TADA:

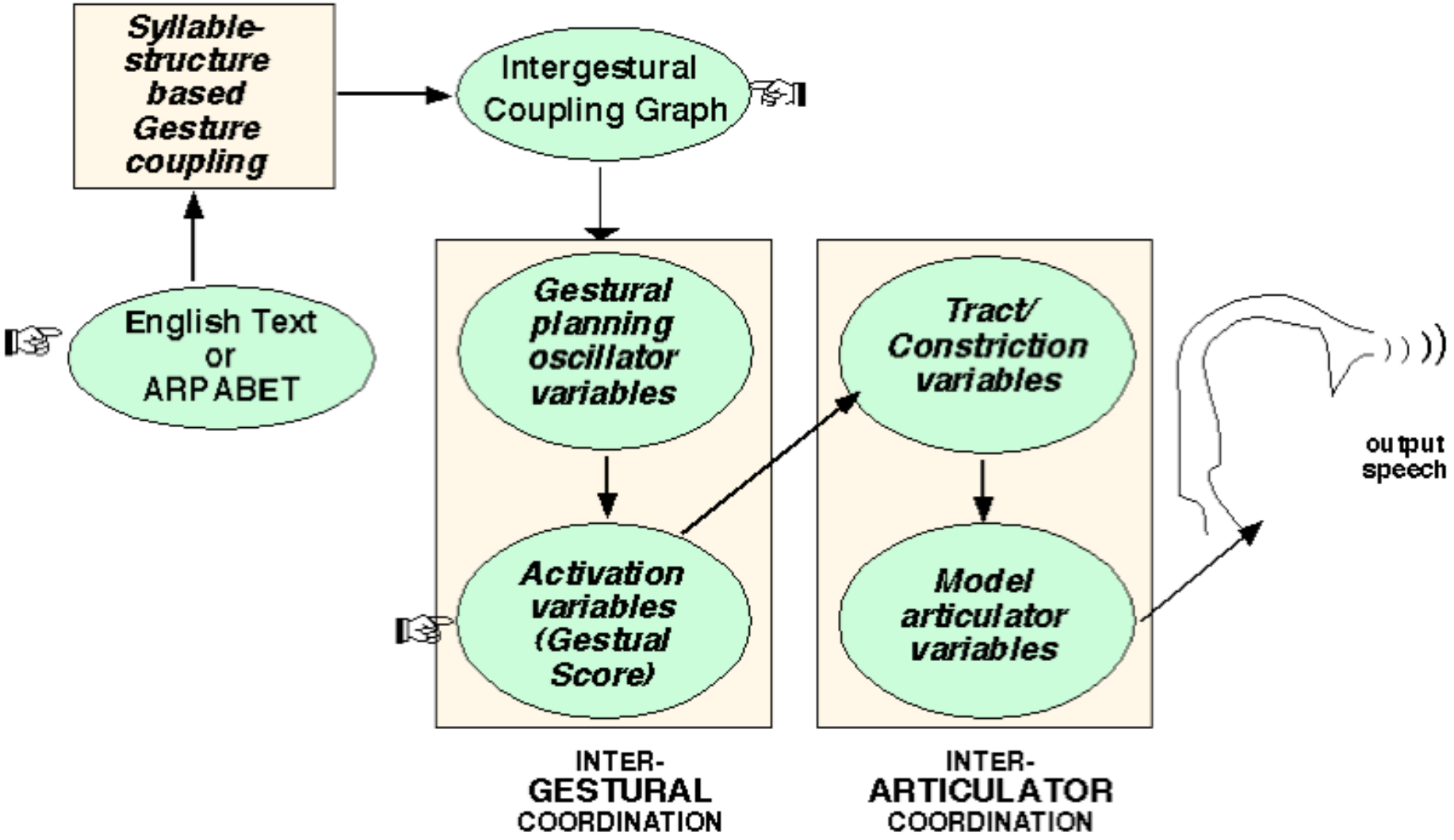
Task Dynamics Application

TaDA is composed of three separate models/modules:

1. Syllable structure-based gesture coupling model
2. Coupled oscillator model of inter-gestural coordination
3. Task dynamic model of inter-articulator coordination

Lower level models can be run without the higher level models.

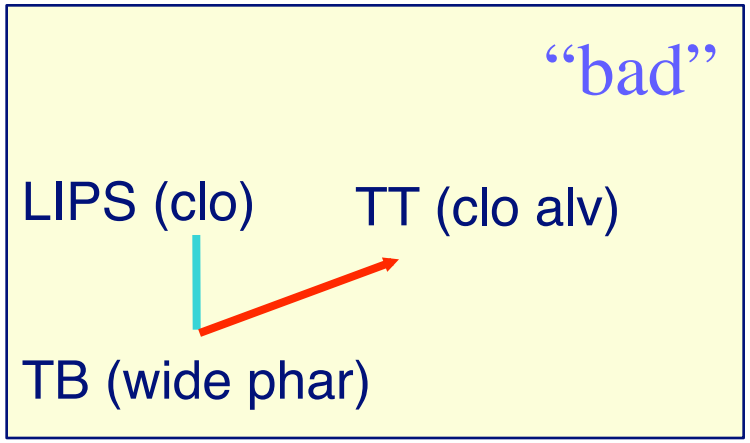
Models

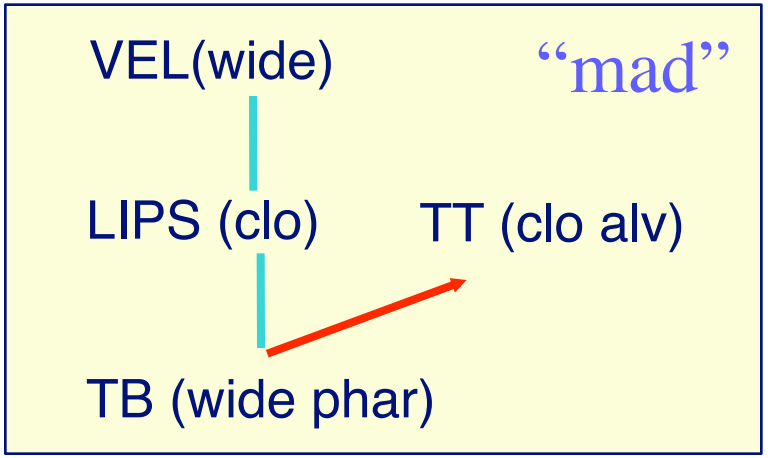

Syllable-structure based Gesture coupling
Intergestural Coupling Graph
English Text or ARPABET
Gestural planning oscillator variables
Activation variables (Gestual Score)
Tract/ Constriction variables
Model articulator variables
output speech
INTER-GESTURAL COORDINATION
INTER-ARTICULATOR COORDINATION

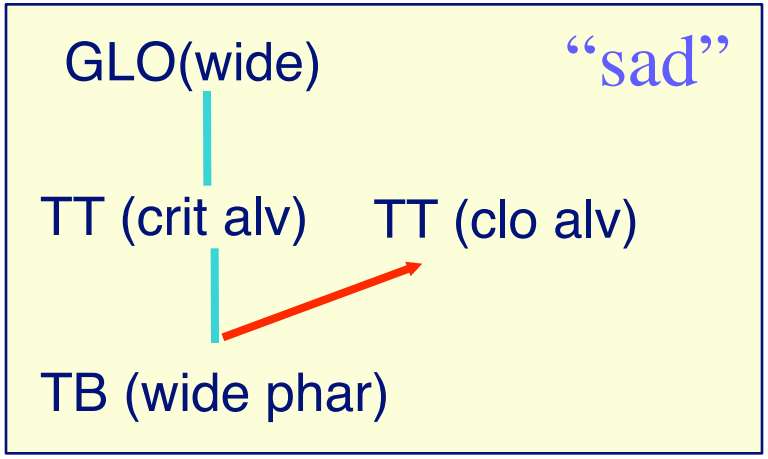
Model of Phonological Representation (Articulatory Phonology)

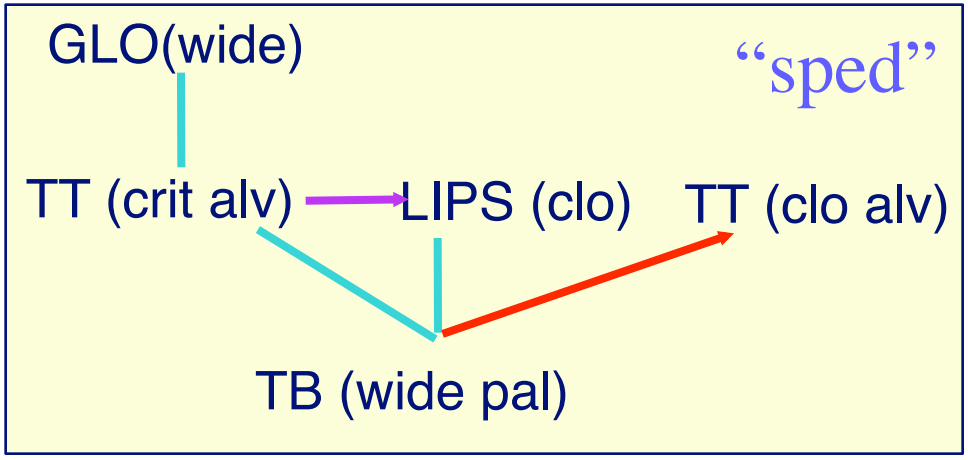
- Phonological representation of an utterance is a gestural coupling graph:
  - NODES specify gestures: context-invariant tasks for VT constriction devices
    - LIPS TT (Tongue Tip) TB(Tongue Body)
    - VEL (Velum) GLO (Glottis)
  - EDGES specify coordination among gestures: relative phase targets for pairs of gestural oscillators
    - Each gesture is associated with a timing oscillator
    - Timing oscillators trigger the activation of their associated gesture(s)

Example Coupling Graphs



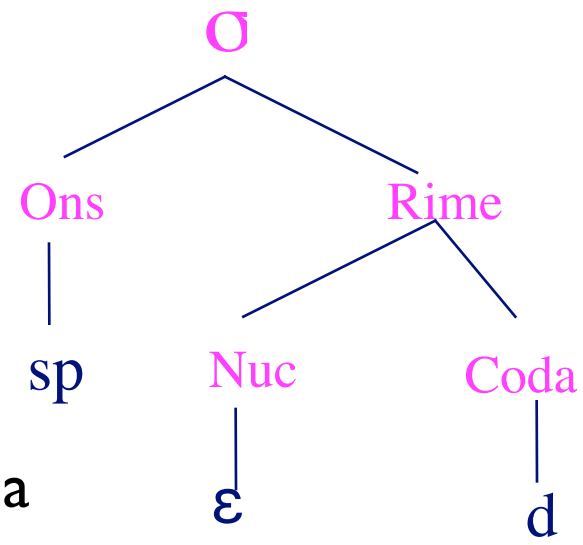




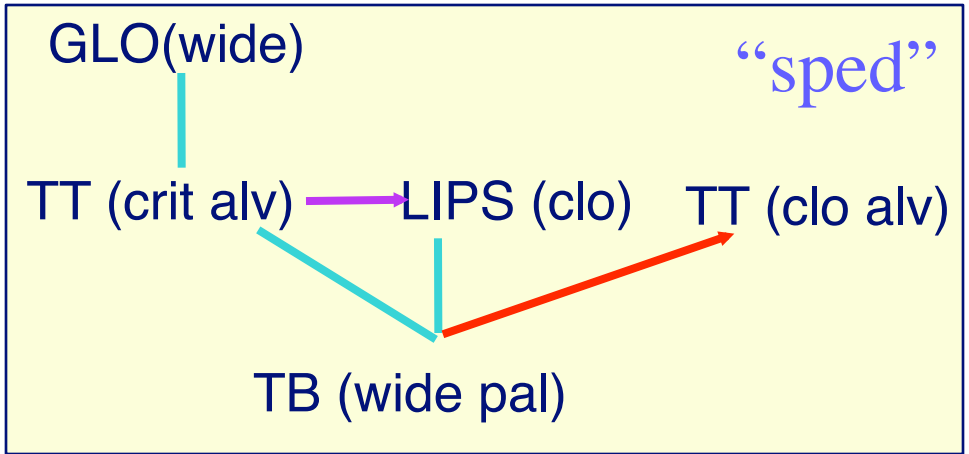


Topology of coupling graph defines syllable structure

- Traditional view of syllable
- Coupling model of the syllable



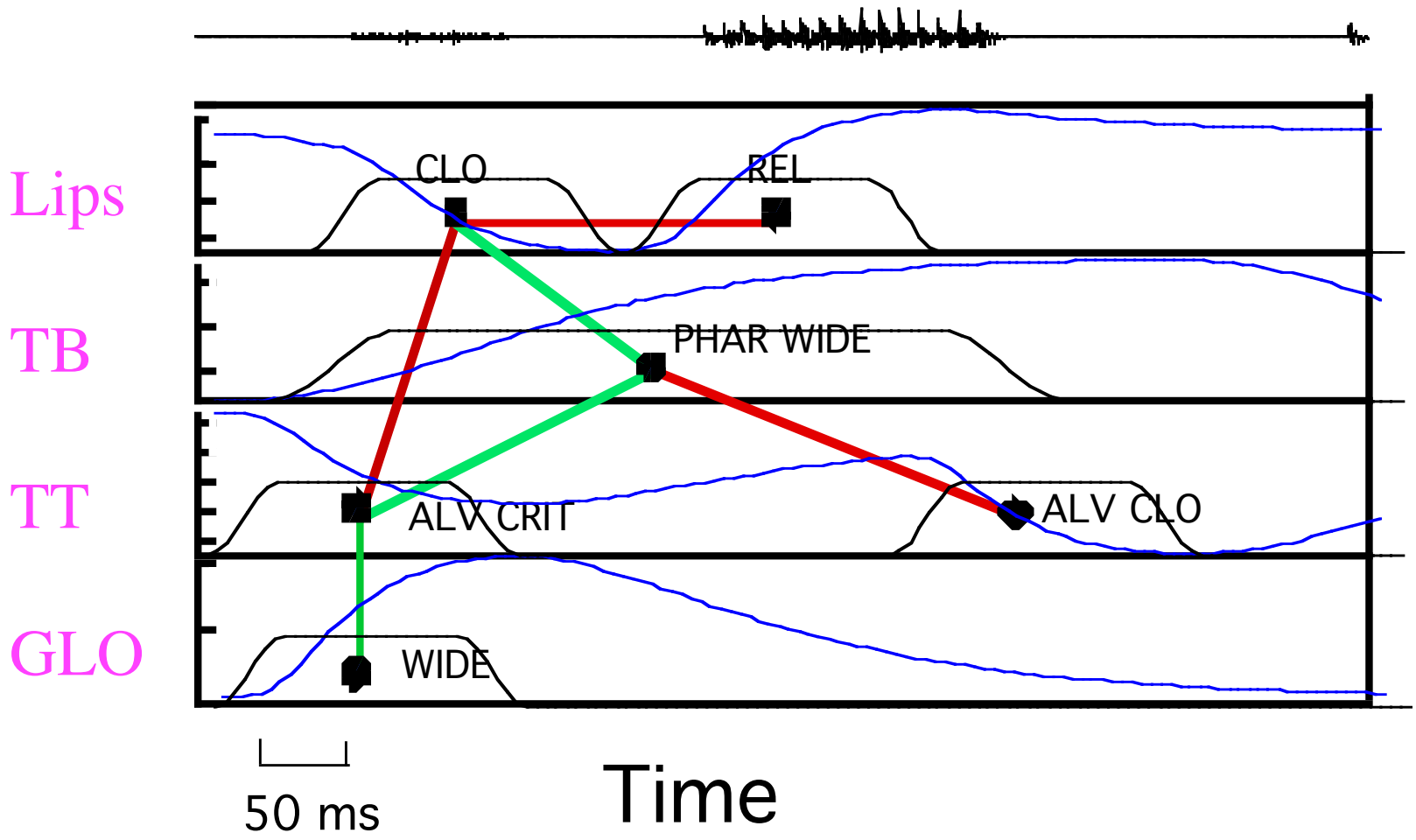
- Ons gestures in-phase to Nuc gestures
- Coda gestures anti-phase to Nuc gestures
- Oral Constriction gestures within Ons or Coda other non-0 phase to each other



Stages of Speech Production Model

- Planning
  - Gesture oscillators all start at random phases.
  - Over repeated cycles, coupling forces in graph cause oscillators to settle at stabilized relative phases (Saltzman & Byrd, 2000).
  - Cycles of stabilized oscillations used to determine times of gestural activations and deactivations (gestural score)
- Constriction Formation
  - Coordinated motion of articulators results from activations of invariantly specified gesture tasks.

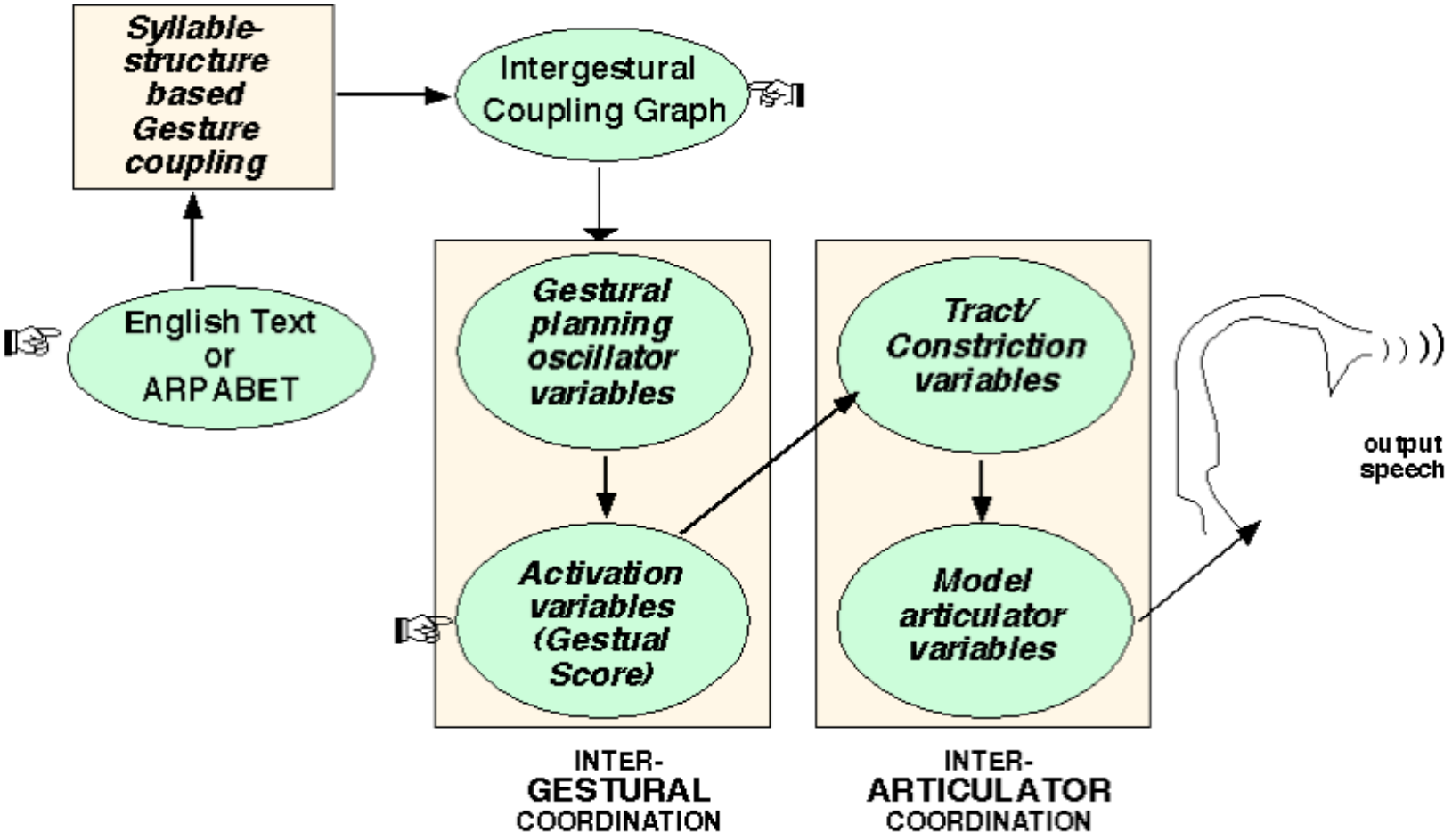
Example: /spæt/



Input and output wrappers

- Get syllabified gestures from text input
  - Computation of coupling graph
  - Coupled oscillator model of planning
  - Task-dynamic model of constriction formation
- Generation of acoustic output from articulator movements

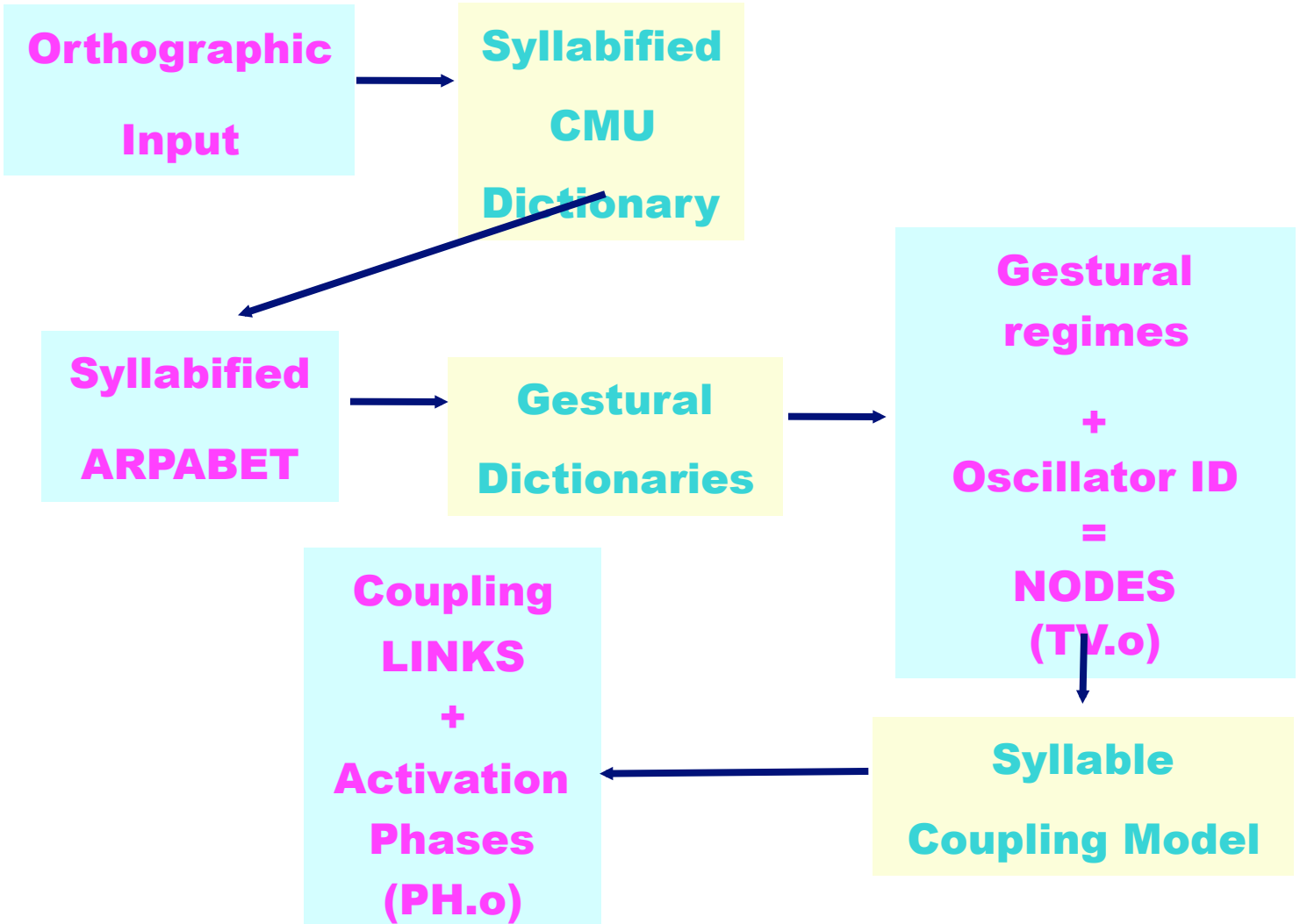
Models and possible inputs



TADA inputs

- Gestural score file (*tv<id>.g*) (run only model 3)
- Coupling graph files (run models 2 and 3)
  - *tv<id>.o*
  - *ph<id>.o*
- Text (run all models)
  - English Orthography
    - `'cathie#best'`
    - Must be in lower case
    - Real English words
    - Generates American English pronunciation
  - ARPABET (syllabified)
    - `'(KAETHIY)#(BEHST)'`
    - Can be used for non-words

Automatic Computation of Coupling graph



Gestural Dictionaries: ARPABET to gestures

ARPA	Organ	Osc	TV	Constr
B	Lips	clo	LA	CLO
	Lips	rel	LA	REL
	Velum	clo	VEL	CLO
P	Lips	clo	LA	CLO
	Lips	rel	LA	REL
	Glottis	h	GLO	WIDE
	Velum	clo	VEL	CLO
M	Lips	clo	LA	CLO
	Lips	rel	LA	REL
	Velum	n	VEL	WIDE

ARPA	Organ	Osc	TV	Constr
D	TT	clo	TTCL	ALV
	TT	clo	TTCD	CLO
	TT	rel	TTCL	REL
	TT	rel	TTCD	REL
	Velum	clo	VEL	CLO
T	TT	clo	TTCL	ALV
	TT	clo	TTCD	CLO
	TT	rel	TTCL	REL
	TT	rel	TTCD	REL
	Glottis	h	GLO	WIDE
	Velum	clo	VEL	CLO
N	TT	clo	TTCL	ALV
	TT	clo	TTCD	CLO
	TT	rel	TTCL	REL
	TT	rel	TTCD	REL
	Velum	n	VEL	WIDE

Etc..

See gestures_english.xls

Gestural Dictionaries: Onset Fix-up

- Model is not segmental, though gestures are assigned to ARPABET segments for convenience.
- Complex onsets and complex codas by default are assigned the union of sets of gestures associated with each ARPABET segment.
- Cases in which this is not the case are handled by fix-up dictionaries that delete some gestures.

ARPA	C	TV	Constr
SP	P	GLO	WIDE
ST	T	GLO	WIDE
SK	K	GLO	WIDE
SF	F	GLO	WIDE

Gestural Dictionaries: Gestural Control Regimes

TV	Constr	Target	Alpha	LX	JA	UH	LH	CL	CA	TL	TA	NA	GW
TTCL	DENT	40	1	.	32	.	.	32	32	1	1	.	.
TTCL	ALV	56	1	.	32	.	.	32	32	1	1	.	.
TTCL	ALVPAL	60	1	.	32	.	.	32	32	1	1	.	.
TTCL	PAL	80	1	.	32	.	.	32	32	1	1	.	.
TTCL	REL	24	1	.	32	.	.	32	32	1	1	.	.
TTCD	CLO	-2	100	.	32	.	.	32	32	1	1	.	.
TTCD	CRIT	1	10	.	32	.	.	32	32	1	1	.	.
TTCD	NAR	2	1	.	32	.	.	32	32	1	1	.	.
TTCD	REL	11	1	.	32	.	.	32	32	1	1	.	.

```
% Input string: <spin#pans>
%
%
% Word 1:   spin
% arpabet:  (S P-IH1_N)
%
%
% syllable 1:   S P-IH1_N
%
%    onset cluster = <S P>
%    segment 1 [S]:
'GLO' 'ons1_h1' 0.4 16 1 GW=1 0 0
'TBCD' 'ons1_crt1' 10 8 1 JA=10,CL=1,CA=1 10 0.1
'TBCL' 'ons1_crt1' 110 8 1 JA=10,CL=1,CA=1 10 0.1
'TTCL' 'ons1_crt1' 56 10 1 JA=640,CL=32,CA=32,TL=1,TA=1 1 1
'VEL' 'ons1_crt1' -0.1 8 1 NA=1 0 0
'TTCD' 'ons1_crt1' 1.2 10 1 JA=640,CL=32,CA=32,TL=1,TA=1 10 0.1
'TTCL' 'ons1_rel1' 24 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1
'TTCD' 'ons1_rel1' 11 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1
%    segment 2 [P]:
'LA' 'ons2_rel1' 11 8 1 JA=8,UH=5,LH=1 1 1
'VEL' 'ons2_clo1' -0.1 8 1 NA=1 0 0
'LA' 'ons2_clo1' -2 8 1 JA=8,UH=5,LH=1 100 0.01
%
%    nucleus cluster = <IH1>
%    segment 1 [IH]:
'TBCL' 'v1' 95 3 1 JA=10,CL=1,CA=1 1 1
'TBCD' 'v1' 8 3 1 JA=1,CL=1,CA=1 1 1
%
%    coda cluster = <N>
%    segment 1 [N]:
'VEL' 'cod1_n1' 0.2 8 1 NA=1 1 1
'TTCD' 'cod1_clo1' -2 8 1 JA=32,CL=32,CA=32,TL=1,TA=1 100 0.01
'TTCL' 'cod1_clo1' 56 8 1 JA=32,CL=32,CA=32,TL=1,TA=1 1 1
'TTCL' 'cod1_rel1' 24 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1
'TTCD' 'cod1_rel1' 11 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1
##
```

Sample:
spin#pans

TVspin_pans.O

```
%
% Word 2:   pans
% arpabet:  (P-AE1_N Z)
%
%
% syllable 2:   P-AE1_N Z
%
%    onset cluster = <P>
%    segment 1 [P]:
'LA' 'ons1_rel2' 11 8 1 JA=8,UH=5,LH=1 1 1
'GLO' 'ons1_h2' 0.4 16 1 GW=1 0 0
'VEL' 'ons1_clo2' -0.1 8 1 NA=1 0 0
'LA' 'ons1_clo2' -2 8 1 JA=8,UH=5,LH=1 100 0.01
%
%    nucleus cluster = <AE1>
%    segment 1 [AE]:
'TBCL' 'v2' 170 4 1 JA=1,CL=1,CA=1 1 1
'TBCD' 'v2' 17 4 1 JA=1,CL=1,CA=1 1 1
%
%    coda cluster = <N Z>
%    segment 1 [N]:
'VEL' 'cod1_n2' 0.2 8 1 NA=1 1 1
'TTCD' 'cod1_clo2' -2 8 1 JA=32,CL=32,CA=32,TL=1,TA=1 100 0.01
'TTCL' 'cod1_clo2' 56 8 1 JA=32,CL=32,CA=32,TL=1,TA=1 1 1
%    segment 2 [Z]:
'GLO' 'cod2_h2' 0.25 16 1 GW=1 0 0
'TTCL' 'cod2_crt2' 56 10 1 JA=640,CL=32,CA=32,TL=1,TA=1 1 1
'TTCD' 'cod2_crt2' 1.2 10 1 JA=640,CL=32,CA=32,TL=1,TA=1 10 0.1
'VEL' 'cod2_crt2' -0.1 8 1 NA=1 0 0
'TBCD' 'cod2_crt2' 10 8 1 JA=10,CL=1,CA=1 10 0.1
'TBCL' 'cod2_crt2' 110 8 1 JA=10,CL=1,CA=1 10 0.1
'TTCL' 'cod2_rel2' 24 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1
'TTCD' 'cod2_rel2' 11 8 1 JA=512,CL=512,CA=512,TL=1,TA=1 1 1
##
```

PHspin_pans.O

Oscillator Definitions

```
%'OSC_ID' NatFreq m,n escap amp_init phase_init / riseramp plateau fallramp
'v1' 2   1   4   1 NaN/ 10 200 210
'v2' 2   1   4   1 NaN/ 10 200 210
'ons2_clo1' 2   1   4   1 NaN/ 5 60 65
'ons1_clo2' 2   1   4   1 NaN/ 5 60 65
'ons1_rel1' 2   1   4   1 NaN/ 5 20 25
'ons2_rel1' 2   1   4   1 NaN/ 5 20 25
'ons1_rel2' 2   1   4   1 NaN/ 5 20 25
'ons1_crt1' 2   1   4   1 NaN/ 5 60 65
'cod1_clo1' 2   1   4   1 NaN/ 5 55 60
'cod1_clo2' 2   1   4   1 NaN/ 5 55 60
'cod1_rel1' 2   1   4   1 NaN/ 5 20 25
'cod2_rel2' 2   1   4   1 NaN/ 5 20 25
'cod2_crt2' 2   1   4   1 NaN/ 5 55 60
'ons1_h1' 2   1   4   1 NaN/ 5 75 80
'ons1_h2' 2   1   4   1 NaN/ 5 75 80
'cod2_h2' 2   1   4   1 NaN/ 5 55 60
'cod1_n1' 2   1   4   1 NaN/ 5 85 90
'cod1_n2' 2   1   4   1 NaN/ 5 85 90
```

PHspin_pans.O

Coupling Definitions

```
/coupling/

%'OSC_ID1' 'OSC_ID2' strength1(to OSC1) strength2(to OSC2) TargetRelPhase
'ons1_crt1' 'ons2_clo1' 1  1 90
'ons1_crt1' 'ons1_rel1' 1  1 65
'ons2_clo1' 'ons2_rel1' 1  1 65
'ons1_clo2' 'ons1_rel2' 1  1 65
'ons1_crt1' 'ons1_h1' 1  1 20
'ons1_clo2' 'ons1_h2' 1  1 20
'ons1_crt1' 'v1' 1 1 0
'ons2_clo1' 'v1' 1 1 0
'ons1_clo2' 'v2' 1 1 0
'cod1_clo2' 'cod2_crt2' 1  1 45
'cod1_clo1' 'cod1_rel1' 1  1 60
'cod2_crt2' 'cod2_rel2' 1  1 60
'cod2_crt2' 'cod2_h2' 1  1 20
'cod1_n1' 'cod1_clo1' 1  1 45
'cod1_n2' 'cod1_clo2' 1  1 45
'v1' 'cod1_clo1' 1   1 180
'v2' 'cod1_clo2' 1   1 180
'cod1_rel1' 'ons1_clo2' 1 1 0
```

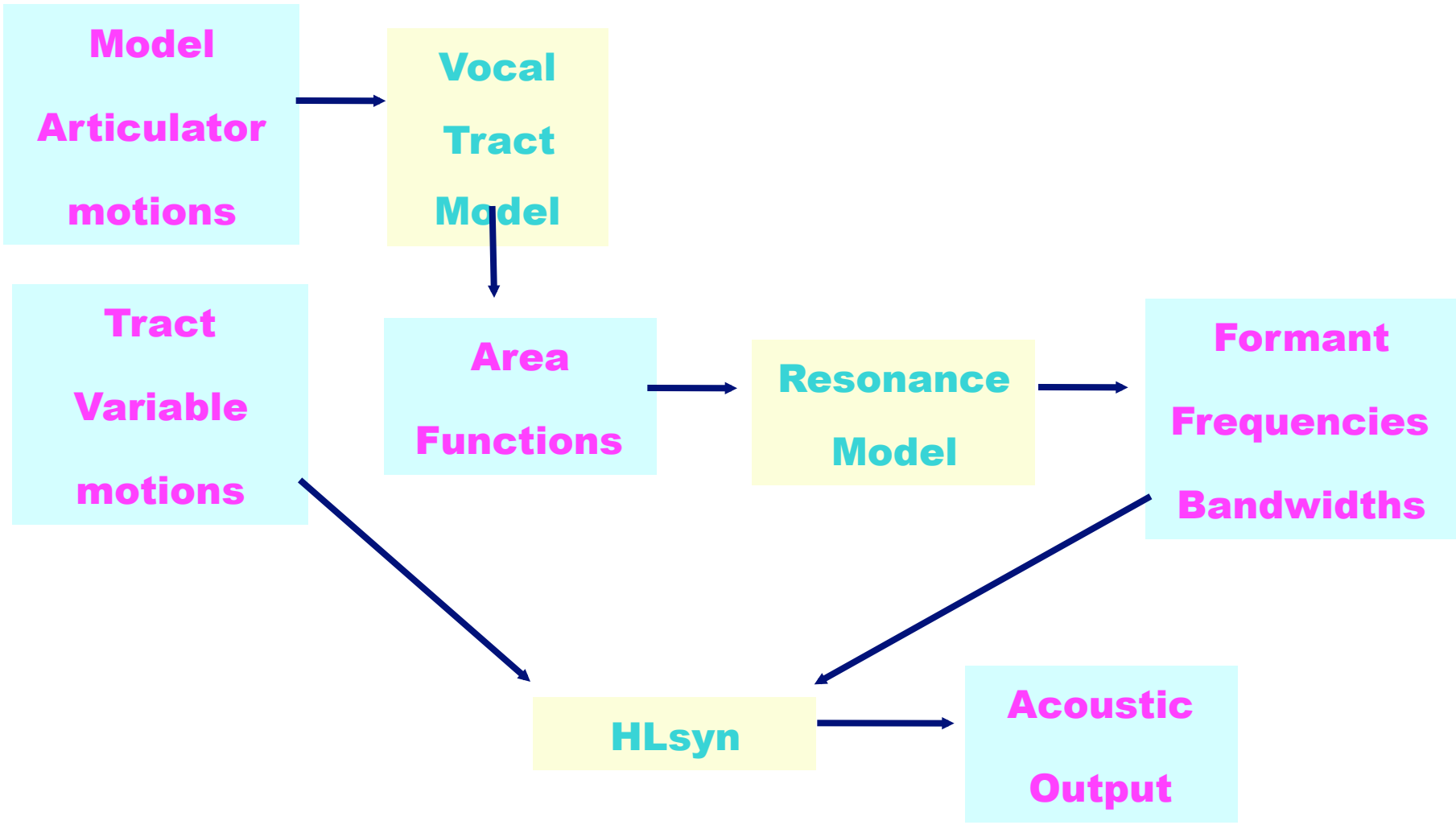
Coupling Principles

```
/coupling/

% C     = (clo | crt | nar | voc)
% CNS   = (clo | crt | nar)
% OBS   = (clo | crt)

ONS_OBS ONS_CNS 1 1 90      % anti-phase relation in onset clusters

ONS_VOC ONS_NAR 1 1 0       % VOC gesture of /r/, /l/ sychronous with primary NAR constriction

ONS_CNS ONS_REL 1 1 65      % REL is anti-phase with respect to Constriction

ONS_CRT ONS_H 1 1 20           % GLO gesture is synchronous with frics
ONS_CLO ONS_H 1 1 20        % else GLO gesture is delayed for stops
ONS_CLO ONS_N 1 1 0         % VEL gesture synchronous wih oral constr.

ONS_CNS* V 1 1 0            % all CNS gestures synchronous with V
ONS_H V 1 1 0               % GLO synchronous with V, if not coupled to CNS

% vowel
V_RND V 1 1 0               %rounding synchronous with V tongue constr.

% coda
COD_C COD_C 1 1 45      % C in coda are phased 180 degrees
% COD_VOC COD_NAR 1 1 45        % VOC gesture anti-phase to NAR constr.

COD_CNS COD_REL 1 1 60      % REL is anti-phase with respect to Constriction

COD_CLO COD_H 1 1 20        % GLO gesture is delayed for stops
COD_CRT COD_H 1 1 20           % else GLO gesture is synchronous with frics
COD_N COD_CNS 1 1 45        % VEL gesture anti-phase to oral constr.

V COD_C 1 1 180         % first coda CNS anti-phase to V
```

TADA outputs

- Model articulator time functions
- Constriction (Tract Variable) time functions
- Pseudo-sound
- Input file to HLsyn *(<id>.HL)*

Generation of Acoustic output

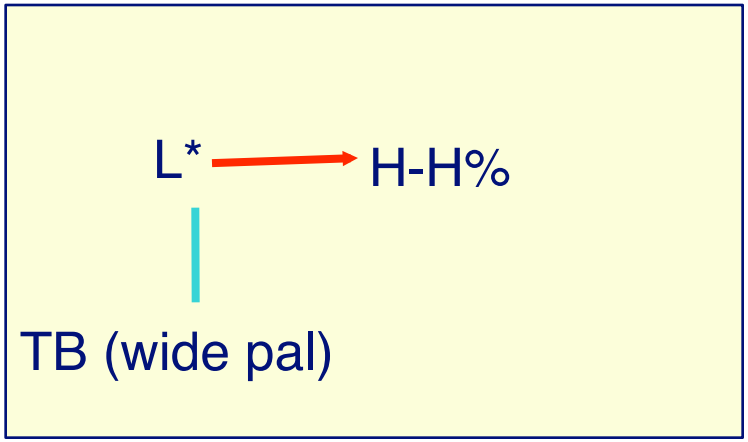


Prosody

- No prosodic structure or stress is automatically generated at present
- But there is a toolkit
- We will be developing code to automatically add an input tone sequence to the coupling graph generated by the first model of TaDA.

Prosodic Toolkit

- Tones
  - Tone gestures (goal = f0)
    - can be added to tv.o file manually
    - can be coupled to other gestures
  - "Cathi Best?"



Prosodic Toolkit

- Π-gestures (Byrd & Saltzman, 2002)
  - Act to slow the gestural activation clock, effectively stretching gestures in time
  - Activation intervals for Π-gestures can be added manually to gestural score.
  - "Cathi Best?" with Π-gesture added.