The Phonetics of Phonology

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Phonology seeks to understand the behavior of speech sounds in human languages - the way they pattern. Some of their behavior arises from phonetic factors. Here are some examples.

Emergent stops

Occasionally one finds a stop consonant emerging between a nasal consonant (such as [m]) and a following oral consonant (e.g., [f], [s] [t], [r], [l]): *Thompson* (from *Thom + son*), *Alhambra* (from Arabic *al hamra*, "the red (edifice)"), *humble* (related to *humility*, from Latin *humilis*), *empty* < Old English *amtig*.

To understand how these stops arise, it is necessary to view speech production (in part) as a process controlling the flow of expiratory air using certain anatomical structures as valves. A nasal consonant is made by channeling air through the nasal cavity: there must be a valvular closure in the mouth and a valvular opening into the nasal cavity (by a lowering of the soft palate). The nasal consonant [m], for example, has the lips closed while the passage between the oral and nasal cavities is open (represented schematically in Fig. 1a). An oral consonant like [s] on the other hand, requires a closure of the nasal valve (by an elevation of the soft palate); see Fig. 1c. If the oral consonant's soft palate closure is made prematurely, that is, during the latter part of the nasal consonant, then with both the oral and nasal valves closed (and there are no other outlet channels for the expiratory airflow) a complete stoppage of the air flow is produced; see Fig. 1b. This is an example of a very common process known as "assimilation" (the position of the soft palate during the [m] assimilates to the position of the following oral obstruent).

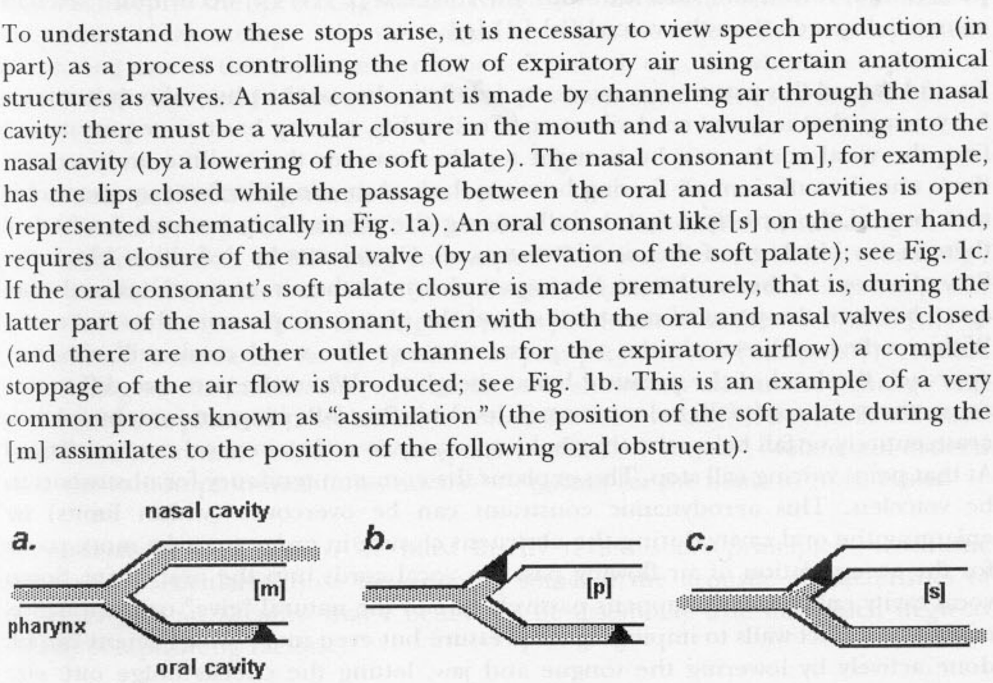

Fig. 1. Schematic representation of the vocal tract and the valves which regulated the flow of air; expiratory air symbolized by grey; valves by black triangles. (a) the nasal [m], (b) the transition between [m] and [s], where complete blockage of air occurs, (c) the oral fricative [s].

Such brief stops are common in present-day speech in words such as *some*[p]*thing*, *warm*[p]*th*, *team*[p]*ster*, *young*[k]*ster* and so on. Normally these pass unnoticed and are regarded as predictable consequences of the transition between a sequence of **nasal consonant + oral consonant**. Occasionally, however, listeners may misinterpret these "accidental" stops as purposeful parts of the pronunciation and subsequently incorporate them in their own pronunciation, possibly exaggerating them in the process. Such a misinterpretation by a listener is one of the most common causes of

sound change, the change of pronunciation over time.

The process which led to the [p] in *empty* (and may yet lead to an intentional [p] in *warmth*) is an example of a sound change which comes about due to the influence of the context the sound is in, that is, the latter portion of the nasal [m] became oral under the influence of the following oral sound [t]. It can thus be characterized as a contextual sound change. A great many sound changes have this character and some others will be discussed below.

The "bias" towards voicelessness in obstruents

Obstruents can be either voiced or voiceless, that is produced with accompanying vibration of the vocal cords. [b] [d] [g] [v] [z] are examples of voiced obstruents; [p] [t] [k] [f] [s] are examples of voiceless obstruents. As it happens, there is a well documented "bias" among the obstruents to be voiceless. Some languages, like Korean and Mandarin have only voiceless stops; in languages like English that possess both voiced and voiceless stops, the voiceless [p] [t] [k] occur more often in connected speech than the voiced [b] [d] [g].

To understand this pattern it is necessary briefly to discuss the physical requirements for voicing, that is, vocal cord vibration. To simplify, voicing has two requirements: first, the vocal cords must be brought together towards the midline and, second, there must be sufficient air flowing between them. Assuming the first requirement is met, one of the principal factors influencing the second requirement is whether there is any blockage of the air "downstream". Obstruents by definition block the flow of air out of the vocal tract. During an obstruent the air accumulates in the air space between the point of constriction and the glottis; air pressure thus increases. Within a few milliseconds the air pressure above the vocal cords will rise and approach the level of the pressure below the glottis. When the pressure difference across the vocal cords falls below a certain level, air flow falls proportionately and may cease entirely or fall below the threshold necessary to maintain vocal cord vibration. At that point voicing will stop. This explains the common tendency for obstruents to be voiceless. This aerodynamic constraint can be overcome (within limits) by enlarging the oral cavity during the obstruent closure in order to make more room for the accumulation of air flowing past the vocal cords into the oral cavity. Some vocal cavity enlargement happens passively due to the natural "give" or compliance of the vocal tract walls to impinging air pressure but even more enlargement can be done actively by lowering the tongue and jaw, letting the cheeks bulge out, etc. However, this option is limited the further back the closure is made. The voiced velar stops [g] is thus vulnerable; they may lose their voicing, their stop character or both. This is the reason why some languages which otherwise exhibit voicing contrasts with stops having more forward places of constriction are missing the voiced velar stop /g/, e.g., Dutch, Thai, Czech (in native vocabulary).

The story of [w]

The glide [w] is one of the few speech sounds to have two more or less equal constrictions, one at the lips and a second one between the tongue back and soft palate. See Fig. 2c. These (and other somewhat more rare sounds found primarily in West African languages, [kp] [gb] [ŋm]) are called labialvelars. But in spite of their two constrictions in certain cases these sounds pattern with simple labials such as [p] [b]

[m] or simple velars [k] [g] [ŋ]. But their behavior as labial or velar depends on the nature of the particular contextual effect involved.

[w] dissimilates with labials

Above I discussed cases involving the absence or infrequent occurrence of certain types of speech sounds in languages' speech sound inventory. There are also cases where certain speech sounds fail to occur next to other similar sounds. Such cases are said to exhibit "dissimilation". In English (and some other languages) [w] exhibits such a pattern with respect to preceding labial consonants. [w] can appear after non-labial consonants, e.g., *twice, dwarf, quick* (where 'qu' = [kw]), *Gwen, swell*), it does not appear in native words after the labial sounds /p b m f v/ (although it does occur in loanwords such as *pois* [pwa], *bwana*). [w] and labial sounds create similar acoustic patterns and thus create an ambiguity for the listener: if two sounds both create a similar acoustic effect within the same short time period the listener may misinterpret the speech signal as having only one sound. This is very similar to the process of camouflage: when the visual scene has two objects that are very similar in coloring one of the objects may not be recognized, e.g., the white Arctic hare on a snow drift, the mottled brown and white of a fawn against the sun-dappled forest floor.

[w] causes assimilating nasals to be velar

A very common type of assimilation involves nasal consonants assimilating to the place of articulation of following consonants. This may occur within a word, e.g., when prefixes are joined to stems (as in English *impossible,* from the negative prefix *in + possible* or *congress* where the original [n] is pronounced as the velar nasal [ŋ]) or across word boundaries (as in Spanish *un poco* pronounced [um poko]). A nasal assimilating to the labialvelar [w], insofar as it shows any assimilatory change and shows only one place of articulation, becomes the velar nasal [ŋ], not the labial nasal [m]. Tswana /-roma/ "send" + /wa/ (passive suffix) = /-roŋwa/; Melanesian dialects show the variant pronunciation /mwala/ ~ /ŋwala/ for the name of *Mala Island.*

To understand this pattern we must briefly review some principles of acoustic phonetics, particularly those determining some of the acoustic characteristics of nasals. (I give an account that I believe to be essentially true but which neglects certain complicating factors.)

Acoustically speech consists of a sound source, typically the buzzing sound made by the vocal cords, plus the shaping or filtering of that sound by the resonances of the vocal tract "downstream" of the vocal cords. These resonances are determined by the length and crossdimensional area of the air cavity including any branches in the air cavity. Fig. 2 shows a highly schematic representation of the air cavities that determine the acoustic shape of the nasal consonants [m] [ŋ] and a labial-velar nasal (such as would be formed by a nasal consonant assimilating to the place of a labial-velar consonant like [w] or [kp]. As is evident from the figure, all nasal consonants have the pharyngeal-nasal air space in common (marked by a dashed line). What differentiates one nasal from another is the length of the air cavity (marked by a dotted line), a cul-de-sac, which branches off of this pharyngeal-nasal air space. Measured from the point where the two air cavities diverge, this branch is quite long in the case of the labial nasal [m] but is quite short in the case of the velar nasal [ŋ]. In the case of the labial-velar nasal there are two constrictions, one labial and one velar, but only the rearmost constriction defines the extent of the branch (measured from the point where it diverges from the pharyngeal-nasal cavity); the forwardmost (labial) constriction will be largely irrelevant in determining the characteristic resonances. Thus labial-velar nasals will tend to sound like simple velar nasals.

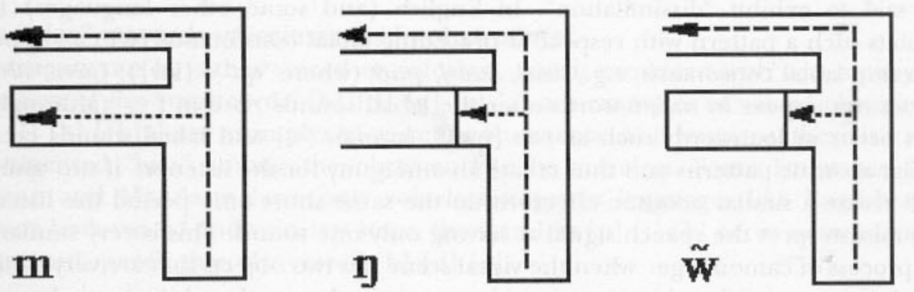

Fig. 2. Schematic representation of the air spaces creating the distinctive resonances for nasal consonants. From left to right: [m], [ŋ], and a labial-velar nasal. Dashed lines show the air spaces identical in all nasals; the dotted lines show those air spaces whose dimensions may differ between nasals.

Explanations for sound patterns in language

As mentioned at the start of this article, only some of the behavior or patterning of speech sounds are amenable to a phonetic explanation. Psychological and historical-cultural elements will have to be invoked in other cases, e.g., paradigm regularisation (e.g., the occasional replacement of *brought*, past tense of *bring*, by *brang*, on the analogy of *sing-sang*). Nevertheless, those sound patterns that show up in the same or similar form in diverse, unrelated, languages undoubtedly need to be explained by the only factors which are universal to all languages: the phonetics of speech production and perception.

Equally important - or perhaps more important - in contemporary phonology is not only explaining the behavior of speech sounds but also the establishment of sound philosophical and scientific criteria for what constitute valid explanations in the first place, i.e., ones that avoid circularity, that exclude unknown ("occult") entities and forces, and ones subject to empirical evaluation.

A empirically-based understanding of how speech sounds are structured and how they behave will have payoff in such diverse areas as historical phonology, speech technology (text-to-speech synthesis and automatic speech recognition), second language teaching, and clinical phonetics.

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