Gestural Scores and Allophonic Variation
Gestures for English Consonants
Gestural Score for “bob”

TADA input/output for “bob”:

- **TBCD**
- **GTBCD**
- **VEL**
- **GVEL**
- **LA**
- **GLA**

**G(VEL)=** -0.1

**G(TBCD)=** 11

**G(LA)=** -2

**G(LA)=** 11

**G(LA)=** -2

**G(LA)=** 11

%/'b/

'LAC' 0 0 9 0 -2 8 1 JA=8, UH=5, LH=1 100 0.01
'LAC' 0 9 13 11 1 8 1 JA=8, UH=5, LH=1 1 1
'VEL' 0 0 9 0 -0.1 8 1 NA=1 0 0

%/'aa/

'TBCD' 0 0 30 0 11 4 1 JA=1, CL=1, CA=1 1 1
'TBCD' 0 0 30 0 170 4 1 JA=1, CL=1, CA=1 1 1

%/'b/

'LAC' 0 25 34 0 -2 8 1 JA=8, UH=5, LH=1 100 0.01
'LAC' 0 34 37 0 11 8 1 JA=8, UH=5, LH=1 1 1
'VEL' 0 25 34 0 -0.1 8 1 NA=1 0 0
“bob” to “mob”

- Change initial VEL goal from -0.1 to 0.2

```
% /m/
'LA' 0 0 9 0 -2 8 1 JA=8,UH=5,LH=1 100 0.01
'LA' 0 9 13 0 11 8 1 JA=8,UH=5,LH=1 1 1
'VEL' 0 0 9 0 0.2 8 1 NA=1 0 0

% /aa/
'TBCD' 0 0 30 0 11 4 1 JA=1,CL=1,CA=1 1 1
'TBCL' 0 0 30 0 170 4 1 JA=1,CL=1,CA=1 1 1

% /b/
'LA' 0 25 34 0 -2 8 1 JA=8,UH=5,LH=1 100 0.01
'LA' 0 34 37 0 11 8 1 JA=8,UH=5,LH=1 1 1
'VEL' 0 25 34 0 -0.1 8 1 NA=1 0 0
```
Glottal Aperture Task for voiceless stops and fricatives

• How do we change “bob” to “pop”?

• Goal for GLO = 0.3 for voiceless stops and fricatives

• Default during speech: GLO=0.0 (will produce voicing)
All the tasks remain the same, we just add a new one.

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10 0 5

%/p/
'LA' 0 0 9 0 -2 8 1 JA=8, UH=5, LH=1 100 0.01
'LA' 0 9 13 0 11 8 1 JA=8, UH=5, LH=1 1 1
'VEL' 0 0 9 0 -0.1 8 1 NA=1 0 0
'GLO' 0 0 18 0 0.3 16 1 GW=1 0 0

%/aa/
'TBCD' 0 0 30 0 11 4 1 JA=1, CL=1, CA=1 1 1
'TBCL' 0 0 30 0 170 4 1 JA=1, CL=1, CA=1 1 1

%/p/
'LA' 0 25 34 0 -2 8 1 JA=8, UH=5, LH=1 100 0.01
'LA' 0 34 37 0 11 8 1 JA=8, UH=5, LH=1 1 1
'VEL' 0 25 34 0 -0.1 8 1 NA=1 0 0
'GLO' 0 25 40 0 0.3 16 1 GW=1 0 0
Compositionality

• Note that the gestures scores for related words are compositionally related.

• To create “pop” from “bob” involves adding two composition units (glottal opening gestures). Everything else stays the same.

• This is the basis of phonology as a compositional system.
Tongue Tip Tasks

for /t,d,n/

TTCD=-2
TTCL=56

TTCD=11
TTCL=24

closure
release
Articulators for TT Tasks

And also Jaw Angle (JA), Tongue Center (CL, CA)
“beat”

% /b/
'LA' 0 0 9 0 -2 8 1 JA=8, UH=5, LH=1 100 0.01
'LA' 0 9 13 0 11 8 1 JA=8, UH=5, LH=1 1 1
'VEL' 0 0 9 0 -0.1 8 1 NA=1 0 0

% /iy/
'TBCD' 0 0 30 0 4 4 1 JA=1, CL=1, CA=1 1 1
'TBCL' 0 0 30 0 95 4 1 JA=1, CL=1, CA=1 1 1

% /t/
'TTCD' 0 25 34 0 -2 8 1 JA=32, CL=32, CA=32, TL=1, TA=1 100 0.01
'TTCL' 0 25 34 0 56 8 1 JA=32, CL=32, CA=32, TL=1, TA=1 1 1
'TTCL' 0 34 39 0 24 8 1 JA=512, CL=512, CA=512, TL=1, TA=1 1 1
'TTCD' 0 34 39 0 11 8 1 JA=512, CL=512, CA=512, TL=1, TA=1 1 1
'VEL' 0 25 34 0 -0.1 8 1 NA=1 0 0
'GLO' 0 28 39 0 0.4 16 1 GW=1 0 0
Tasks for velar stops

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TBCL=1.10
TBCD=-2
closure

TBCD=6
release
"cop"

10 0 7

% k
 'TBCD' 0 0 9 0 -2 8 1 JA=100,CL=1,CA=1 100 0.01
 'TBCL' 0 0 9 0 110 8 1 JA=10,CL=1,CA=1 10 0.1
 'TBCD' 0 9 13 0 6 8 1 JA=10,CL=1,CA=1 1 1
 'VEL' 0 0 9 0 -0.1 8 1 NA=1 0 0
 'GLO' 0 3 14 0 0.4 16 1 GW=1 0 0

%AA
 'TBCL' 0 0 30 0 170 4 1 JA=1,CL=1,CA=1 1 1
 'TBCD' 0 0 30 0 11 4 1 JA=1,CL=1,CA=1 1 1

%P
 'LA' 0 25 34 0 -2 8 1 JA=8, UH=5, LH=1 100 0.01
 'LA' 0 34 37 0 11 8 1 JA=8, UH=5, LH=1 1 1
 'VEL' 0 25 34 0 -0.1 8 1 NA=1 0 0
 'GLO' 0 28 37 0 0.4 16 1 GW=1 0 0
### Tasks for stop consonants

<table>
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<tr>
<th>Lip (Labial)</th>
<th>T Tip (Alveolar)</th>
<th>T Body (Velar)</th>
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<tr>
<td>CLO</td>
<td>REL</td>
<td>CLO</td>
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<tr>
<td>LA=-2</td>
<td>LA=11</td>
<td>TTCL=56</td>
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<tr>
<td>b</td>
<td>VEL=-.1</td>
<td>d</td>
</tr>
<tr>
<td>p</td>
<td>VEL=-.1</td>
<td>t</td>
</tr>
<tr>
<td>m</td>
<td>VEL=.2</td>
<td>n</td>
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</table>

Linguistics 285 (USC Linguistics)  
Lecture 15: Speech Synthesis and Task Dynamics  
March 11, 2014
% /b/

% clo
'LA' ... -2 8 1 JA=8, UH=5, LH=1 100 0.01

% rel
% 'LA' ... 9 13 0 11 8 1 JA=8, UH=5, LH=1 1 1

% /d/

% clo
'TTCL' ... 56 8 1 JA=32, CL=32, CA=32, TL=1, TA=1 1 1
'TTCD' ... -2 8 1 JA=32, CL=32, CA=32, TL=1, TA=1 100 0.01

% rel
'TTCL' ... 24 8 1 JA=512, CL=512, CA=512, TL=1, TA=1 1 1
'TTCD' ... 11 8 1 JA=512, CL=512, CA=512, TL=1, TA=1 1 1

% /g/

% clo
'TBCL' ... 110 8 1 JA=10, CL=1, CA=1 10 0.1
'TBCD' ... -2 8 1 JA=100, CL=1, CA=1 100 0.01

% rel
'TBCD' ... 6 8 1 JA=10, CL=1, CA=1 1 1

Stops:
Oral
Constriction
Gestures
Glottal and Velic gestures for stops and fricatives

% Velic closure for stops and fricatives

'VEL' ... -0.1 8 1 NA=1 0

% Velic opening for nasals

'VEL' ... 0.2 8 1 NA=1 1 1

% Glottal opening for voiceless stops and fricatives

'GLO' ... 0.4 16 1 GW=1 0
Differentiating oral constriction gestures

A given constrictor can produce several different distinctive gestures by varying:

- **Constriction Degrees**
  (how narrow is the constriction? )
  - stop ("dip, tip")
    complete obstruction of tube
    generates “pop” sound source
  - fricative ("zip, sip")
    narrowing to create jet noise source
  - approximant ("rip")
    narrowing with no source change

- **Constriction Locations**
  (exactly where is is it?)
Constriction Locations (TTCL) for fricatives

dental
“thick”

alveolar
“sick”

palatoalveolar
“Shick”
Fricatives: Oral Constriction Tasks

θ  z ʃ
# Fricatives: Oral Constriction Tasks

<table>
<thead>
<tr>
<th>θ</th>
<th>s</th>
<th>∫</th>
</tr>
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<tbody>
<tr>
<td>clo</td>
<td>rel</td>
<td>clo</td>
</tr>
<tr>
<td>TT</td>
<td>TTCL=40 TTCD=1.2</td>
<td>TTCL=24 TTCD=11</td>
</tr>
<tr>
<td>TB</td>
<td>TTCL=110 TTCD=10</td>
<td>TBCL=95 TBCD=8</td>
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<tr>
<td></td>
<td>TTCL=56 TTCD=1.2</td>
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<tr>
<td></td>
<td>TTCL=60 TTCD=1.2</td>
<td>TTCL=40 TTCD=11</td>
</tr>
<tr>
<td></td>
<td>TBCL=95 TBCD=8</td>
<td></td>
</tr>
</tbody>
</table>
sop

10 0 5

% s
'TTCD' 0 9 0 1.2 10 1 JA=640,CL=32,CA=32,TL=1,TA=1 10 0.1
'TTCL' 0 9 0 56 10 1 JA=640,CL=32,CA=32,TL=1,TA=1 1 1
'TTCD' 0 9 13 0 11 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1
'TTCL' 0 9 13 0 24 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1

'TBCL' 0 9 0 110 8 1 JA=10,CL=1,CA=1 10 0.1
'TBCD' 0 9 0 10 8 1 JA=10,CL=1,CA=1 10 0.1

'GLO' 0 3 14 0 0.4 16 1 GW=1 0 0
'VEL' 0 9 0 -0.1 8 1 NA=1 0 0

%AA
'TBCL' 0 0 30 0 170 4 1 JA=1,CL=1,CA=1 1 1
'TBCD' 0 0 30 0 11 4 1 JA=1,CL=1,CA=1 1 1

%P
'LA' 0 25 34 0 -2 8 1 JA=8,UH=5,LH=1 100 0.01
'LA' 0 34 37 0 11 8 1 JA=8,UH=5,LH=1 1 1
'VEL' 0 25 34 0 -0.1 8 1 NA=1 0 0
'GLO' 0 28 37 0 0.4 16 1 GW=1 0 0
"shop"

10 0 5

% s
'TTCD' 0 0 9 0 1.2 10 1 JA=640,CL=32,CA=32,TL=1,TA=1 10 0.1
'TTCL' 0 0 9 0 56 10 1 JA=640,CL=32,CA=32,TL=1,TA=1 1 1
'TTCD' 0 9 13 0 11 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1
'TTCL' 0 9 13 0 24 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1

'TBCL' 0 0 9 0 110 8 1 JA=10,CL=1,CA=1 10 0.1
'TBCD' 0 0 9 0 10 8 1 JA=10,CL=1,CA=1 10 0.1

'GLO' 0 3 14 0 0.4 16 1 GW=1 0 0
'VEL' 0 0 9 0 -0.1 8 1 NA=1 0 0

%AA
'TBCL' 0 0 30 0 170 4 1 JA=1,CL=1,CA=1 1 1
'TBCD' 0 0 30 0 11 4 1 JA=1,CL=1,CA=1 1 1

%P
'LA' 0 25 34 0 -2 8 1 JA=8,UH=5,LH=1 100 0.01
'LA' 0 34 37 0 11 8 1 JA=8,UH=5,LH=1 1 1
'VEL' 0 25 34 0 -0.1 8 1 NA=1 0 0
'GLO' 0 28 37 0 0.4 16 1 GW=1 0 0
Fricatives: examples

\[ \theta \quad s \quad \int \]
Fricatives: Oral Constriction Gestures

% /th/
% clo
'TTCL' ... 40 10 1 JA=32,CL=32,CA=32,TL=1,TA=1 1 1
'TTCD' ... 1.2 10 1 JA=32,CL=32,CA=32,TL=1,TA=1 10 0.1
% rel
'TTCL' ... 24 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1
'TTCD' ... 11 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1

% /s/
% clo
'TTCL' ... 56 10 1 JA=640,CL=32,CA=32,TL=1,TA=1 1 1
'TTCD' ... 1.2 10 1 JA=640,CL=32,CA=32,TL=1,TA=1 10 0.1
'TBCL' ... 110 8 1 JA=10,CL=1,CA=1 10 0.1
'TBCD' ... 10 8 1 JA=10,CL=1,CA=1 10 0.1
% rel
'TTCL' ... 24 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1
'TTCD' ... 11 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1

% /sh/
% clo
'TTCL' ... 60 10 1 JA=640,CL=32,CA=32,TL=1,TA=1 1 1
'TTCD' ... 1.2 10 1 JA=640,CL=32,CA=32,TL=1,TA=1 10 0.1
'TBCL' ... 95 8 1 JA=10,CL=1,CA=1 100 0.01
'TBCD' ... 8 8 1 JA=10,CL=1,CA=1 100 0.01
% rel
'TTCL' ... 40 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1
'TTCD' ... 11 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1
Liquids: Multiple oral constrictions

“lie”

- **Tongue Tip**
  CD: approximant (2mm)
  CL: alveolar (56 degrees)

- **Tongue Body**
  CD: approximant, (4mm)
  CL: uvular (125 degrees)

"rye"

- **Lips**
  CD: approximant

- **Tongue Tip/Body**
  CD: approximant, CL: palatal

- **Tongue Root**
10 0 5

% 1
'TTCD' 0 0 9 0 28 1 JA=32,CL=32,CA=32,TL=1,TA=1 1 1
'TTCL' 0 0 9 0 56 8 1 JA=32,CL=32,CA=32,TL=1,TA=1 1 1
'TTCD' 0 9 13 0 11 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1
'TTCL' 0 9 13 0 24 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1

'TBCD' 0 0 9 0 48 1 JA=10,CL=1,CA=1 100 0.01
'TBCL' 0 0 9 0 125 8 1 JA=10,CL=1,CA=1 10 0.1

%AA
'TBCL' 0 0 30 0 170 4 1 JA=1,CL=1,CA=1 1 1
'TBCD' 0 0 30 0 11 4 1 JA=1,CL=1,CA=1 1 1

%P
'LA' 0 25 34 0 -2 8 1 JA=8,UH=5,LH=1 100 0.01
'LA' 0 34 37 0 11 8 1 JA=8,UH=5,LH=1 1 1
'VEL' 0 25 34 0 -0.1 8 1 NA=1 0 0
'GLO' 0 28 37 0 0.4 16 1 GW=1 0 0
## Contrastive Consonant Phonemes & Gestures

<table>
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<tr>
<th></th>
<th>lips</th>
<th>tip</th>
<th>body</th>
<th>velum</th>
<th>glottis</th>
</tr>
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<tr>
<td><strong>b</strong></td>
<td>bilabial</td>
<td>opening</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>p</strong></td>
<td>bilabial</td>
<td>opening</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>m</strong></td>
<td>bilabial</td>
<td>opening</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>t</strong></td>
<td>alveolar</td>
<td></td>
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</tr>
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<td><strong>d</strong></td>
<td>alveolar</td>
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<td><strong>n</strong></td>
<td>alveolar</td>
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</tr>
<tr>
<td><strong>k</strong></td>
<td></td>
<td>velar</td>
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<td><strong>g</strong></td>
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<td>velar</td>
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<td><strong>ŋ</strong></td>
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<td>velar</td>
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<td></td>
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<tr>
<td><strong>s</strong></td>
<td>alveolar</td>
<td>(velar approx)</td>
<td>opening</td>
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<tr>
<td><strong>z</strong></td>
<td>alveolar</td>
<td>(velar approx)</td>
<td>opening</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>l</strong></td>
<td>alveolar stop</td>
<td>(uvular approx)</td>
<td>opening</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Vowel Tasks

- IY
  - TBCL = 95
  - TBCD = 5

- IH
  - TBCL = 95
  - TBCD = 8

- EH
  - TBCL = 95
  - TBCD = 11.5

- AE
  - TBCL = 95
  - TBCD = 17

- UW
  - TBCL = 125
  - TBCD = 4

- OH
  - TBCL = 150
  - TBCD = 5

- AA
  - TBCL = 170
  - TBCD = 11

LA = 5
LP = 12

TBCL = 95
TBCD = 17
Glides: Oral Constriction Gestures

% /w/
%clo
'LA' ... 1 8 1 JA=8, UH=5, LH=1 1 1
'TBCL' ... 125 8 1 JA=10, CL=1, CA=1 10 0.1
'TBCD' ... 2 8 1 JA=10, CL=1, CA=1 100 0.01
%rel
'LA' ... 11 8 1 JA=8, UH=5, LH=1 1 1

% /j/
'TBCL' ... 95 8 1 JA=10, CL=1, CA=1 100 0.01
'TBCD' ... 2 8 1 JA=10, CL=1, CA=1 100 0.01
The consonant and vowel gestures that form a word are each active for a fixed interval in time.

The multiple gestures associated with a given consonant or vowel segment (phoneme) may not be synchronous with each other.

Gestures of successive segments may be synchronous (at their onsets).

What is the appropriate timing?

How do we find out?
Finding Gestures in Time

- To find when gesture is active in time, examine the movements of the constricting device that forms the constriction for that gesture.

- When it begins to move towards the gesture’s constriction target, this is the moment of **gestural activation**.

- When it begins to move away the gesture’s constriction target, this is (usually) the moment of **gestural deactivation**.

- The gestural score is a description of a particular token of some utterance (the x-axis is real time, and tokens may vary as a function of speaking rate, etc.) but we often refer to a “typical” gestural score for some word that captures the important temporal relationships.
Gesture Activation Times

Audio:

- T4DIST
- T4y
- T1DIST
- T1y
- LA
- LLy
- ULy

Three back:

- U Lip
- L Lip
- LA
- TT
- TTCD
- TB
- TBCD

“two back”
Principles underlying Gesture Timing

• Gestures for word-initial C and the V begin at the same time!
  • Initial C and V are co-produced

• The V gesture continues about two and a half times as long as the C gesture

• The gesture for the final C begins roughly when the V gesture ends.
Gestural Scores

- Representation of the temporal organization of gestures

- Time along horizontal dimension

- Boxes represent intervals of time during which gestures are active in the vocal tract.

- Gestures of oral constrictors, velum, glottis are displayed on different rows, e.g., “bad”:

- Labels on the boxes indicate the constriction degree (and location) of the gesture.

- Default Simplifications (gestures left out of displays):
  - Glottal narrowing for voicing
  - Velic closure for oral stops
  - Release gestures
Gestural Score for “bob”

TADA input/output for “bob”:

- **G(VEL)** = -0.1
- **G(TBCD)** = 11
- **G(LA)**: 
  - G(LA) = -2 (at 200 ms)
  - G(LA) = -2 (at 250 ms)
- **LA**,
- **VEL**,
- **TBCD**

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%/

'/b/

'LA' 0 0 9 0 -2 8 1 JA=8, UH=5, LH=1 100 0.01
'LA' 0 9 13 0 11 8 1 JA=8, UH=5, LH=1 1 1
'VEL' 0 0 9 0 -0.1 8 1 NA=1 0 0

%/aa/

'TBCD' 0 0 30 0 11 4 1 JA=1, CL=1, CA=1 1 1
'TBCL' 0 0 30 0 170 4 1 JA=1, CL=1, CA=1 1 1

%/b/

'LA' 0 25 34 0 -2 8 1 JA=8, UH=5, LH=1 100 0.01
'LA' 0 34 37 0 11 8 1 JA=8, UH=5, LH=1 1 1
'VEL' 0 25 34 0 -0.1 8 1 NA=1 0 0
Gestural Scores & contrast

• Because of the compositionality of gestural scores, contrast can be read off the score.

• Contrast can be found in:
  • presence or absence of particular gestures
  • gestures' values of CD and CL
    • Can be abbreviated with “names” but are quantitative values (of target and stiffness of appropriate task variables)
  • organization of gestures in time
Presence or absence of gestures: compositionality

- **“bad”**
  - Pharyngeal
  - Alveolar stop
  - Bilabial

- **“pad”**
  - Pharyngeal
  - Alveolar stop
  - Bilabial

- **“ban”**
  - Pharyngeal
  - Alveolar stop
  - Bilabial

- **“pan”**
  - Pharyngeal
  - Alveolar stop
  - Bilabial

- **“Ann”**
  - Pharyngeal
  - Alveolar stop

- **“tan”**
  - Pharyngeal
  - Alveolar stop
  - Opening
Contrast in gesture parameters: CL and CD

```
YELUM
TONGUE TIP
TONGUE BODY
LIPS
GLOTTIS
```

```
opening

alveolar fric  alveolar stop

pharyngeal wide

opening

pal-alv fric  alveolar stop

pharyngeal wide

opening

“sad”

“shad”
```
Contrast: organization in time

“bad”

“dab”
Allophony & Gestural Scores

- The same phonological segment can be realized differently in different contexts. These realizations are traditionally called **allophones** and represented in a “narrow phonetic transcription.”

- For example in English voiceless stops are realized as:
  
  - aspirated stops when they are single stops in word initial position: 
    \[ /pæd/ \rightarrow [pʰæd]; \]
  
  - unaspirated stops following word initial \(/s/\): \(/spæt/ \rightarrow [spæt]\)

- When analyzed in terms of gestural composition, the allophonic variants usually exhibit the same **same set of gestures** but organized differently in time.

- Since the temporal organization is also represented in the gestural score, the gesture score captures both contrastive units and allophonic variants in a single representation.
Aspiration of initial voiceless stops
Allophony: voiceless stops and clusters

• Voiceless stops are aspirated when they are single word-initial consonants.

• Approximants are at least partially voiceless following initial voiceless stops.

• Voiceless stops are unaspirated following /s/ at the beginning of a word.

**Principle 1:** Glottal Gestures in onset

English allows only one glottal opening gesture in onset
Aspiration in /#p.../, but not /#sp.../

[pʰ eI d] [s p eI d]
**Principle 1:** Glottal Gestures in onset
English allows only one glottal opening gesture in onset

<table>
<thead>
<tr>
<th>Principle 1: Glottal Gestures in onset</th>
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<th>YELUM</th>
<th>TONGUE TIP</th>
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<td>palatal mid</td>
<td>bilabial stop</td>
<td>opening</td>
</tr>
<tr>
<td>&quot;spade&quot; [spɛɪd]</td>
<td>alveolar fricative</td>
<td>palatal mid</td>
<td>bilabial stop</td>
<td>opening</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>YELUM</th>
<th>TONGUE TIP</th>
<th>TONGUE BODY</th>
<th>LIPS</th>
<th>GLOTTIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;prayed&quot; [pɹɛɪd]</td>
<td>alveolar approx</td>
<td>palatal mid</td>
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</tr>
</tbody>
</table>
French

• Voiceless stops are always unaspirated
  
  • peine “pain”
  
  • pleine “full”
  
  • spa “spa”
  
  • splendide “splendid”

• Glottal opening gesture is shorter in French: equal in length to closure.

“two”

“tous”

[Diagrams showing the positions of the tongue, lips, and glottis for the words “two” and “tous”]
English: Nasalization of vowels before final nasals
Gestural Score

- Velum lowering gesture for final nasal precedes oral constriction

Figure 1: French nasal vowel production: pan [a:1.0 0.5 0.0] → [i:.v˜]

Figure 2: French coda nasal consonant production: panne

Figure 3: On\[p˜\] failure, by subject Fr2, is illustrated in Fig. 2. Like the co-
ned in frames showing maximum lowering and retraction of the
tongue body in the pharyngeal region (e.g. Fig. 1, right). Tim-

3.1. Quantifying Lingual and Velic Timing

For each utterance, six time intervals were calculated between

1. Onset to vocalic target (V);
2. Onset to initiation of velic lowering (Vel);
3. Onset to tongue tip closure (TT);
4. Vocalic target to initiation of velic lowering;
5. Vocalic target to tongue tip closure;
6. Initiation of velum lowering (Vel), (iii) onset to tongue tip clo-

3.2. Lingual and Velic Coordination

In the eight French words containing nasal vowels examined

- Velum remains raised throughout the articulation of the pre-
- Velum lowers as the tongue tip achieves its alveolar target (frame 204).
- The velum remains raised throughout the production of the vowel.
- Velum remains open throughout the production of the vowel.
- Velum is already fully lowered (frame 147) – well before the t
dimensional targets.

Yvonne

“yvonne”

“bun”

Figure 4: MRI images of the oral cavity showing articulatory structures.
In French, the velum gesture for a final nasal is synchronous with the oral constriction.
Velarization of /l/

- English /l/ is described as “dark” or “velarized” in coda, and “brighter” not velarized in onset.

- The gestures in the two positions are in fact the same, but the timing is different.

- In coda, the retraction of the TB occurs first and contributes to the “velarized” percept.

- Pattern in very similar to that for nasals.
Principle 2: Coordination in onset vs coda in English

Onset: all gestures composing a C begin synchronously

Coda: gestures composing a C can be sequential, with wider constriction leading
Nasal Assimilation to a following following coronal

- “ten times” [tẽn] vs “ten things” [tẽŋ]

- overlap of alveolar nasal and dental fricative results in blending of the two TT gestures
sound produced by a given gesture to change (if you listen very carefully). The difficulty we have in perceiving this is probably due to the fact that we perceive the underlying contrastive gestural units, not their context-dependent consequences.

"ten times" vs. "ten themes"

Overlap of two gestures that attempt to control the same constrictor causes blending of the two gestures.
MRI evidence for blending

“shorten this”

[ŋ]

[ð]

“open every”

[ŋ]