortcomings of induction and data-driven methods have sparked increased attention in phonological theories based on grammar-external principles, departing from the hypothesis that reference to phonetics may offer greater insight into the underlying causalities of observed phonological patterns and, in so doing, provide greater explanatory power to phonological theory itself (cf. Boersma 1998, Kirchner 1998, Hayes and Steriade 2004). Here, phonology is grounded in and makes reference to phonetics, the biomechanical framework through which grammars operate and from which they emerge. Deductive or phonetically-driven processing begins with observation of phonetic principles, rather than specific data, as illustrated in (3).

(3) *Deductive Explanatory Procedure:*

Returning to the example above, *CODA might well be reformulated, making specific reference to the causalities leading to coda avoidance, e.g., the reduction in lung air after sonority peaks (i.e., vowels) or to the relative lack of perceptual importance given to acoustic information in post-vocalic environments. This is inherently more satisfactory, as it avoids the tautology noted above and refers to extragrammatical principles.

It is important to note that a deductive approach neither denies the importance of data or empirical evidence, nor asserts that all phonology can be deduced from phonetics; even phonetically-driven phonology places importance on the role of faithfulness and input representations. It is nevertheless asserted that a deductive framework can contribute to a greater understanding of phonological grammars and the constraints or rules contained therein, inasmuch as phonetic principles have a role in shaping these. With regard to the topic at hand, a deductive approach offers distinct advantages. /R/ variation is accounted for in a production grammar integrating constraints based on phonetic principles, rather than ones posited ad hoc or

based solely on empirical data. Variable output is furthermore accounted for without positing a minimally restrictive /R/ input, assumed to more accurately reflect the psychological reality of /R/. Finally, the present approach demonstrates that it is possible and even advantageous to pursue a phonological explanation following a deductive process.

1.3. Methodological outline

The present analysis begins with a description of the phonetic properties of dorsal continuants, i.e., their gestural characteristics and acoustic profiles. Phonetic considerations are subsequently integrated within a system of oppositions or contrasts based on the relative amount of effort required by different variants. It is proposed that speakers learn more and less effort inducing gestures, as well as the effort implied by different acoustic signals, leading to the categorization of phonetic oppositions in phonology (cf. Hayes and Steriade 2004). These phonological grammars require a definition of effort for both speakers and hearers which are captured in effort-based constraints, applied to an OT phonological model.

While the notion of effort as described in the following sections is inherently phonetic, effort is also a phonological consideration, as relative degrees of effort are assumed to be learned and categorized by speakers (Hayes 1996: 3–5). As such, the notion of effort is both phonetic and phonological, hinting that the two components of speech are not orthogonal, but interdependent. Effort is considered to be at the heart of /R/ variation, based on the theoretical assumption that the relative effort leads to structural markedness, i.e., that speakers learn more and less effortful patterns and that, *mutatis mutandis*, the former are avoided (Kirchner 2004: 320–321).

2. GESTURAL PROPERTIES OF DORSAL CONTINUANTS

Each manifestation of /R/ seen in (1) involves the positive activation of the tongue dorsum and contact with, but not complete occlusion at, the velum and/or uvula. The gestures involved in the articulation of all dorsal continuants occur in a relatively expansive region behind the hard palate and above the pharyngeal cavity, the source of most noise turbulence. Air flowing from the glottis passes through a relatively close aperture, where the tongue dorsum is positioned normal to the soft tissue behind the palate, producing a turbulent airstream.³ Figure 1 provides a schematized representation of dorsal constriction in the oral cavity.

In addition to the distal target of active articulator (i.e., tongue) displacement, trilled versus non-trilled /R/ variants differ in articulator configuration. Whereas the tongue is relatively non-constricted when trilling is not involved, it must be lowered centrally and raised laterally in order for the uvula to flap against the lowered central portion of the tongue dorsum. Any aperture at the point of constriction must

³This gestural configuration is particularly quantal, i.e., micro variations of the place of obstruction and/or in the configuration of the tongue during obstruction do not result in dramatically different acoustic signals (cf. Stevens 1989).

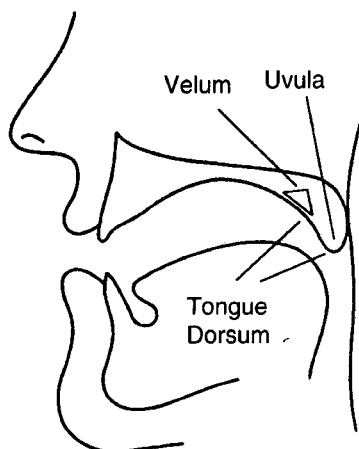


FIGURE 1
Articulatory stylization of dorsal continuants

not be so close as to impede air flowing through the glottis, which is necessary to produce the open-close movement or periodic flapping of the uvula against the tongue body (Bary 1997). By contrast, articulator configuration is relatively less precise (i.e., requires the activation of fewer muscle groups) for fricative and approximant variants. The tongue must only be drawn back and up for both; it must also be constricted, forming a “u-like” or grooved contour, for trilling to occur.

Any of the above gestural configurations may be accompanied by or absent of source voicing. For a voiced sound, air moves through an adducted glottis, i.e., one which is positioned in such a way as to facilitate the periodic resonance of vocal folds. This may obtain by the contraction of tongue and laryngeal muscles, decreasing the stiffening of glottal walls and the lowering of the larynx (Stevens 1998: 483). Voicing may be achieved by default or passively, in the context of other voiced segments and when occlusion is relatively short in duration. Voicelessness may also obtain passively, especially when a significant increase in pressure differentials between the sub- and supra-glottal cavities arises, especially common in final positions (Westbury and Keating 1986; Russell Webb 2004).

2.1. Acoustic properties of dorsal continuants

The acoustic signals associated with all dorsal continuants contain widely distributed noise spectra, with relatively clear formant peaks or areas of acoustic prominence below 3000 Hz. Russell Webb (2002: 118–121) observed average /R/ resonance frequencies at ± 700 Hz, ± 1500 Hz and ± 3000 Hz for his French speakers, across positional and phonotactic contexts. Closer apertures in the oral cavity produce relatively more dispersed acoustic energy, with more fricative-like fre-

quency striations; greater apertures produce clearer, more vowel-like frequency striations. Illustrations in Figures 2 and 3 provide spectrographic evidence of the acoustics of the velar rhotics of an adult female speaker from Lyon, contrasting initial and final occurrences.

Trilled dorsal continuants present relatively clear regions of acoustic prominence, at approximately the same frequencies — if not slightly lower in the case of second resonances. The most striking qualitative characteristic of these segments is their periodicity, manifest acoustically as a pulse pattern, alternating cycles of noise and its absence (Russell Webb 2002: 115, 119–121; Ladefoged and Maddieson 1996: 225, 227).

2.2. Effort and /R/ variation

For the purposes of this work — and acknowledging many of the deficiencies inherent therein — effort is defined as the positive, potential or realised expenditure of energy (Kirchner 1998: 35–51, 149–151). When faced with the task of articulation, speakers must expend energy in the form of muscle activation, drawing air into the lungs, as well as configuring and displacing articulators. Listeners require a clear signal which can be mapped onto learned patterns and which does not risk confusion among other possible signals, implying a distinctly different type of effort (cf. Ohala 1983, 1993).⁴ It is assumed that different gestural configurations require more effort than others, where effort is defined as physical activity, and that different acoustic signals imply greater perceptual effort than others, where effort is defined as cognitive activity; furthermore, it is assumed that effort will be avoided whenever possible and that, when effort is required, the least amount of effort will be expended to accomplish a given task (Boersma 1998: 149; Kirchner 1998: 41).

Three considerations are primary with regard to effort and dorsal continuants: the positive displacement of the tongue and its configuration or contour; the relative degree of precision implied by different gestural configuration; and the state of the glottis. Also of concern are the effects of different gestures upon the acoustic signal, specifically the presence or absence of a more or less robust acoustic signal. Rather than refer to a unary phenomenon, effort is combinatory, involving characteristics inherent to a gesture or acoustic signal and those inherited or derived from a larger context. For instance, a voiceless [ɣ] is less effortful in the context of a voiceless plosive, e.g., [t], as no additional activation of laryngeal muscles is implied for this output to obtain. A voiced [ɣ] implies more effort in this context, but less when adjacent to a voiced plosive, e.g., [d] (Russell Webb 2004).

⁴Steriade (2001) refers to the perceptual mapping of output signals, making explicit assumptions about the role of perception in phonological grammars as being counterpart to that of gestural effort.

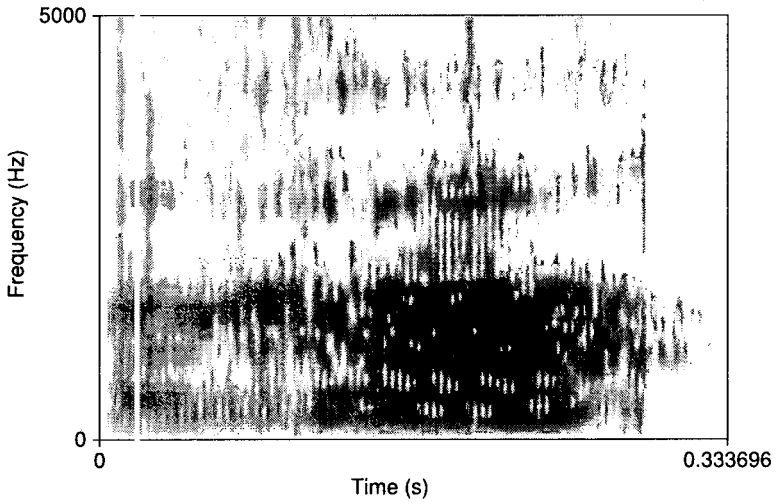


FIGURE 2
Spectrogram of *rat* (adult female)

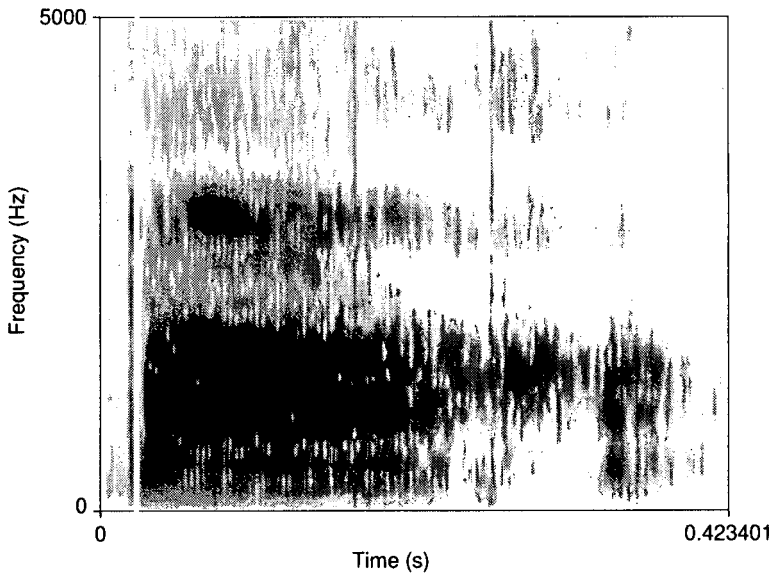


FIGURE 3
Spectrogram of *par* (adult female)

3. PHONOLOGICAL CATEGORIZATION OF EFFORT

Rather than deduce a phonology favouring either gestural effort reduction or acoustic salience, the present work advocates an approach wherein both forces are active.⁵ Fundamental to this analysis is an understanding that the biomechanical imperatives involve tension between two poles of phonetic goodness, one promoting ease of production and another ease of reception or processing. This reflects Lindblom's H&H (hyper-hypo) theory, which conceives of speech production as a "tug-of-war" between articulatory economy and receptive salience (1990). For phonology, it is necessary to provide for the opposition of possible outputs. The relative effort implied by gestures and their resulting acoustic signals must therefore be categorized as more or less effortful either intrinsically or contextually (or both). This is an inherently phonological question, as it involves a departure from gradient gestures and acoustic signals and the establishment of taxonomic oppositions.

In prevocalic or onset position (e.g., *gras*), relatively less lexical and/or contextual information is available to listeners. Given the acoustic proximity between the variants of /R/, most notably those that are less fricative and more approximant, a more robust acoustic signal will result from a more precise gestural configuration involving a closer aperture or, in the case of a system in which the trill is available, a gestural configuration favouring the production of periodic noise. These variants are either more intense (fricative versus approximant) or systemically more distinct vis-à-vis all other continuant consonants in French (trilled versus non-trilled). Prevocalic output may be deduced from listener-oriented considerations; in these positions, trilled [ʀ] or [ʁ] and fricative [ʁ] or [x] provide relatively better acoustic signals, with decreased potential for confusion, although they might imply greater gestural effort.

In intervocalic positions (e.g., *Arras*), articulation involves transition from configurations involving little to no tongue contact with passive articulators, as well as to and from targets in other areas of the oral cavity. Any reduction in the degree of movement — such as that which might obtain from relatively quicker or shorter displacement — is positive from the articulatory point of view, as it requires a shorter duration of effort and a reduced articulator displacement. The acoustic information available to listeners in such contexts is nevertheless relatively abundant; listeners have access to formant transitions and other coarticulatory effects. In essence, intervocalic contexts are ideal from the standpoint of both articulatory and perceptual ease, leading to the categorization of either trilled or fricative variants as relatively more effort-inducing variants.

In immediate post-vocalic positions (e.g., *courte*, *courge*, *harpe*), the dynamics of dorsal continuant articulation and perception are similar to those of inter-

⁵Boersma (1998) accomplishes this using distinct evaluation matrices, deriving from what he terms articulatory and perceptual drives. These are combined in the present work, largely for the purpose of methodological economy.

vocalic contexts. With regard to the degree of active articulator displacement or aperture at the point of constriction, it is more likely that less precise gestures will be favoured, as well as those involving shorter and quicker positive displacement of the tongue. In contexts involving increased airway constriction resulting in full obstruction, such as in vowel -/R/- obstruent sequences, the tongue must move from a vowel configuration, be drawn back and then move to a ternary configuration. When the following obstruent is labial (e.g., *harpe*), alveolar or dental (e.g., *courte*), or palatal (e.g., *courge*), a relatively greater overall displacement effort is required of the tongue. Effort reduction in these instances favours the avoidance of close, but not occluded velum-tongue dorsum contact (i.e., fricative [ʁ]) or the relatively more precise tongue configuration required for uvular trilling (i.e., [R]). For contexts involving a following velar obstruent (e.g., *orgue*), effort reduction implies a shortened transition, essentially the avoidance of the precise gestural configurations required of either frication or trilling prior to full occlusion.

The production of dorsal continuants in final, post-occlusive positions (e.g., *cadre*, *apre*) involves relatively more gestural effort than any of the above contexts, as the tongue must be released from full occlusion — complete impedance of air-flow through the oral cavity — and be subsequently drawn back, providing a close aperture at a moment when pulmonic air volume is at its lowest. A relatively less effort-inducing gestural configuration will be of shorter duration, favour greater apertures at the point of constriction and require the activation of fewer muscle groups, providing for the categorization of approximants [ʁ] and [ʁ̥] as the least effortful outputs. Listeners do not benefit from the regressive influence on vowel formants in these instances, as with intervocalic or post-vocalic contexts; they do, however, have access to a good deal of lexical and contextual information, as well as from acoustic cues inherent to all /R/.

For all dorsal continuants, regardless of position, effort may be avoided by the passive configuration of the glottis, i.e., the absence of targeted activation of muscles in the larynx. In the sequence of voiced obstruent -/R/- vowel, effort reduction implies the continuation of voicing throughout; the reverse is true of sequences involving a voiceless obstruent. Simple onsets consisting of a dorsal continuant alone are likely to result in variation, this being motivated by contextual issues such as position in the breath group and/or adjacent segments. In an environment where both preceding and following segments are specified for voicing, such as in intervocalic positions, passive voicing implies continual glottal adduction, i.e., voicing. Since there is no categorized opposition between voiced and voiceless dorsal continuants in French, the glottis may anticipate and pre-emptively prepare for the following consonant configuration, providing passive voicing in contexts where the following obstruent is [+voice] (e.g., *courbe*) and voicelessness where this is [-voice] (e.g., *courte*). In post-occlusive, final contexts (e.g., *quatre*, *cadre*), the articulatory goal implied by a following obstruent is lacking; here, it is highly likely that vowel source voicing will continue during dorsal continuant production, although the degree and relative duration of this will likely vary according to other contextual or

productive factors (cf. section 3.1).

A summary of the above discussion is provided in (4), reflecting the three archetypal systems presented in (1).⁶

(4) a. V-system:

- [ʋ , x] < [ʋ , x] / V __, X __]
 [ʋ , ʋ] < [x , x] / __ X or X __
 [x , x] < [ʋ , ʋ / __ X or X __, X __]
 | ʋ , x | < | ʋ , x | / __ V

b. VU-system:

- [ʋ , x] < [r , x] / V __
 [r , ʋ] < [x , x] / __ X or X __
 [x , x] < [r , ʋ] / __ X or X __, X __]
 | r , x | < | ʋ , x | / __ V

c. U-system:

- [r] < [x] / __ X or X __
 [x] < [r] / __ X or X __

It should be stressed that the oppositions in (4) are phonological taxonomies, i.e., categorizations of binary oppositions within specific contexts. These are not an absolute interpretation of effort, but reflect contrasts that are assumed to be available to speakers who have acquired these categorizations as part of their grammar.

3.1. Effort-based phonological constraints

In OT phonology, considerations of categorized ease or goodness are subject to evaluation by markedness constraints promoting effort avoidance and/or reduction. These constraints are based on grammar-external principles, specifically the relative ease or difficulty implied by candidate gestures and signals.⁷ The present work employs cover constraint LAZY, as in (5), which captures the effort-reduction/avoidance principle evoked in section 2.2.

(5) LAZY: minimize articulatory effort (Kirchner 1998: 38, his 2-1)

LAZY may be binarized, as in (6), reflecting the categorization of effort, i.e., the discrete gradience that is assumed to be learned by speakers.

(6) ... LAZY $n + 1$ \gg LAZY n \gg LAZY $n - 1$... (where $n =$ "Do not expend effort $\geq n$ ") (Kirchner 1998: 201, his 6-13)

⁶ < = "less effort inducing than"; [] = gestural configuration, | | = acoustic signal, X = any segment.

⁷ Hayes refers to the inductive grounding of phonology, reflecting the learned goodness of phonetic detail (i.e., oppositions; 1996: 3-5). Likewise, Boersma asserts that phonological features arise from language use, the emergent categorization of useful oppositions (1998: 179).

With regard to the relative articulatory and perceptual efforts systematized in (4), n may be defined as any gestural configuration or acoustic signal which is more effort inducing than another. Essentially, each candidate on the right side of the taxonomies in (4), i.e., which is more effortful, results in a violation of LAZY ($n + 1$). If a candidate is more effortful under two categorizations, it violates LAZY ($n + 2$). Although this binarization could be continued indefinitely, only two levels are necessary for the present explanation.

Using the V-system for illustrative purposes, binarized LAZY predicts dorsal continuant output in complex onsets, codas and intervocalic positions, as seen in (7a) through (7c). In prevocalic positions, following a voiceless obstruent (7a), only the voiceless fricative [x] provides no violations of LAZY; by contrast, all other candidates violate either LAZY ($n + 1$) or this and LAZY ($n + 2$). A complementary situation would naturally obtain when the preceding obstruent is voiced (e.g., *gras*), providing the voiced fricative [ʁ] as optimal. In intervocalic contexts (7b), the voiced approximant candidate is optimal, given the binary categorizations of (4); in post-vocalic, pre-obstruent contexts (e.g., *porte* [7c]) [x̣] is selected, where gestural properties of approximants are categorized as less-effort inducing. Parallel to onset clusters, post-vocalic, voiced approximant [ʁ̣] would be optimal where the following obstruent is voiced (e.g., *garde*).

(7) a. Prevocalic following voiceless obstruent: e.g., *prie*, *très*, *cru*

	TRV/	Lazy($n + 2$)	Lazy($n + 1$)
	T _B V		*
☞	T _x V		
	T _ʁ V	*	*
	T _{x̣} V		*

b. Intervocalic: e.g., *ira*, *Paris*, *terror*

	VRV/	Lazy($n + 2$)	Lazy($n + 1$)
	V _B V		*
	V _x V	*	*
☞	V _ʁ V		
	V _{x̣} V		*



c. Postvocalic preceding voiceless obstruent: e.g., *porte*, *harpe*, *remorque*

	VRT/	Lazy($n + 2$)	Lazy($n + 1$)
	V _B T	*	*
	V _x T		*
	V _ʁ T		*
☞	V _{x̣} T		



Similar tableaux might be generated for both VU- and U-systems; in each of these instances, a grammar containing the crucially ranked $\text{LAZY}(n+2) \gg \text{LAZY}(n+1)$ is sufficient to predict the output in these contexts.

Looking to other licensed dorsal continuant instantiations, simple onsets and codas, as well as post-occlusive or extrametrical /R/, the proposed constraint ranking fails to predict a singular, optimal output. As illustrated in (8a) and (8b), two candidates are evaluated as equally optimal. In the case of initial /R/ in a simple coda (8a), neither fricative ([x] or [ʁ]) is categorized as more or less effort inducing, though approximant [χ] and [ʁ̥] each violate $\text{LAZY}(n+1)$ and may be eliminated. Likewise, final, post-obstruent /R/ (8b) leads to the selection of either [x] and [ʁ], as both [x] or [ʁ] violate $\text{LAZY}(n+2)$.

(8) a. Simple onset: e.g., *rat*, *rit*, *roue*

	/RV/	Lazy($n+2$)	Lazy($n+1$)
()	ʁV		
()	xV		
	ʁ̥V		*
	χV		*

b. Postvocalic following voiced obstruent: e.g., *cadre*, *vibre*, *ogre*

	/VDR/	Lazy($n+2$)	Lazy($n+1$)
	VDʁ	*	*
	VDx	*	*
()	VDʁ̥		*
()	VDχ		*

The selection of two candidates underscores a distinct advantage of the deductive approach. For phonology to be truly effective, it must predict not only those instances where one or another variant will be selected, to the exclusion of all others, but those instances where several variants are equally good. Essentially, it must be possible to deduce better candidates, as well as the best candidate. In cases such as (8), hereafter referred to as instances of co-optimality, both articulatory and perceptual goodness are in competition to the extent that two candidates are evaluated as being equally optimal. For initial /R/, any prediction of the optimal candidate must look beyond the word to the larger phonological structure or context, e.g., the breath group.⁸ In the case of final /R/ following a voiced occlusive, a shorter

⁸Should /R/ be preceded by a voiced consonant within the phonological word, as in *grande rue* 'large street', the present analysis predicts that /R/ will be voiced, this following the same logic as complex onsets of the type *grue* 'crane'. Likewise, voicelessness should obtain from contexts where the preceding element is voiceless, such as *petite rue* 'small street', mirroring /R/ in onsets such as *prude* '—'.

obstruction or occlusion prior to /R/ may favour continued voicing, if egressive air is sufficient for vocal cord vibration; should the volume of air be insufficient or the occlusion longer, any voicing that occurs during the production of the preceding obstruent is likely to be of relatively short duration, favouring glottal abduction prior to the /R/ gestural configuration. Here again, the grammar can only eliminate the sub-optimal candidates, rather than select a singular candidate.

3.2. /R/ representation

While output in a given context may be predictable from such focused grammatical models as (7) and (8), these are of no use if the segment is not situated within a larger structure of contrasts, including minimal pairs and contrastive distributions. Regardless of how sound systems are formally modelled, they depend upon segmental representation, the gestural and/or acoustic information implied by a segment for both those who are producing the sound (speakers) and those who receive it (listeners).

Antecedent analyses of French /R/ have begun with specific considerations of /R/ representation, based on assumed featural values for place and manner. Tranel (1987) posits an inherently fricative rhotic, whereas Fougeron and Smith (1993) consider this phoneme to be uvular. Barry (1997) and Delattre (1971) both consider the unity of various /R/ to be attributable to the gestural and acoustic properties of uvular trills. In all such cases, a particular dorsal continuant is posited as underlying. Though the mentioned works do not explicitly treat questions of variation in surface form, any attempt to do so would necessarily imply a series of rules or constraints. Assuming a representation specified as [uvular], [vibrant] and [+voice] (e.g., /R/), surface variation may be accounted for rather straightforwardly, e.g., trill-approximant variation by an intervocalic weakening rule and voiced-voicelessness by an agreement rule, where rules or constraints are either phonetically-driven or induced from data.

While such an approach is adequate for the purposes of describing output or surface form, the selection of one central or underlying /R/ reverts to ad hoc solutions, deriving from theory-internal necessity rather than system-external principle. Determination of underlying representation is hampered by the complementary distribution of non-trilled variants, as well as by similar distribution between trilled and non-trilled /R/ among speakers using both. I am aware of no study quantifying the number of French speakers using one or another rhotic, nor of any offering explicit motivation for one or another input or subjacent form. Given these considerations, it is explanatorily more satisfactory to promote a minimal representation, encompassing only those features or categorizations that allow /R/ to be distinguished from other, systemically distinct segments, i.e., other French phonemes.

Assuming the representation of /R/ contains only those categorizations necessary for the distinction of this segment from others in the inventory, two input feature sets emerge, regardless of other particularities (i.e., V-, VU- or U-type systems, speaker style, etc.). With regard to articulatory properties, the only representational

information necessarily contained in /R/ is a notion of tongue position (backness or dorsality) and constriction (continuance or non-occlusion); with regard to perception, such information includes the frequency profile (regions of relative acoustic prominence at and below 3000 Hz) and the quality of noise (dispersed but relatively concentrated frequency resonance).⁹

In addition to responding to markedness constraints, output is constrained by faithfulness, the counterpart to markedness which promotes the correspondence between input and output. Faithfulness considerations provide for the elimination of *[ʒu] (cf. *joue* 'play'), for instance, for input /Ru/ (*roue* 'wheel'), as this output candidate does not maintain the input dorsality specification. Candidate *[u] (cf. *ou* 'or') is also excluded, as it violates faithfulness on several counts (all articulatory and perceptual information). Although faithfulness has been excluded from the tableaux in (7) and (8), as these are crucially dominated, constraints militating against feature loss are assumed to be present in all grammars.

It should be noted that this is neither a classically underspecified nor a radically unspecified representation, in which features are assumed to be present or repairable via rules of insertion, deletion or redundancy. Representation of /R/ from the above standpoint makes no such claims. In contrast to Underspecification Theory (Archangeli 1988; Pulleyblank 1988), it assumes no recourse to information not contained in the representation, i.e., denies the availability of redundancy or default rules. The preceding is a positive statement of /R/ representation, constrained negatively; /R/ is defined as everything and anything within the articulatory and perceptual space as provided above, while being nothing beyond these spaces. Essentially, such a representation assumes to reflect both what /R/ "is" and "isn't," this within the larger construct of the French phonological inventory (Russell Webb 2002: 163–170).¹⁰

4. DISCUSSION

The present work pursues a deductive approach to French /R/ variation, avoiding ad hoc rules in favour of constraints deriving from principles of articulatory and perceptual effort and from the categorization thereof. This is founded upon an understanding of how dorsal continuants are produced, the results of this production on the acoustic signal and, by extension, on the reception of speech signals. The productive (gestural) and receptive (acoustic) properties of different /R/ variants are subsequently categorized according to the relative effort that they imply in specific contexts. Output within a production grammar is predicted using markedness constraints which make direct reference to categorized effort and to effort reduction. Crucial to this analysis is a minimal representation of /R/, where only that

⁹It is likely that some speakers have more richly specified representations of this and many other segments, involving for instance specification for place (e.g., uvula). These idiolectal representations are nevertheless heteronymous to the larger, shared representation.

¹⁰The reader is referred to Hall (2001) for further discussion of representational issues.

information susceptible to distinguish this phoneme from others is assumed to be part of its input specification and where the output form emerges as a product of constraint interaction, reflecting patterns of learned phonetic goodness.

The present analysis offers several descriptive and explanatory advantages over more traditional ones. Firstly, it avoids the theoretical shortcomings of data-driven analyses, specifically the selection of one variant as being central and the introduction of ad hoc constraints or rules to explain variation. Secondly, it is based on phonetic principles active in the larger system, specifically those advocating effort avoidance or reduction, rather than targeted or /R/-specific ones; while the categorizations of (4) are specific to dorsal continuants, categorizations of relative effort may be derived for all sound segments. Finally, a deductive approach provides for greater heuristic and explanatory adequacy than does induction, as it is capable of not only explaining particular data, but of making predictions relative to other linguistic data. Such predictions may be local or global. Locally, a grammar predicting /R/ lenition in extrametrical positions in French will also predict vowel paragoge, as the insertion of a neutral vowel (e.g., [ø]) between an obstruent and /R/ results in a more salient acoustic signal. The same grammar will predict that /l/, the other continuant licensed in these contexts, will undergo elision and/or trigger vowel paragoge, given the same effort considerations.¹¹ Globally, the effort-based constraints and functionally oriented grammars fundamental to the deductive approach predict common dynamics — if not necessarily parallel data — with regard to questions such as lenition and neutralization (cf. Kirchner 1998 et seq.).

Several questions remain unanswered, due in large part to the focused nature of the present work. Foremost among these is the precise nature of representations, i.e., the systemic categorizations of distinction and similarity active in the minds of both speakers and listeners. Also left unanswered are questions regarding speakers' preferences for different system types, i.e., why some speakers have only a trilled /R/, whereas others avoid this, and yet others have both trilled and non-trilled /R/. While the present work has demonstrated how plurality is tolerated by the system and how output form may be predicted, it has not made any statements about the causality behind such a plurality. Future work should focus on these questions, looking not only to /R/ and to French, but to other languages and segments.

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¹¹Although /l/ output is not as variable as that of /R/, possibly due to the gestural properties of the former, both segments are regularly elided in extra-metrical positions, e.g., *table* '—' as [tab] in fast speech.

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