Introduction to General Linguistics
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Phonology 4:
Features for consonants

Overview of this section:
In this section, the central features used for classifying consonants in phonological theory are introduced. Their usefulness in phonology is illustrated with phonological rules in which these features are important. At the end of the section, a table illustrates how they are jointly put to use for distinguishing the consonants from each other.

1. The feature [consonantal] and nasal harmony in Malay

Numerous languages show a process of nasal harmony. In this section, two such processes will be discussed, since they are useful for understanding the features that cross-classify consonants. Nasalization is transcribed by a tilde [~] on top of a nasal sound. For example, [ã] is nasalized [a]. With the nasal consonants like [m, n, ŋ], the fact that they are nasal is not separately transcribed.

The articulation of all nasal sounds has in common that the velum is not raised, and so air can escape through the nasal tract. In some cases, this is accompanied by a complete blockage of the airflow in the mouth (as in the case of [m, n, ŋ]), in other cases, such as nasal vowels, there is both oral and nasal airflow.

The data in (1) are taken from Walker (1999). They illustrate nasal harmony in the Johore dialect of Malay. [m, n, ŋ] are phonemes here. (1) shows that there are also nasal vowels and nasal glides. These are not underlingly nasal, but derived as allophones of non-nasal vowels by a rule. This rule is the rule of nasal harmony. The harmony here takes effect with one of the nasal consonants [m, n, ŋ] and makes adjacent vowels or glides nasalized under certain circumstances.

(1) a. banõn 'to rise'
b. mâjâŋ 'stalk (palm)'
c. mânâvân 'to capture (active)'
d. màratappi 'to cause to cry'
e. pànâwâsan 'supervision'
f. pômândañan 'scenery'
g. màkan 'to eat'

Processes of nasalization can be distinguished in terms of the direction in which the nasal property spreads, in terms of the sounds that trigger it, and the sounds that block it.

The example in (1g) shows you something important about the direction of nasalization in this language: the first vowel [a], following [m], gets nasalized by the [m]. However, the second vowel [a], immediately before [n], does not get nasalized by the following [n]. We can hypothesize that the property of being nasal spreads rightward from [m, n, ŋ] in this language, but not leftward.

Look at the other examples, one sees that this works out more generally, but only with an additional assumption: nasalization is iterative: it can in principle apply not just to the sound following a nasal consonant, but can go on to further sounds from there. For example, in (1b) and (1e) the first nasal consonant of the words makes not only the following vowel nasal, but also two more sounds on the right.
However, not all sounds to the right of a nasal consonant are nasalized. Certain sounds block this process: they do not become nasalized, and nasalization cannot 'jump' across them either. The table in (2) shows what sounds in (1) become nasalized, and what sounds block nasalization.

(2) sounds that become nasalized | sounds that block nasalization
--- | ---
vowels like [o] in (1a) [baŋõn] | liquids like [r] in (1d) [mãrâtappi]

| glides like [j] in (1b) [mãjån] | fricatives like [s] in (1e) [pœjâwâsan] |
| and [w] in (1c) [mânâwân] | plosives like [k] in (1g) [mâkân] |

We cannot tell whether the nasal consonants [m, n, ñ] undergo this process. For example, in (1c) [mânâwân], the underlined sound [n] could be said to undergo nasalization trivially. We cannot tell this from its pronunciation, since it is already nasal, being a nasal consonant, and so there would not be a change if [n] would undergo nasalization. We can also not tell this from the following sounds: they would be nasalized in any case, either because [n] makes them nasal, or because the nasal property of the word-initial [m] goes rightward through [n] and makes the later sounds nasal as well. Therefore, we cannot be sure where in the table in (2) the nasal consonants belong.

However, let us assume that they belong with the other consonants on the right in (2). Then the table in (2) illustrates an important split between two large classes of sounds, a split that is also relevant in many other phonological processes of other languages: The vowels and glides form a natural class, to the exclusion of all the consonants. This split motivates the feature [consonantal]. It is defined as follows.

You may recall that we used a similar formulation to separate consonants and vowels in the first session on phonology/phonetics. The definition of the feature [consonantal] now replaces these earlier definitions, in our formal theory of phonology.

[+consonantal]: articulated with a significant constriction of the airflow in the oral tract. 
( these include plosives, fricatives, affricates, nasal stops, and the liquids)

[-consonantal]: articulated without such a significant constriction. 
( these include the vowels and the glides)

The constriction of the airflow in the oral tract can be complete, as with the plosives and with the nasal consonants, or almost complete, as with the fricatives. It is still a significant constriction in the case of liquids like [l], where the air can flow out freely on the side(s) of the tongue, but cannot flow through the middle of the oral cavity. With vowels, the shape of the tongue determines the resonance-properties of the oral tract, which leads to the different vowel sounds. However, there is no significant constriction of the airflow in the oral tract.

We have not talked about glides [G. Gleitlaute, Halbvokale] so far, though you know them from your readings of the chapter by Ladefoged. English has the glides [j] as in 'yes' [jes] and [w] as in 'woman' [wumân]. German only has the glide [j], as in 'jagen' [jaqen] or [jaqên]. [w] is not a sound of German. Orthographic 'w' in German is generally pronounced as the voiced labiodental fricative [v] as in 'will' [vîl] or 'Wolf' [volf]. Across languages, [j] and [w] are the most common glides, though a few others also exist.

[j] is very similar to [i] in its articulation, and [w] is very similar to [u] in its articulation, though the opening that is left for the air to flow through seems to be a bit narrower with the glides than with the corresponding vowels. Nevertheless, there are numerous processes in phonology in which the glides and the vowels form a natural class, captured with the feature [-consonantal]. In the sense relevant for the feature [consonantal], there is no significant constriction of the airflow with the glides.

Apart from the feature [consonantal], the account of the nasal harmony in (1) also involves the feature [nasal].

[+nasal]: articulated with the velum not raised, so that nasal airflow is allowed
[-nasal]: articulated with the velum raised, so that no nasal airflow is allowed.
Thus the nasal consonants [m, n, ŋ] as well as nasal vowels or glides like [ā] and [ŋ] are [+nasal]. Non-nasal vowels and glides are [-nasal], as are (typically) plosives, fricatives, and liquids.

Here, then, is the rule that captures nasal harmony in the Johore dialect of Malay:

(3) **Nasal harmony** (Johore dialect of Malay):
[-consonantal] -> [+nasal] / [+nasal]  
'Vowels and glides become nasal when they follow a nasal sound.'

The feature [-consonantal] to the left of the arrow captures that the nasalization affects only vowels and glides. They become nasal (the feature after the arrow). They do so when they follow a nasal sound (environment of the rule, after "/").

The analysis assumes that all vowels in this language are underlyingly oral; put differently: the inventory of Johore Malay is assumed to contain oral vowels, but not nasal vowels. The rule of nasalization will then turn (for (1f)) /makan/ into [mākan], for example, creating then nasal vowel as an allophone of the underlying oral vowel.

What, then, of longer strings of nasalized sounds as in (1b) [mājān]? Here the phonological analysis maintains that the rule of nasalization applies iteratively: It reapplyes to its own output, as shown in (4).

(4) **Iterative application of the rule of nasalization:**

<table>
<thead>
<tr>
<th>Step</th>
<th>String</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>UR</td>
<td>/majaŋ/</td>
<td>(UR contains [m], the trigger of nasalization here)</td>
</tr>
<tr>
<td>Nasal harmony</td>
<td>mājaŋ</td>
<td>(rule applies to [a], which is [-cons])</td>
</tr>
<tr>
<td>Nasal harmony</td>
<td>mājāŋ</td>
<td>(rule applies to [ŋ], which is [-cons])</td>
</tr>
<tr>
<td>PR</td>
<td>[mājāŋ]</td>
<td>(rule applies to [a], which is [-cons])</td>
</tr>
</tbody>
</table>

In this account, the first vowel [a], after is nasalized, is itself [+nasal], and will then trigger the rule in (3) in the next step, making the following glide [ŋ] nasal as well. When [ŋ] has become nasal, it will make [a] nasal in the following step. Each time, the [-consonantal] segment of the rule in (3) is a different segment: the one that is becoming nasalized, because it stands after a [+nasal] segment.

We have to add the information of iterative application to the rule of nasalization. Many rules of languages apply iteratively, but other rules do not apply iteratively.

This concludes our discussion of Johore Malay nasalization. The most important point of the discussion was for you to see motivation for the feature [consonantal], which separates vowels/glides from the consonants. This feature is crucially used in the rule in (3), where it generalizes across vowels and glides, which both undergo nasalization. Importantly, the feature [-consonantal] in this rule excludes all consonants. The rule therefore correctly does not apply to consonants. This explains that consonants block nasalization.

Other important elements of phonology you have seen in this subsection are the feature [nasal], the iterative application of a phonological rule, and some remarks on the class of glides.

2 **The feature [sonorant] and nasal harmony in Ijo**

Ijo is one of many languages spoken in Nigeria (in West-Africa). The Kokokuma dialect shows a different process of nasal harmony, illustrated in (5). [r] is a liquid. This language has both nasal and non-nasal vowels in its inventory. The underlying forms are shown on the left in (5), and the pronounced forms are given on the right. (The underlying forms are inferred from a well-argued-for analysis of this process; they are included here to facilitate our understanding.)
Observe the following similarities and differences to nasal harmony in Johore Malay. First, in (5) nasal harmony spreads the feature [+nasal] leftward, rather than rightward. For example, in (5g), the [m] leads to nasalization on the preceding vowel, but not of the following vowel. Second, nasalization also spreads (leftward) not only from [m, n, ñ] but also from underlyingly [+nasal] vowels, as the comparison of UR and PR in (5b) shows. Third, as in the case in (1), nasalization applies iteratively. In (5b), for example, the final vowel [i] first nasalizes the preceding vowel [a], and then the initial glide [w] is also nasalized. In this way, we can understand the nasalized sounds of PR that are not nasal in UR as resulting from a process of leftward nasalization, which starts with the [+nasal] stops [m, n, ñ] and with underlyingly [+nasal] vowels.

A difference to Johore Malay that is particularly important is the following: In (5), not only vowels and glides undergo nasalization. Liquids here undergo nasalization as well. In the examples (5c,d), the 'r'-sound [ɾ] is nasalized. Furthermore, [l] nasalizes, and when it does, it turns to [n]. This is illustrated in (5i): in this form, nasalization is first triggered by the final vowel (which is nasalized in UR), and nasalizes the preceding [l], turning it to [n]. Nasalization goes on from there to the preceding vowel [n]. However, fricatives still block nasalization, as in examples (5d,e,f). Plosives also still block nasalization, as in examples (5g,h,i). In this language, then, we have a different division of the sounds into those that undergo nasalization and those that block it.

(6)

<table>
<thead>
<tr>
<th>sounds that become nasalized</th>
<th>sounds that block nasalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>vowels</td>
<td>fricatives</td>
</tr>
<tr>
<td>glides</td>
<td>plosives</td>
</tr>
<tr>
<td>liquids</td>
<td></td>
</tr>
</tbody>
</table>

As in (1), we cannot be sure to which class of sounds the nasal stops [m, n, ñ] belong. Nevertheless, this process illustrates a second important division among the sounds that is relevant in many rules across languages. This is the division between the sonorants and the obstruents, formalized with the feature [sonorant].

[-sonorant]: produced with build-up of air pressure in the vocal tract.
(called obstruents; this class includes the plosives, fricatives, and affricates)

[+sonorant]: produced without build-up of air pressure in the vocal tract.
(called sonorants; this class includes the vowels, glides, liquids, and nasals)

More on this important division will be explained in the next subsection. For now, let us use the feature [sonorant] for writing a rule of nasal harmony.

(7) Nasal harmony (Kokokuma dialect of Ijo):
[+sonorant] -> [+nasal] / ____ [+nasal]
'Sonorants become nasal when they precede a nasal sound.'
Here the [+sonorant] sounds (vowels, glides, liquids, and vacuously, nasals) are nasalized. In the environment of the rule, "___" precedes "[+nasal]", so that the rule nasalizes a sound when it precedes a sound that is already [+nasal]: [+nasal] spreads leftward. The derivation of [tɔn i] in (8) illustrates.

(8) 'light (a lamp)'

\begin{tabular}{|l|}
\hline
UR & /tsl ɻ/ (UR contains [ɻ], the trigger of nasalization here) \\
Nasal harmony & tɔn i (rule applies to [ɻ], which is [+son], and turns it to [n]) \\
Nasal harmony & tɔn i (rule applies to [ɔ], which is [+son]) \\
Nasal harmony & -- (rule does not apply to [t], because [t] is [-son]) \\
PR & [tɔn i] \\
\hline
\end{tabular}

In this subsection, you have seen nasal harmony in a different language, the Kokokuma dialect of Ijo, with some different properties from the nasal harmony of the Johore dialect of Malay. The most important point of the second process is that the sounds that undergo it, and those that block it, are different. In this second case, the process can be captured in terms of the feature [sonorant], which is used in writing the rule in (7). This feature is discussed more in the following subsection. You have also seen that nasal harmony can go rightward or leftward, depending on the language. This is captured straightforwardly in the environments of the rules: ' [+nasal]___' for 'rightward' and '___ [+nasal]' for 'leftward'.

3 More on sonorants and obstruents

3.1 Obstruents

The class of obstruents comprises the plosives, fricatives, and affricates. These are the [+sonorant] sounds.

obstruents:
- plosives (oral stops) [p, b, ...]
- fricatives [f, v, ...]
- affricates [pf, tʃ, ...]

obstruent [G. Obstruent]: sound that is [-sonorant] (produced with a build-up of air-pressure in the vocal tract). Obstruents include in particular the plosives, the fricatives, and the affricates.

Obstruents often have a voiceless and a voiced counterpart. For example, in English, there is voiceless [p] and voiced [b]. However, the voiceless obstruents are considered unmarked, while the voiced obstruents are considered marked. One way in which this can be seen is in the inventories of languages.

Voicing of obstruents: Typically, either (a) or (b) is found:

(a) A language may have a voiceless obstruent, but no voiced counterpart of it.
(b) A language may have a voiceless obstruent and its voiced counterpart.

In English, each voiceless obstruent has a voiced counterpart.

<table>
<thead>
<tr>
<th></th>
<th>plosives</th>
<th>fricatives</th>
<th>affricate</th>
</tr>
</thead>
<tbody>
<tr>
<td>voiceless</td>
<td>t</td>
<td>s</td>
<td>tʃ</td>
</tr>
<tr>
<td>voiced</td>
<td>b</td>
<td>z</td>
<td>dʒ</td>
</tr>
</tbody>
</table>

In German, many voiceless obstruents have a voiced counterpart. However, some of the obstruents, in particular [ç/x, pf, ts], are voiceless and do not have a voiced counterpart.

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German:

<table>
<thead>
<tr>
<th>voiceless</th>
<th>plosives</th>
<th>fricatives</th>
<th>affricates</th>
</tr>
</thead>
<tbody>
<tr>
<td>voiceless</td>
<td>p</td>
<td>t</td>
<td>k</td>
</tr>
<tr>
<td>voiced</td>
<td>b</td>
<td>d</td>
<td>b</td>
</tr>
</tbody>
</table>

grey: sounds not found in the other language (between English and German)

boldfaced: allophones ([c] and [x])

Here we see the sense in which voiceless obstruents are the 'more normal' ('unmarked') case: There are voiceless obstruents with no voiced counterparts, but there are no voiced obstruents that lack a voiceless counterpart. Or, simply put, there are more voiceless obstruents than voiced ones in the German inventory.

We can make sense of the fact that voiceless obstruents are the unmarked case in terms of the articulation. Simply put, the vocal cords need an airstream through the larynx to vibrate; yet the obstruents, by definition, obstruct the airstream so much that air-pressure is built up in the oral cavity. This obstruction is an obstacle to a strong and full airstream, and therefore an obstacle to voicing on obstruents. It is therefore easier if the obstruent is voiceless, where the vocal cords are apart, and do not vibrate.

Let us look at this in some more detail for the plosives and fricatives separately.

The plosives completely interrupt the airflow in the mouth (and nose) for a short time. During that closure, the air streaming up from the lungs builds up air-pressure in the vocal tract, behind the closure. (This is what makes the plosives [-son] sounds.) During the first part of this closure, some voicing is possible, since some air still comes through the larynx, but at some point the air-pressure in the vocal tract is built up, and no more air will flow through the larynx to allow the vocal cords to vibrate. There are then two possibilities. (a) if the closure is released at or before this point of satisfaction, continuous voicing during the closure is possible. (b), if the closure is longer, voicing stops during the closure, even in the production of a voiced stop sound. There are ways in which voiced and voiceless stops can nevertheless be distinguished, but in many cases, voiced stops are not voiced throughout the closure. With or without interruption of voicing during the closure, voicing is made difficult in the plosives by the fact that the air does not flow out of the vocal tract freely, and that the air-pressure that is built up in the vocal tract slows down the flow of air through the larynx.

With fricatives, there is continuous airflow, and this generally allows continuous voicing with fricatives. However, as you know, fricatives are produced with a very narrow constriction, through which the air is pressed to generate a fricative noise. This also involves the build-up of air pressure in the vocal tract (and the fricatives are thus also [-son] sounds). This production of the fricatives slows down the airflow through the mouth (the nose is closed anyhow), and also makes vibration of the vocal cords more difficult.

In summary, obstruents (sounds with a build-up of air pressure in the vocal tract) can be voiced or voiceless. The voiceless obstruents are unmarked, which is reflected in the inventories of languages like German. This has to do with difficulties that arise in the simultaneous build-up of air pressure characteristic for the obstruents, and the airstream needed through the vocal cords that is needed to generate voicing.

3.2 Sonorants

The class of sonorants comprises the ([-consonant] classes) nasals and liquids, and the [+consonantal] classes vowels and glides.

sonorants:
- nasals (nasal stops) [m, n, ŋ]
- liquids [l, r]
- glides [j, w]
- vowels [a, e, ...]

sonorant [G. Sonant, Sonorlaut]: sound that is [+sonorant] (not produced with a build-up of air-pressure in the vocal tract). Sonorants include the nasals, liquids, glides, and vowels.
While obstruents often distinguish a voiced and voiceless counterpart, sonorants are typically voiced. For example, all sonorants in the English inventory, and all sonorants in the German inventory, are all voiced.

### English phonemes:

<table>
<thead>
<tr>
<th>nasals</th>
<th>liquids</th>
<th>glides</th>
<th>vowels</th>
</tr>
</thead>
<tbody>
<tr>
<td>voiceless</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| voiced | m | n | η | l | r | j | w | i | ...

### German phonemes:

<table>
<thead>
<tr>
<th>nasals</th>
<th>liquids</th>
<th>glide</th>
<th>vowels</th>
</tr>
</thead>
<tbody>
<tr>
<td>voiceless</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| voiced | m | n | η | l | r | j | i | ...

Thus, voicing is considered unmarked for sonorants. Nevertheless, there are voiceless allophones of the liquids and glides in both languages, following initial voiceless plosives. In a very detailed transcription, this is transcribed with a little circle below the voiceless sound:

(9) \[pl\text{i}z\] please \[pl\text{an}\] Plan
    \[tr\text{ri}\] tree \[tr\text{a}gn\] tragen
    \[kw\text{est}\text{an}\] questions \[k\text{juk}\] klug (final [k] is due to a general rule of Final devoicing in German)

Thus, voiceless sonorants are not completely impossible.

The reason for why voicing is the 'normal' case for sonorants has to do with the acoustics and perception of sonorant sounds: The sound of a sonorant comes about by the way the air vibrations from the vocal cords resonate in the vocal tract. An important way of distinguishing the sonorants from each other is to listen to the sound characteristics of the result of this. If there is no voicing, there is nothing that can resonate in this way, and sonorants are difficult to hear and to distinguish. You can get a feeling for this by saying [lll], [nnn], [mmm], [aaa]. When you say these sounds with voicing (normal), they are very clearly distinct. When you whisper them (which is without voicing), they still sound distinct, but only for someone very close to you. The reason why they still sound distinct is that during whispering, you generate a different kind of noise with your focal folds (like the noise a fricative would produce in your oral cavity); this noise still resonates in different ways for [l], [n], [m], and [a] in your vocal tract. The fact that someone has to be close to you to still hear the difference shows you how much less these are distinct without voicing. You can try to take this one step further by producing [lll], [nnn], [mmm], [aaa] with even less noise from the vocal cords. Position your tongue in the position for [l], and just breathe out. Do the same for [n], for [m], and for [a]. Now they are like voiceless sonorants, with the vocal cords spread apart, and their difference is even harder to hear. (The difference does not seem to go away entirely; I think that this is because the air that streams up makes a little bit of noise even with the vocal folds apart.)

In summary, sonorants are typically voiced. They are sounds for which the resonance of the vibrations of the vocal cords in the vocal tract are characteristic. For their properties to be clearly perceptible, vibration of the vocal cords (voicing) is required.

In concluding this section, I mention that voicing is also captured by a phonological feature. It is defined as follows.

\ [+\text{voiced}]\ : sounds produced with vibration of the vocal cords.
\ [-\text{voiced}]\ : sound produced with the vocal cords held apart.
We require one more central feature before we can define the classes 'plosive', 'fricative', 'nasal stop', 'liquid', and 'vowel' in terms of features. This additional feature is introduced in this subsection, using Spanish spirantization for illustration.

In Spanish, the voiced plosives [b, d, g] occur initially and after nasals, as in (10a,b). They have the voiced fricative allophones [β, δ, γ]. [β] is a voiced bilabial fricative (that does not exist in English or German), and [γ] is the voiced counterpart of German [x]. Thus [γ] is a voiced velar fricative. [β, δ, γ] occur after vowels, glides, liquids, and fricatives, as shown in (10c-h). (There is an exception in that [d] rather than [ð] occurs after [l]; I return to this exception below, but will ignore it until then.)

(10)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>N___</td>
<td>β</td>
</tr>
<tr>
<td>b.</td>
<td>#___</td>
<td>δ</td>
</tr>
<tr>
<td>c.</td>
<td>V___</td>
<td>γ</td>
</tr>
<tr>
<td>d.</td>
<td>j___</td>
<td>β</td>
</tr>
<tr>
<td>e.</td>
<td>w___</td>
<td>δ</td>
</tr>
<tr>
<td>f.</td>
<td>l___</td>
<td>γ</td>
</tr>
<tr>
<td>g.</td>
<td>r___</td>
<td>β</td>
</tr>
<tr>
<td>h.</td>
<td>βγγγ</td>
<td>γ</td>
</tr>
</tbody>
</table>

How do we characterize this complementary distribution? It seems that the environments in (10a,b) do not form a natural class: What could generalize across 'word-initially' and 'after a nasal'? So the sounds [b, d, g] are plausibly the 'elsewhere'-case, and thus the underlying sounds. The sounds [β, δ, γ] must then be created by a phonological rule in a single environment, which we want to characterize in terms of a natural class, like we did in other cases in phonology so far. What determines the occurrence of [β, δ, γ] is the preceding sound. But what a natural class of preceding sounds we have in (10c-h)? This class must include {vowels, glides, liquids, fricatives}. Clearly we cannot use [consonantal] here, since there are both consonants and vowels in this class. We also cannot use [sonorant] here, since there are [+sonorant] sounds (vowels, glides, liquids), but also the [-sonorant] fricatives in this class.

There is, however, an important generalization about the production of this class. All the sounds in {vowels, glides, liquids, fricatives} are produced with continuing airflow in the mouth (oral cavity). The airflow in the mouth is fully interrupted only for the remaining classes, the plosives and the nasal stops. To capture cases like the Spanish spirantization, phonologists use the feature [continuant], which is defined in terms of the interruption of airflow in the oral tract.

[+cont(ianu1nt)]: produced with uninterrupted airflow in the oral tract.
(this class includes the fricatives, liquids, glides, and vowels)

[-cont(ianu1nt)]: produced with an interruption of the airflow in the oral tract.
(this class includes the plosives and the nasal consonants)

With the help of this feature, we can represent the class after which [β, δ, γ] occur, namely {vowels, glides, liquids, fricatives}, as the [+cont] sounds: the sounds in which the airflow in the mouth is not interrupted. We thus have the following distribution of the Spanish allophones we are considering:

p. 8, Intro Ling, Phonology 4: Features for consonants
We assume that [b, d, g] but not [β, δ, γ] are part of the inventory of Spanish. We can now write a rule as in (12) for the creation of the allophones [β, δ, γ]. In this rule, the sounds [b, d, g] are still described as a list. We will revise this rule, and add a characterization of this class in terms of features later. Notice that we can use the new feature [continuant] twice here: For one thing, we add it to stops, and thus turn them into fricatives. For another, the environment "[+cont]___" captures the distribution of [β, δ, γ] as we saw in (10c.-h.) and in (11).

(12) **Spanish spirantization** (to be completed below)

\[ [b, d, g] \rightarrow [+cont] / [+cont] _-_ \]

'the voiced plosives become [+cont] fricatives when they follow a [+cont] sound.'

The following derivations illustrate how either [b] or [β] can result from underlying [b]. In *calbo*, [b] is preceded by the [+cont] sound [l], so that Spirantization turns the voiced stop [b] into the voiced fricative [β]. In *bomba*, [b] is preceded by the [-cont] sound [n], and so Spirantization does not change it.

(13) UR /bomba/ /calbo/

<table>
<thead>
<tr>
<th>Spirantization</th>
<th>calβo</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR</td>
<td>[bomba] [calβo]</td>
</tr>
</tbody>
</table>

Let me then briefly comment on the exception to Spirantization that we have seen: As shown in (10f), the sequence [ld] does not lead to Spirantization of the [d], even though [b] and [g] spirantize after [l]. This exception is related to a more general class of exceptions by which sounds that are similar, when they stand next to each other, sometimes block the application of a rule. In the case at hand, [l] and [d] are similar because they are both coronal, while [l] differs from [b] and from [g] (where Spirantization is not blocked) in place of articulation. However, we will not here get into this blocking mechanism in any detail. It is complex, and an understanding of it requires a more advanced theory of phonological representations, which you may learn about in later semesters.

Below, I will return to Spanish spirantization. For now, let me sum up the main lesson we are drawing from it. There is a natural class of sounds that cuts across consonants and vowels, and cuts across sonorants and obstruents. It is defined in terms of the feature [continuant], which distinguishes sounds with uninterrupted airflow in the oral tract ([+cont]) from sounds with a complete interruption of the airflow in the oral tract ([−cont]). Spanish spirantization nicely illustrates this natural class: after [+cont] sounds, we find the allophones [β, δ, γ] of the phonemes [b, d, g].

### 5 The classification of consonants

We can now classify 'plosives', 'fricatives' etc. in terms of the three features [consonantal], [sonorant] and [continuant]. The definitions of the features are repeated here for your convenience.

**[+cons(onal)]**: articulated with a significant constriction of the airflow in the oral tract.

**[-cons(onal)]**: articulated without such a significant constriction.

**[-son(oral)]**: produced with build-up of air pressure in the vocal tract (called *obstruents*).

**[+son(oral)]**: produced without build-up of air pressure in the vocal tract (called *sonorants*).

**[+cont(inant)]**: produced with uninterrupted airflow in the oral tract.

**[-cont(inant)]**: produced with an interruption of the airflow in the oral tract.

The classification is illustrated in the table in (14).
The grey column gives our names for the different classes of sounds. To the left of it, you have their classification in terms of the three features \([\text{consonantal}], \text{sonorant}, \text{and continuant}]. To the right of it, you have the sounds, further classified into columns by places of articulation. The places of articulation also correspond to features, though we will not be concerned with these here (and you don’t have to know the features for place of articulation in the final exam). The table also includes voicing distinctions, which are shown all the way on the right. For the obstruents (upper half of the table), I have written the voiced version immediately below the voiceless version of an obstruent. The sonorants (lower half of the table) are all voiced.

Let us then consider the classification on the left in table (14). (Don’t get confused: \([\text{cons}] and [\text{cont}] are different features! \([\text{cons}] is \text{[consonantal]} and [\text{cont}] is \text{[continuant]}].)

Observe first the distinction between \([+\text{cons}]\) consonants (top two-thirds of the table) and \([-\text{cons}]\) vowels and glides (given in the lower third of the table). The feature-values for \([\text{consonantal}]\) are shown in the leftmost column of the table.

The second column on the left shows the distinction among \([-\text{son}]\) obstruents (top half) and \([+\text{son}]\) sonorants (bottom half). Observe that all \([-\text{son}]\) obstruents are consonants. That makes sense: \([-\text{son}]\) means build-up of air-pressure. This is possible only with a significant constriction of the airflow in the oral cavity \((+[\text{cons}]).\) The \([+\text{son}]\) sonorants include the consonantal classes of nasals and liquids, as well as the vowels and glides. They are \([+\text{son}]\) because none of these classes involve the build-up of air-pressure, thought for different reasons. With the nasal consonants, the air can escape through the nose; with \([l]\) it escapes on the sides of the tongue; with the vowels and glides, it flows directly from the mouth. On the whole, not building up air-pressure can be achieved in a number of ways, some involving a significant constriction in the mouth \((+[\text{cons}]), some not \((-\text{cons})).\)

Consider then the third column of the table, for the feature \([\text{cont}] or [\text{continuant}]. It is important to observe that \([\text{cont}]\) splits the \([-\text{son}]\) obstruents into two classes, and that \([\text{cont}]\) also splits the \([+\text{son}]\) sonorants into two classes. With the \([-\text{son}]\) obstruents, we here get the distinction between plosives and fricatives. Plosives stop the airflow in the mouth completely, and are thus \([-\text{cont}].\) Fricatives involve (pressed but) continuous airflow in the mouth, and are thus \([+\text{cont}]. – With the \([+\text{son}]\) sonorant consonants, we get the distinction between the nasals and the liquids. The nasals block the airflow in the mouth completely, and so are \([-\text{cont}]. The liquids \([l, r]\) do not block the airflow in the mouth completely, and so are \([+\text{cont}].\)

Notice, then, that the process of Spanish spirantization gives us evidence that it is correct that a single feature \([\text{cont}]\) should set apart plosives from fricatives, and should at the same time set apart nasals

<table>
<thead>
<tr>
<th>Feature</th>
<th>labial</th>
<th>coronal</th>
<th>dorsal</th>
</tr>
</thead>
<tbody>
<tr>
<td>([-\text{cont}])</td>
<td>(-\text{cont})</td>
<td>(-\text{cont})</td>
<td>(-\text{cont})</td>
</tr>
<tr>
<td>plosives</td>
<td>(p)</td>
<td>(t)</td>
<td>(k)</td>
</tr>
<tr>
<td>fricatives</td>
<td>(f)</td>
<td>(\theta)</td>
<td>(s)</td>
</tr>
<tr>
<td></td>
<td>(\nu)</td>
<td>(\delta)</td>
<td>(z)</td>
</tr>
<tr>
<td>affricates</td>
<td>(p\tilde{f})</td>
<td>(t\tilde{s})</td>
<td>(t\tilde{f})</td>
</tr>
<tr>
<td>nasals</td>
<td>(m)</td>
<td>(n)</td>
<td>(\eta)</td>
</tr>
<tr>
<td>liquids</td>
<td>(l)</td>
<td>(r)</td>
<td></td>
</tr>
<tr>
<td>glides</td>
<td>(w)</td>
<td>(j)</td>
<td>(w)</td>
</tr>
<tr>
<td>vowels</td>
<td>(u)</td>
<td>(i)</td>
<td>(\bar{u})</td>
</tr>
<tr>
<td></td>
<td>(o)</td>
<td>(e)</td>
<td>(\bar{o})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\bar{\alpha})</td>
<td>(\alpha)</td>
</tr>
</tbody>
</table>

\[p. 10, \text{Intro Ling, Phonology 4: Features for consonants}\]
from liquids. We saw that the fricatives and the liquids (and vowels and glides) form one large natural
class: those that trigger Spirantization. We captured this class in terms of the feature [+cont], which must
include the [-son] fricatives, but also the [+son] liquids (and vowels and glides).

We can now put this new feature-classification to use, and revise the rule of Spanish
spirantization. Instead of [b, d, g], we now write [-son, -cont, +voiced]: This is the natural class of sounds
that are obstruents (plosive/fricative/affricate) and [-cont] (hence plosives), and which are furthermore
voiced (the voiceless plosives [p, t, k] don't spirantize in Spanish). We get:

(15) Spanish spirantization (revised)
[-son, -cont, +voiced] -> [+cont] / [+cont] ___
'the voiced plosives become [+cont] fricatives when they follow a [+cont] sound.'

6 Assimilation

I want you to learn a final term: assimilation. Assimilation is a term for a change by which a sound
becomes more similar to another sound in its environment. There is a phonetic sense of assimilation, but
we will mostly restrict ourselves to the phonological meaning of this word. In a process of assimilation, a
sound takes on a feature of another sound in its environment.

assimilation [G. Assimilation]: a phonetic or phonological process by which a sound becomes more
similar to, or takes on one or more properties of, another sound in its environment.

Most of the phonological rules we have discussed are processes of assimilation. Recall the vowel
harmony of Chamorro: the first vowel of a word becomes [-back] when preceded by a [-back] vowel.
Here a vowel takes on the [-back] property of another vowel in its environment. There is a simple way of
recognizing, in a phonological rule, whether it is assimilation or not. Consider the vowel harmony rule for
Chamorro (here written a bit differently from earlier):

V -> [-back] / [-back] C₀#C₀ ___

The feature following the arrow also occurs in the environment. That means it's assimilation. Intuitively:
the feature that the changing sound adopts (= the one following the arrow) is taken from the environment
(to the right of "/").

Nasal harmony also is assimilation. Here is the rule of nasal harmony in the Kokokuma dialect of
Ijo again:

[+sonorant] -> [+nasal] / ___ [+nasal]

In words: a vowel/glide becomes nasal before another nasal. It takes on the property of being [+nasal]
from the sound following it.

Similarly with Spanish spirantization:

[-son, -cont, +voiced] -> [+cont] / [+cont] ___

The voiced stops here take on the property of being [+cont] from the preceding sound.

There are also phonological rules that are not assimilation. However, assimilation, as in the
examples you have seen, is very frequent in the languages of the world. So frequent that phonologists
prefer rules of assimilation over other rules, if there is a choice. For example, there is a question what
feature distinguishes German [g] and [x]. We saw in German and in Greek that [g] goes with front vowels
and [x] with back vowels. This makes sense in terms of similarity: With [g] the body of the tongue is
further front, as it is with front vowels; with [x] the tongue is further back, as it is with back vowels. In
both cases, the area in the mouth in which the tongue articulates is similar across fricative and
corresponding vowels. Phonologists like to capture this in a phonological rule of assimilation. That is
possible if the feature that distinguishes [ç] and [x] is the feature [back], that we have so far only used for vowels. If we use it for these consonants as well, classifying [ç] as [-back] and [x] as [+back], we get to write the German rule that creates [x] from [ç] as a rule of assimilation:

Dorsal assimilation:

Intuitively, in /aç/ -> [ax], the sound /ç/ takes on the property of being [+back] from a preceding [+back] vowel [a], thus becoming [x].

References