The most important function of features is to form a basis for writing rules.

A typical rule of vowel nasalization, which nasalizes all vowels before a vowel, can be formulated as the following:

\[ [+\text{syllabic}] \rightarrow [+\text{nasal}]/ \_\_ [+\text{nasal}] \]
One challenge in formalizing rules with features is recognizing the features which characterize classes:
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1. Look for values that are same for all segments in the set
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Q. which features characterize the class [i, u] in English? Is this class a natural class?

+high
-low
+ tense
Vowels in English

Front
High i I
Mid e ë ə έ
Low æ

Central

Back
High u u
Mid o
Low a

Tense Vowels
Lax Vowels
ound
Formalizing rules with features

- One challenge in formalizing rules with features is recognizing the features which characterize classes:

  1. Look for values that are same for all segments in the set
  2. Check that no other segment in the inventory also has that combination of values.

Q. which features characterize the class [i, u] in English? Is this class a natural class?

+high
-low
+ tense

This is a natural class in English because there are no other vowels in English inventory with the same combination of features.
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+high
- low
+ tense

This is a natural class in English because there are no other vowels in English inventory with the same combination of features.
Practice

- Refer to the feature chart that has been provided to you and define the following classes in terms of distinctive features.

  i. p t k f s x
  ii. p t b d f s v l m n
  iii. w y l m n a e i o u ü
  iv. p k b g f x v γ
  v. y l m n a e i
  vi. v γ w y a e i o u ü
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i. ptkfsx
i. **p t k f s x**

- Each segment is a voiceless obstruent. Importantly, every voiceless obstruent of the language is included in this first set.
- So, this could be specified by [-sonorant, -voice]
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• So, this could be specified by [-sonorant, -voice]

Why did we not specify [+consonantal]?
- All [-sonorant] segments in this language are [+ consonantal]. Hence, it is enough to specify [-sonorant]
Each segment is a voiceless obstruent. Importantly, every voiceless obstruent of the language is included in this first set.

So, this could be specified by [-sonorant, -voice]

Why did we not specify [+consonantal]?

All [-sonorant] segments in this language are [+ consonantal]. Hence, it is enough to specify [-sonorant]

In fact, we could just say [-voice] because all the voiceless segments in the language are [-sonorant]. So, when you say [-voice], [-sonorant] is automatically specified.
Each segment is a voiceless obstruent. Importantly, every voiceless obstruent of the language is included in this first set.

- So, this could be specified by \([-\text{sonorant}, -\text{voice}]\)

Why did we not specify \([+\text{consonantal}]\)?

- All \([-\text{sonorant}]\) segments in this language are \([+\text{consonantal}]\). Hence, it is enough to specify \([-\text{sonorant}]\)

In fact, we could just say \([-\text{voice}]\) because all the voiceless segments in the language are \([-\text{sonorant}]\). So, when you say \([-\text{voice}]\), \([-\text{sonorant}]\) is automatically specified.

Conclusion: Use only those features which are absolutely necessary.
What if this language had aspirated sounds \([p^h, t^h, k^h]\)?
Would [-voice] be adequate to specify \([p,t,k,f,s,x]\)?
What if this language had aspirated sounds [pʰ, tʰ, kʰ]? 
Would [-voice] be adequate to specify [p,t,k,f,s,x]?

Remember:
1. Look for values that are same for all segments in the set
2. Check that no other segment in the inventory also has that combination of values.
What if this language had aspirated sounds \([p^h, t^h, k^h]\)?
Would \([-\text{voice}]\) be adequate to specify \([p,t,k,f,s,x]\)?

**Remember:**
1. Look for values that are same for all segments in the set
2. Check that no other segment in the inventory also has that combination of values.

- We will need to also mention \([-\text{spread glottis}]\) in order to achieve definition of the set that excludes \([p^h, t^h, k^h]\).
- Hence, \([-\text{voice}, -\text{spread glottis}]\)
ii. \[ptbdfsvlmn\]

- This set includes only consonants, but it does not include all the consonants of the language.
ii. \[ \text{p t b d f s v l m n} \]

- This set includes only consonants, but it does not include all the consonants of the language.

\[ \text{p t b d f s v l m n} \quad \leftarrow \text{Selected class of segments} \]
\[ \text{p t k b d g f s x v y w y l m n} \quad \leftarrow \text{Entire set of consonants} \]
ii. $ptbdfsvlmn$

- This set includes only consonants, but it does not include all the consonants of the language.

$ptbdvfsvlmn$ ← Selected class of segments

$ptkbdfsvxv\gamma wylmn$ ← Entire set of consonants
This set includes only consonants, but it does not include all the consonants of the language.

- Selected class of segments
- Entire set of consonants

velars  glides
This set includes only consonants, but it does not include all the consonants of the language.

- Selected class of segments
- Entire set of consonants

velars
[+high, +back]

glides → [−consonantal]
This set includes only consonants, but it does not include all the consonants of the language.

Q: 1. Are there any other sounds in the inventory with these values?
2. What is we use only [-high]?

Hence, [+consonantal, - high]
iii. w y l m n a e i ò o u ü

- This set includes a mixture of consonants and vowels.
iii. w y l m n a e i o u ü

- This set includes a mixture of consonants and vowels.

*Questions we should be asking to ourselves:*

1. what kinds of vowels does it include?
2. what kind of consonants does it include?
This set includes a mixture of consonants and vowels.

Questions we should be asking to ourselves:
1. what kinds of vowels does it include? ➔ All vowels
2. what kind of consonants does it include? ➔ glides, nasals and liquid [l]

Remember:
1. Look for values that are same for all segments in the set
2. Check that no other segment in the inventory also has that combination of values.
This set includes a mixture of consonants and vowels.

Questions we should be asking to ourselves:
1. what kinds of vowels does it include? → All vowels
2. what kind of consonants does it include? → glides, nasals and liquid [l]

Remember:
1. Look for values that are same for all segments in the set
2. Check that no other segment in the inventory also has that combination of values.

[+sonorant, +voice]
This set includes a mixture of consonants and vowels.

Questions we should be asking to ourselves:
1. what kinds of vowels does it include? → All vowels
2. what kind of consonants does it include? → glides, nasals and liquid [l]

Remember:
1. Look for values that are same for all segments in the set
2. Check that no other segment in the inventory also has that combination of values.
   
   [+sonorant, +voice]
3. Does [+voice] contribute anything here?
   (Use only those features which are absolutely necessary) → [+sonorant]
This set also includes a mixture of consonants and vowels.

Questions:
1. what kinds of vowels does it include?
2. what kind of consonants does it include?
This set also includes a mixture of consonants and vowels.

Questions:
1. what kinds of vowels does it include? → all the vowels
2. what kind of consonants does it include? → glides, voiced obstruents
This set also includes a mixture of consonants and vowels.

Questions:
1. what kinds of vowels does it include? → all the vowels
2. what kind of consonants does it include? → glides, voiced obstruents

Can we use [sonorant] feature to pick out this class of segments?
This set also includes a mixture of consonants and vowels.

**Questions:**

1. what kinds of vowels does it include? → all the vowels
2. what kind of consonants does it include? → glides, voiced obstruents

• Can we use [sonorant] feature to pick out this class of segments?
• All the members of this set are voiced. So, lets compare this set with the set of all voiced segments in the language.

\[
\begin{align*}
&v \gamma w y a e i o u ü \\
&b d g v \gamma w y l m n a e i o u ü
\end{align*}
\]
• This set also includes a mixture of consonants and vowels.

Questions:
1. what kinds of vowels does it include? → all the vowels
2. what kind of consonants does it include? → glides, voiced obstruents

• Can we use [sonorant] feature to pick out this class of segments?
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This set also includes a mixture of consonants and vowels.

Questions:
1. what kinds of vowels does it include?  → all the vowels
2. what kind of consonants does it include? → glides, voiced obstruents

Can we use [sonorant] feature to pick out this class of segments?

All the members of this set are voiced. So, let's compare this set with the set of all voiced segments in the language.

\[ \text{v y w y a e i o u ü} \rightarrow \text{[+continuant]} \]

\[ \text{b d g v y w y l m n a e i o u ü} \rightarrow \text{[-continuant]} \]
vi. vγw y a e i o u ü

- This set also includes a mixture of consonants and vowels.

Questions:
1. what kinds of vowels does it include? → all the vowels
2. what kind of consonants does it include? → glides, voiced obstruents

- Can we use [sonorant] feature to pick out this class of segments?
- All the members of this set are voiced. So, let's compare this set with the set of all voiced segments in the language.

vγw y a e i o u ü → [+continuant]

b d g v y w y l m n a e i o u ü → [-continuant]

What about these??
vi. \(\{v y w y a e i o u \bar{u}\}\)

- This set also includes a mixture of consonants and vowels.  

**Questions:**

1. what kinds of vowels does it include? → all the vowels  
2. what kind of consonants does it include? → glides, voiced obstruents

- Can we use [sonorant] feature to pick out this class of segments?  
- All the members of this set are voiced. So, lets compare this set with the set of all voiced segments in the language.

\[
\begin{align*}
\text{[+]continuant} \\
\text{[-continuant]}
\end{align*}
\]

What about these??  
- [l] is [+lateral], nasals [-continuant]
This set also includes a mixture of consonants and vowels.

Questions:
1. what kinds of vowels does it include? → all the vowels
2. what kind of consonants does it include? → glides, voiced obstruents

Can we use [sonorant] feature to pick out this class of segments?
All the members of this set are voiced. So, lets compare this set with the set of all voiced segments in the language.

What about these??
- [l] is [+lateral], nasals [-continuant]
Again, the most important function of features is to form a basis for writing rules. Hence, it is very important to recognize appropriate features that characterize natural classes.

It helps to start with the complete set of sounds in a language and then use just enough features to take away the sounds not wanted, leaving the target natural class in place.

*For e.g., to describe the glides, you can use [-syllabic] to take away all the vowels in a language, then [-consonantal] to get rid of non-glide consonants.*

Only use features that are absolutely needed.

*Remember why we didn’t need [+consonantal] in (i) and [+voice] in (iii)*
Features vs. phonetic symbols

- It is okay to use phonetic symbols (instead of features) where they lead to no harm.

  *e.g.*, **Indonesian has a rule that deletes velar nasal before liquids, glides and other nasals.**
It is okay to use phonetic symbols (instead of features) where they lead to no harm.

e.g., Indonesian has a rule that deletes velar nasal before liquids, glides and other nasals.

ŋ → Ø / __ { -syllabic
               + sonorant }
Features vs. phonetic symbols

- It is okay to use phonetic symbols (instead of features) where they lead to no harm.

  *e.g.*, **Indonesian has a rule that deletes velar nasal before liquids, glides and other nasals.**

  \[
  \eta \rightarrow \emptyset / _{-}\text{-syllabic} \\
  \quad + \text{sonorant}
  \]

- The use of phonetic symbol makes this rule more readable. It leads to no harm because the rule applies to velar nasal and not a class of sounds.
Features vs. phonetic symbols

- It is okay to use phonetic symbols (instead of features) where they lead to no harm.
  
  *e.g.*, *Indonesian has a rule that deletes velar nasal before liquids, glides and other nasals.*

  \[\eta \rightarrow \emptyset / _{-syllabic} + \text{sonorant}\]

- The use of phonetic symbol makes this rule more readable. It leads to no harm because the rule applies to velar nasal and not a class of sounds.

- However, notice that we **had** to use features to capture the natural class (in the environment).
Features vs. phonetic symbols

- We must use features **to capture a natural class**.
  
e.g., *Delete [m,n, η] that occur word finally when preceded by a vowel.*
  
*Assuming that [m,n, η] are the only nasals in this language.*
We must use features **to capture a natural class.**

e.g., Delete \([m,n, \eta]\) that occur word finally when preceded by a vowel. Assuming that \([m,n, \eta]\) are the only nasals in this language.

\[
[+\text{nasal}] \Rightarrow \emptyset / [+\text{syllabic}] _\#
\]

Natural classes