

Is the voicing-dependant duration of obstruents physiological in French?

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The relation between phonetic properties and phonological features has been the object of many theoretical suggestions which attempt to link the acoustic signal and linguistic representations. Phonetic redundancy and covariation in phonological contrasts are central points in this questioning. A correlation between consonant durations and voicing has been widely documented across many languages, e.g. [1]. The durational redundancy or covariation in voicing is largely seen as supported by a physiological substratum, e.g. an aerodynamic constraint on vocal vibration making voiced obstruents shorter [2, 3]. However other work, for example on French, has shown that the difference in obstruent duration according to underlying voicing feature resists complete voice assimilation [4] and total devoicing, as in whispered speech [5], arguing for linguistic conditioning. Here, the physiological vs. phonological conditioning of voicing-dependant durations of French obstruents was tested by comparing five normal and pathological phonations differing in the nature of the phonatory organ and source for voicing (see Figure 1): (i) MODal voice, i.e. periodic laryngeal phonation; (ii) WHIspered voice, i.e. non-periodic laryngeal phonation; (iii) TUCKer voice due to a partial laryngectomy, i.e. non-periodic laryngeal phonation; (iv) ESophageal voice due to a complete laryngectomy, i.e. non-periodic non-laryngeal phonation produced by an aerodynamic excitation of the esophagus; (v) Pseudo-WHIspered voice due to complete laryngectomy and no use of esophagus, i.e. non-periodic supralaryngeal voice produced by an aerodynamic excitation of only the vocal tract.

Acoustical durations were measured from 6 pairs of voiced-voiceless obstruents, i.e. /b-p/, /t-d/, /k-g/ and /f-v/, /s-z/, /ʃ-ʒ/ in initial (for fricatives), medial and word-final positions of isolated lexical words read in random ordered lists (one repetition). Table 1 reports information about speakers and data for each phonation type. Statistical effect of *Voicing* (voiced vs. voiceless) was tested by three-way ANOVAs with *Voicing*, *Articulation* (stop vs. fricative) and *Lexical Position* as the fixed effects (Table 1). The statistical comparisons between MOD and other phonations were stated on *Voicing* and *Phonation* interaction in two-ways ANOVAs included only the data for the same obstruents in the same lexical position. Reported here as a pilot study: one P-WHI speaker was analysed but not statically compared with MOD; the other one was excluded because of its total unintelligibility.

In all phonation types and word positions, the underlying voiced stops or fricatives are significantly shorter than the phonological voiceless obstruents. Table 1 shows that the voicing-dependant difference is significantly preserved regardless of phonatory organ and acoustical source type, as is confirmed by the absence of *Voicing*Phonation* interactions for every comparison with the MOD condition. To neutralize the speaking rate variation between speakers and conditions, mean ratio durations across speakers were calculated as the duration difference, i.e. voiceless consonant duration minus voiced consonant duration, divided by the voiceless consonant duration. Figure 1 shows a gradual reduction increasing with the distance from the production mechanism of modal voice used by healthy subjects. However any clear boundary seems match the change of the phonatory organ (laryngeal vs. non laryngeal) or of the phonatory source (periodic vs. non- periodic). Moreover, although phonetically reduced, the ratio of durational differences of the underlying voicing contrast remains fairly large (around 0.3). The physiological conditioning therefore seems to have only a limited effect, since the duration contrast overcomes the various physical constraints of the different phonatory mechanisms. The resistance of voicing-dependant durations to laryngectomies argues for an encoding of the systematic phonetic information at a phonological level and/or for a “phonetic knowledge” component in the grammar [6].

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Phonation	N speakers	Data type	N data	C _[-voi] duration	C _[+voi] duration	Voicing <i>p</i>
MOD	15	F: initial, median, final S: median, final	1444	203	117	$F(1,1444)=1199$ $p < .001$
WHI	15	F: initial, median, final S: median, final	1218	201	127	$F(1,1218)=733.25$ $p < .001$
TUC	14	S: median	423	113	78	$F(1,423)=168.721$ $p < .001$
OES	6	F: initial, median, final S: median, final	1135	220	170	$F(1,1135)=26.806$ $p < .001$
P-WHI	1	F: initial, final S: final	95	152	107	$F(1,95)=30.223$ $p < .001$

Table 1 : Corpus information (F for fricatives and S for stops in observed word positions) and statistical effect of *Voicing* on cross-speaker mean durations (in ms) by phonation conditions.

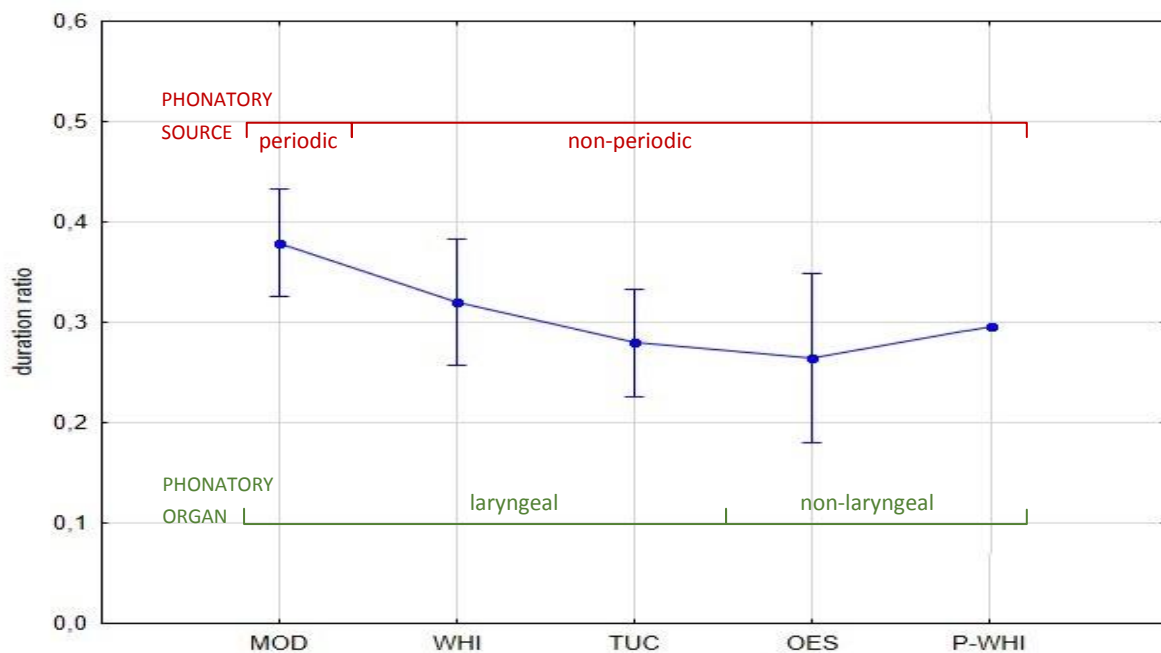


Figure 1 : Cross-speaker mean ratio of duration difference between voiced and voiceless obstruents (see text) for the five phonation conditions (bars represent standard deviation). Values higher than 0 indicate longer voiceless consonants.