Reading Issues in Children: What Audiologists Need to Know

Carol Sullivan, MS, CCC/SLP
Rebecca Kooper, AuD, CCC/A
April 2010
AAA

Audiologists as a member of the literacy team

- Why?
  - Audiologists evaluate many students for auditory processing disorders whose primary complaint is a reading problem.
  - Children need "about 20,000 hours of relentless auditory attention" in order to learn to read. (English, K, Audiology, MarApr 2010)
  - Recent research establishes a "significant link between subcortical ***auditory*** function and reading. (Banai et al, Reading and Subcortical Function, Cerebral Cortex, Nov 2009)

Recent research findings

Speech ABR

- Provides objective physiological information
- Sensitive to speech encoding in the auditory pathway
- Poor readers show abnormal timing of ABR's to speech sounds (Banai, Hornickel, Skoe, Nicol, Zecker, Kraus, 2009)
- Not found in click sounds (Song, 2006)

Encoding speech

- Poor readers have abnormal representation of acoustic elements of speech necessary for phonemic discrimination

- Results in impoverished input to higher level areas dedicated to phonological processing

What is the relationship between reading and subcortical functions ?

- Phonological decoding, measured in non word reading correlates with the *timing* of subcortical processes

- Relates to the robustness of subcortical representation of the harmonic content of speech. Banai, Hornickle, Skoe, Nicol, Zecker, Krauss, 2009

20,000 hours!!!!

- Need for early amplification
- Need for consistent amplification

Audiological test battery

- Currently, most audiologists test using (central) auditory processing tests which include
  - Temporal
  - Binaural integration/ separation
  - Monaurally degraded signal
    - Speech-in-noise
  - Binaural interaction

Consistent with a team approach to both reading and APD…..

- Evaluation should only be done after receipt of some information from other members of the team:
  - SLP evaluation
  - Psychological evaluation
  - Academic performance
  - Reading assessment

Audiologists' recommendations following (C)APD evaluation:

- Recommendations include
  - Remediation and compensatory strategies dependent on APD results
  - Referral back to SLP for a phonological-orthographical substitution evaluation
  - Referral back to reading specialist after SLP assessment
- Do not make recommendations in isolation. Communicate with school personnel.

What is the difference between a "reading impairment" and "dyslexia"?

A disorder characterized by difficulties in single word decoding, usually reflecting insufficient phonological processing. Snowling,2008, Vellutino,2004

This disability is "often unexpected in relation to age, and other cognitive and academic abilities..."
Shaywitz, Fletcher & Shaywitz, 1994

Traditional reading process

According to the National Institute for Literacy, lists five areas of reading instruction

- Phonemic awareness
- Phonics
- Fluency
- Vocabulary
- Text comprehension

Terminology

Phoneme- the smallest part of spoken language that makes a difference in the meaning of words

Phonological processing - includes phonemic awareness- ability to hear, identify and manipulate individual phonemes in words. Also includes work with rhymes, words, syllables, and onsets and rimes.

Phonological Processing

Phonological Awareness

- Blending words
- Elision
- Sound matching

Phonological Memory

- Memory for digits
- Non-word repetition

Rapid Naming

- Rapid color naming
- Rapid object naming
- Rapid letter naming
- Rapid digit naming

Comprehensive Test of Phonological Processing (CTOPP) ,Wagner, Torgesen, & Rashotte, 1994.

How do these patterns develop?

Reading develops through bottom-up and top down-processes

Top-down processes

Using context to support reading the word

Example

C___d_ won the gold medal in hockey.

A doorbell is not a d_c_b_l.

Auditory closure

- Filtered words

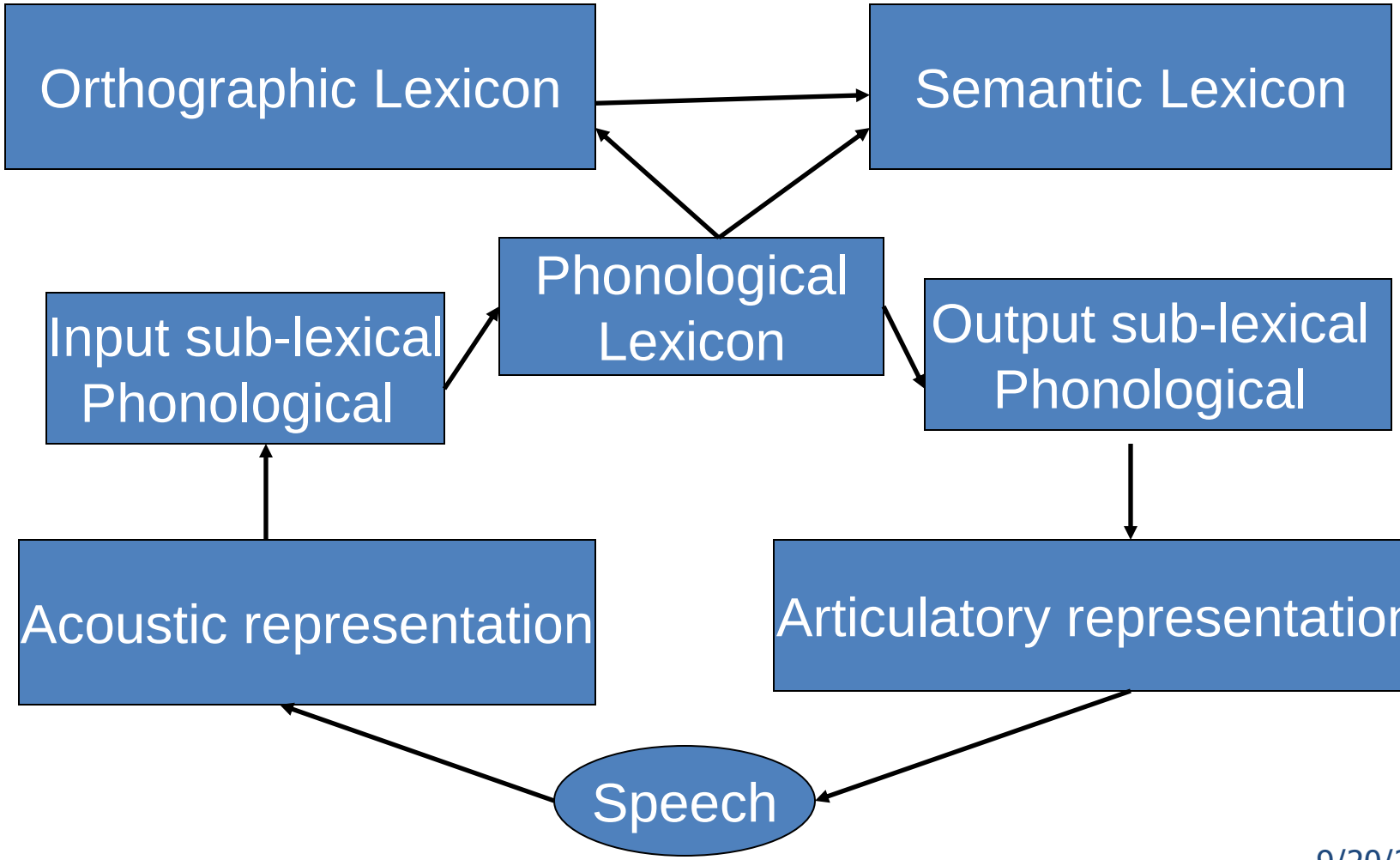
Reading and Auditory Systems

Reading depends upon the development of an accurate acoustic representation of language through encoding.

The acoustic representation of language could impact the development of speech (articulation) and the development of speech could impact the acoustic representation of language.

Interaction of acoustic input and articulatory output

Sullivan, C. & Kooper, R. 2007



What happens when this process breaks down?

Poor speech perception gives rise both to "fuzzy" or "underspecified" lexical and phonological representations and to weak verbal short term memory. It results in poor perception of phonological units.

(Studdert-Kennedy, Haskins Laboratories, 2002)

…which will adversely impact reading and spelling

Phonemes that are critical to early reading development

Short vowels

Vowels are the core phonemes of speech utterances

- Short vowels are present in all words taught in the early phases of reading development
- Vowel perception is influenced in the presence of noise
- Reading curriculum frequently spends a short period of time teaching short vowels

Concepts underlying development of phonological intervention

- Bottom-up processing
  - Auditory processing requires neurophysiological and cognitive mechanisms
  - Interaction between bottom up and top down processing
  - Bottom up processing requires detection and processing within the auditory system

Creation of a criterion referenced test to detect phonographic-orthographic error patterns

- The P-O-S-E. is a prescriptive, criterion referenced screening and rehabilitation system designed to assess and to correct the degree of deviation between a child's phonological (spoken) orthographic (written) representations of target short vowels.

Phonological- Orthographic Substitution Evaluation (POSE)

- Criterion-referenced test designed to assess vowel errors through reading and spelling tasks
- Targeted for general application at 3rd grade or higher grades
- Uses low frequency of occurrence real words and nonsense words
- Probes the phonological/orthographic code used during spelling and reading.

How is the test administered ?

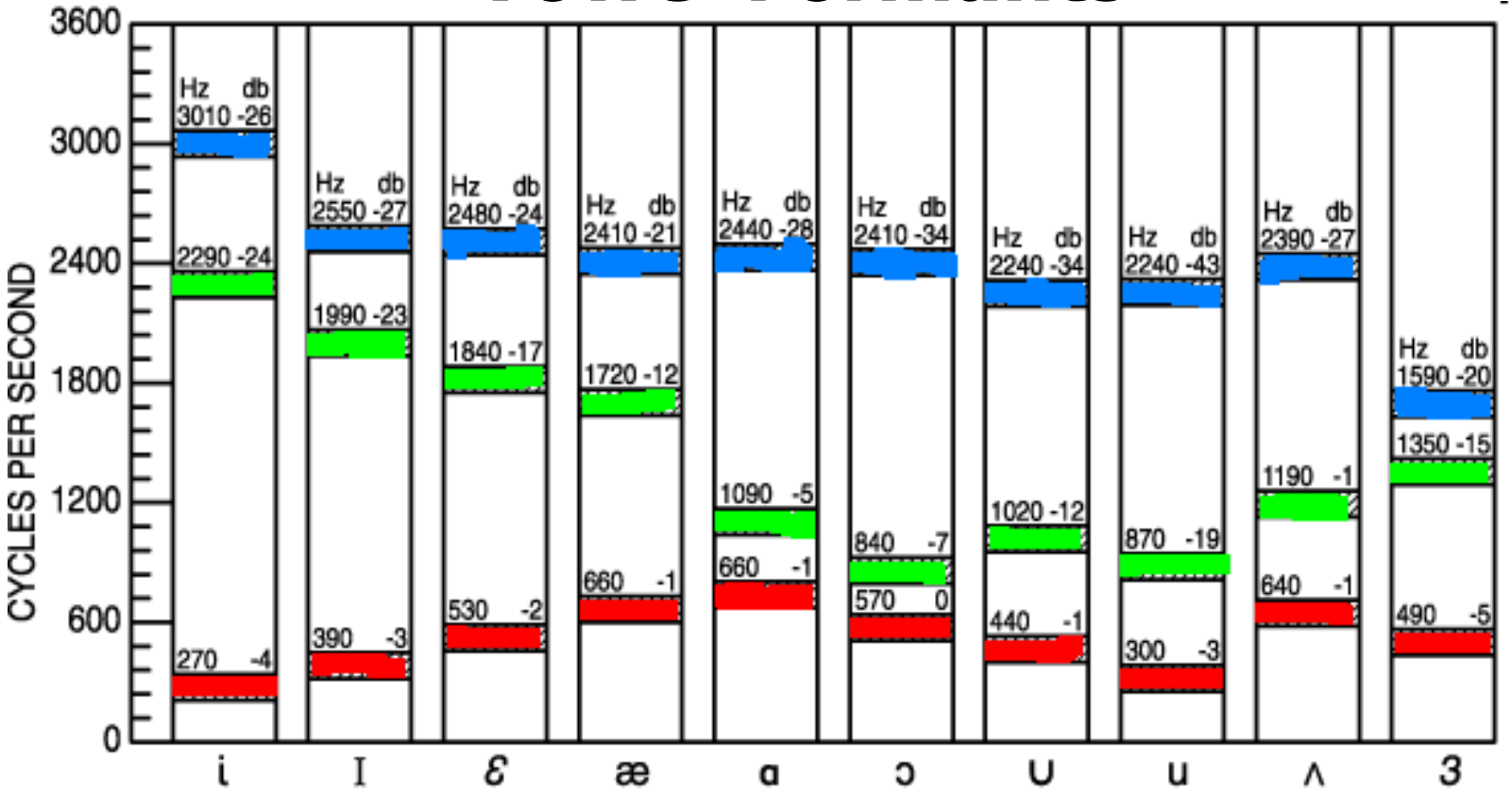
Students are first asked to spell two lists of 30 words.

Nonsense and real words

- Real words were selected to have a low frequency of occurrence to prevent students from using a "sight vocabulary" approach
  - CVCs
  - CCVCCs
  - CVCe

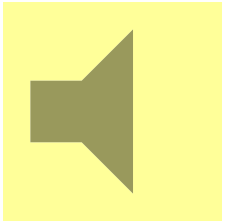
- A week later the students read the same two lists of 30 words per list

Vowel Formants



Mean F1, F2, F3 for 33 male speakers, for English vowels in a CVC context. Relative formant amplitudes are given in dB with respect to first formant of [ɔ] (bought). After [Peterson and Barney, reprinted in J. L. Flanagan, *Speech Analysis Synthesis and Perception*, Springer-Verlag, Berlin, 2nd edition, 1965.

VOWEL FORMANT SYNTHESIS



VOWEL SYMBOL SETS

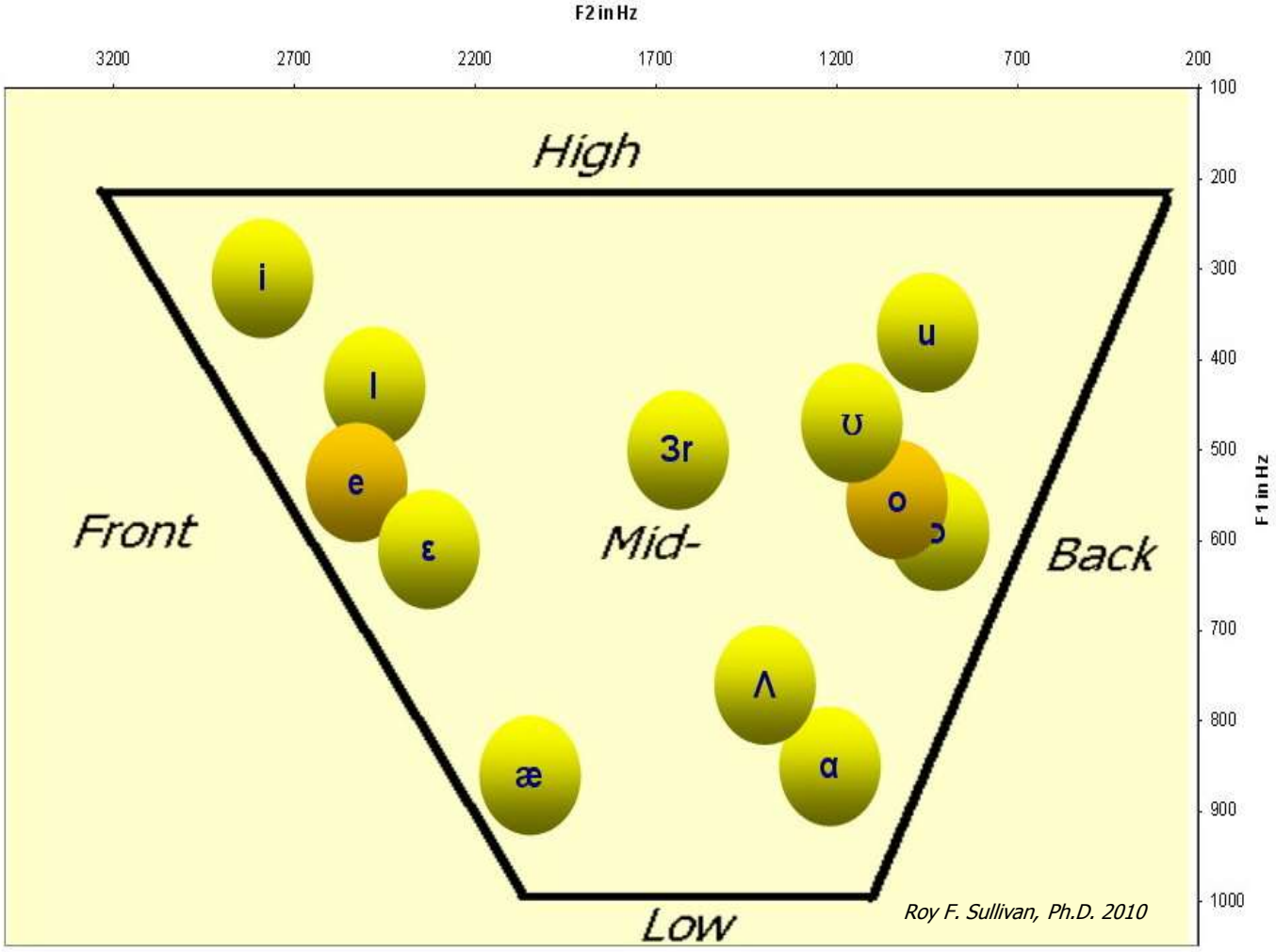
IPA International Phonetic Alphabet (Clinical/Linguistics)	AHD American Heritage Dictionary (Schools)	SAMPA Speech Assessment Methods Phonetic Alphabet (ASCII Keyboard)	Examples
i	ē	i	beat
ɪ	ĭ	I	pit
e	ā	e	bait
ɛ	ĕ	E	pet
æ	ă	{	pat
ɑ	ŏ	A	pot
ʌ	ŭ	V	putt
ɔ	ô	O	bought
o	ō	o	boat
ʊ	o͝o	U	put
u	o͞o	u	boot
ɜr	û	3'	bird

Short vowels

VOWEL QUADRANGLE: IPA

(International Phonetic Alphabet)

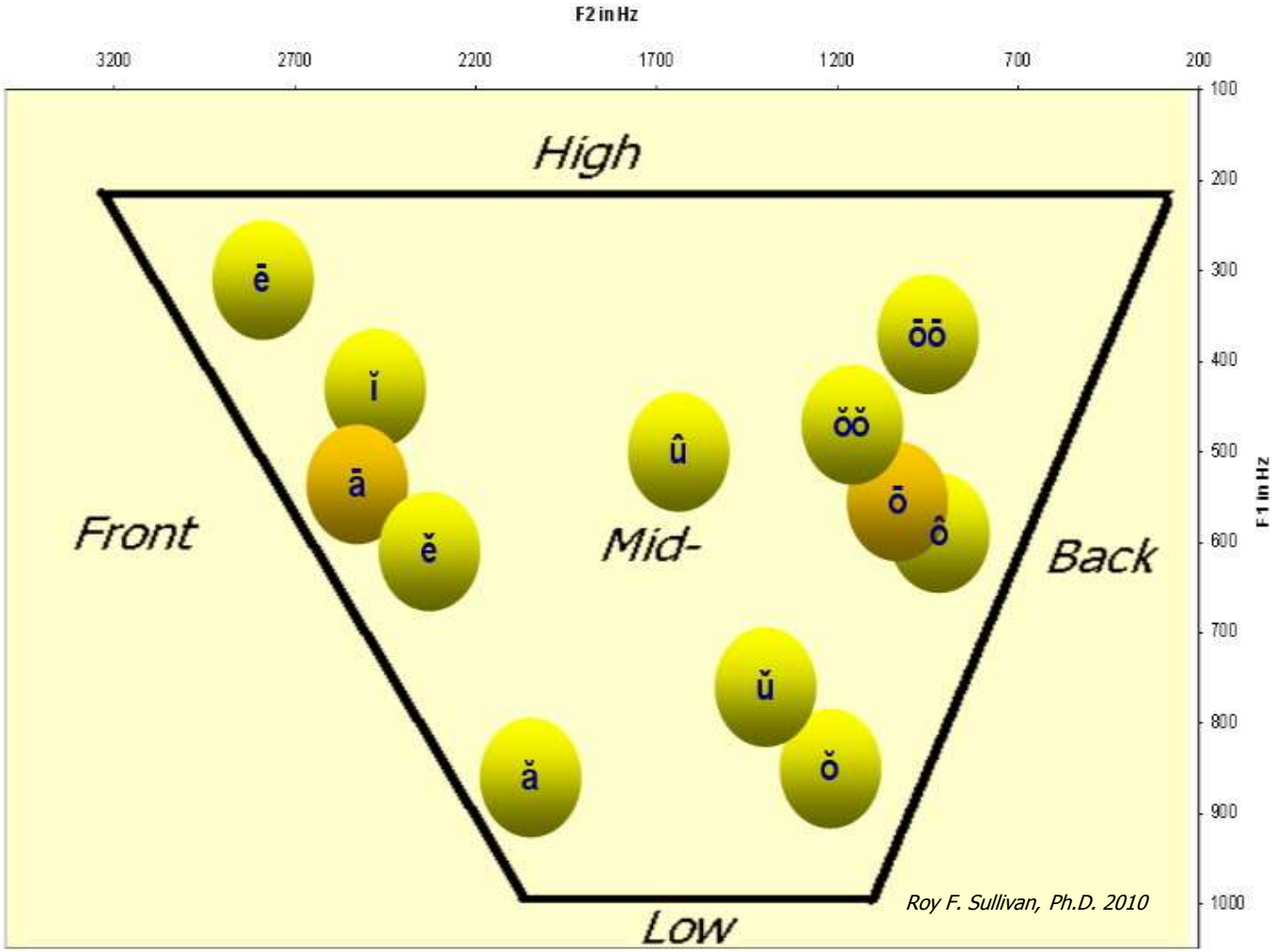
After Peterson & Barney, 1952 N=26F, Gen. Amer.



VOWEL QUADRANGLE: AHD

(American Heritage Dictionary)

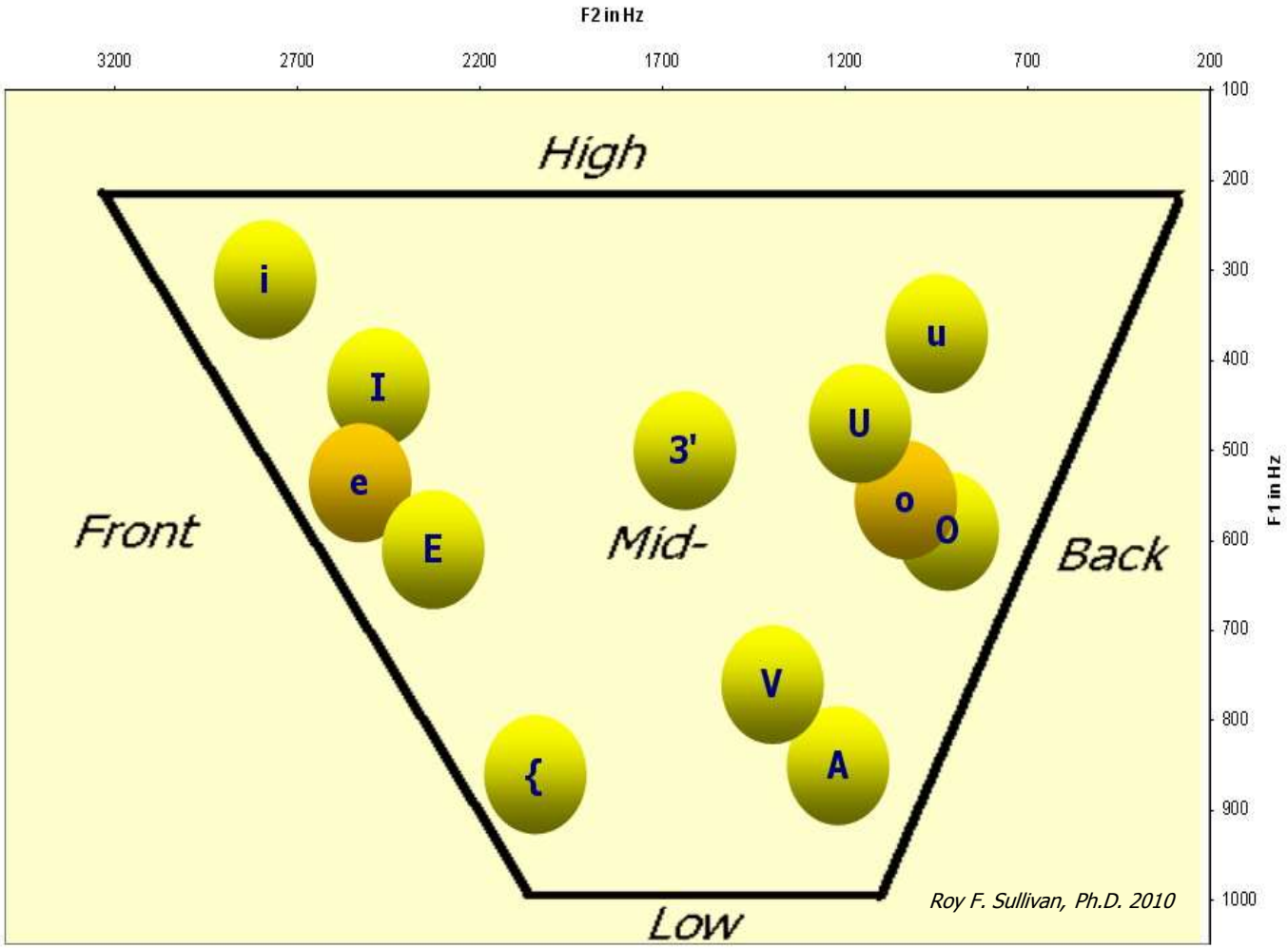
After Peterson & Barney, 1952 N=26F, Gen. Amer.



VOWEL QUADRANGLE: SAMPA

(Speech Assessment Methods Phonetic Alphabet)

After Peterson & Barney, 1952 N=26F, Gen. Amer.



P.O.S.E.
Phonological-Orthographic Substitution Evaluation

Name: Holden Caulfield
Date: 9-20-09 Examiner: CSullivan

Spelling Nonsense words

CVC	Response	Beginning Consonant	a	e	i	o	u	Final Consonant	Other
vip	+	v						p	
ret	+	r						t	
sug	sog	s					ŏ	g	
tob	tub	t				ŭ		b	
pag	+	p						g	
zib	+	z						b	
fem	+	f						m	
dut	dot	d					ŏ	t	
lod	lud	l				ŭ		d	
wap	+	w						p	

CCVCC	Response	Beginning Consonant	a	e	i	o	u	Final Consonant	Other
shug	shog	sh					ŏ	g	
grob	grub	gr				ŭ		b	
glesh	+	gl						sh	
blick	+	bl						ck	
plash	+	pl						sh	
trub	trob	tr					ŏ	b	
chog	chug	ch				ŭ		g	
bemp	+	b						mp	
slind	+	sl						nd	
grat	+	gr						t	

CVCe	Response	Beginning Consonant	a	e	i	o	u	Final Consonant	Silent E	Other
nide	+	n						d	e	
gute	+	g						t	e	
maze	+	m						z	e	
hake	+	h						k	e	
vone	+	v						n	e	
sime	+	s						m	e	
fute	+	f						t	e	
bipe	+	b						p	e	
bave	+	b						v	e	
wode	+	w						d	e	

P-O-S-E © DIAGNOSTIC SUMMARY

LNAME: Caulfield FNAME: Holden

I.D. 330101 DATE: 9/20/2009

DATA ENTRY: SPELLING / NONSENSE

CVC									
	1	vip	v		i	i	I	p	
	2	ret	r		e	e	E	t	
	3	sug	s		u	o	A	g	
	4	tob	t		o	u	V	b	
	5	pag	p		a	a	{	g	
	6	zib	z		i	i	I	b	
	7	fem	f		e	e	E	m	
	8	dut	d		u	o	A	t	
	9	lod	l		o	u	V	d	
	10	wap	w		a	a	{	p	
CCVCC									
	11	shug	sh		u	o	A	g	
	12	grob	gr		o	u	V	b	
	13	glesh	gl		e	e	E	sh	
	14	blick	bl		i	i	I	ck	
	15	plash	pl		a	a	{	sh	
	16	trub	tr		u	o	A	b	
	17	chog	ch		o	u	V	g	
	18	bemp	b		e	e	E	mp	
	19	slind	sl		i	i	I	nd	
	20	grat	gr		a	a	{	t	
CVCe									
	21	nide	n		i	i	al	de	de
	22	gute	g		u	u	ju	te	te
	23	moze	m		o	o	o/oU	ze	ze
	24	hake	h		a	a	e/el	ke	ke
	25	vone	v		o	o	o/oU	ne	ne
	26	sime	s		i	i	al	me	me
	27	fute	f		u	u	ju	te	te
	28	bipe	b		i	i	al	pe	pe
	29	bave	b		a	a	e/el	ve	ve
	30	wode	w		o	o	o/oU	de	de

P-O-S-E © DIAGNOSTIC SUMMARY

LNAME: Caulfield FNAME: Holden

I.D. 330101 DATE: 9/20/2009

	Target	Spell,n CVC			Read,n CVC		
1	vip	v	i	p	v	i pĭt	p
2	ret	r	e	t	r	ĕ pet	t
3	sug	s	o	g	s	ŏ pot	g
4	tob	t	u	b	t	ŭ putt	t
5	pag	p	a	g	p	ă păt	g
6	zib	z	i	b	z	i pĭt	b
7	fem	f	e	m	f	ĕ pet	m
8	dut	d	o	t	d	ŭ putt	t
9	lod	l	u	d	l	ŭ putt	d
10	wap	w	a	p	w	ă păt	p

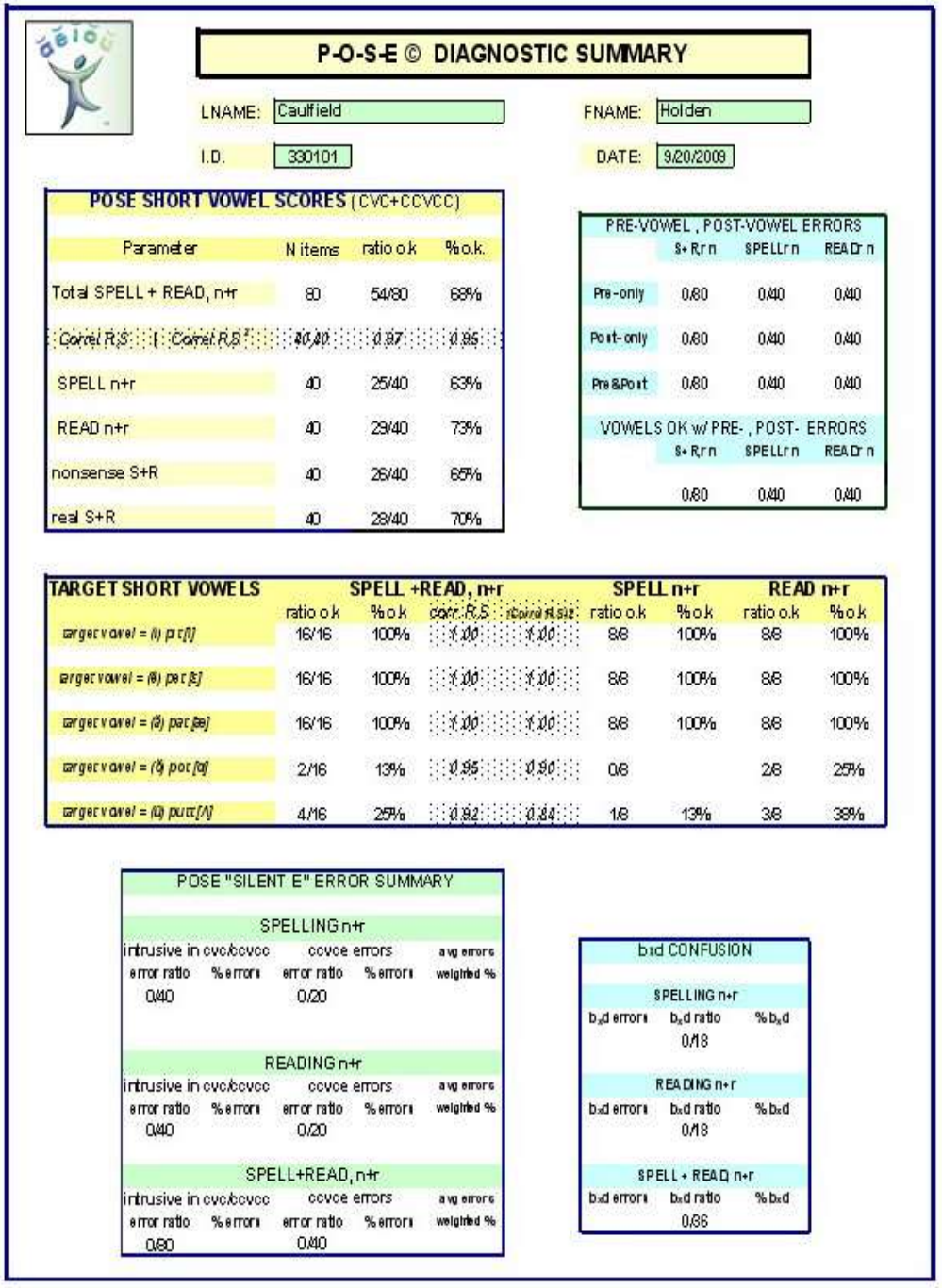
	Target	Spell,r CVC			Read,r CVC		
1	tab	t	a	b	t	ă păt	b
2	nip	n	i	p	n	i pĭt	p
3	pun	p	o	n	p	ŭ putt	n
4	wed	w	e	d	w	ĕ pet	d
5	cog	c	u	g	c	ŭ putt	g
6	sap	s	a	p	s	ă păt	p
7	bib	d	i	b	d	i pĭt	b
8	rut	r	o	t	r	ŏ pot	t
9	den	d	e	n	d	ĕ pet	d
10	cop	c	u	p	c	ŏ pot	p

	Target	Spell,n CCVCC			Read,n CCVCC		
11	shug	sh	o	g	sh	ŏ pot	g
12	grob	gr	u	b	gr	ŏ pot	b
13	glesh	gl	e	sh	gl	ĕ pet	sh
14	blick	bl	i	ck	bl	i pĭt	ck
15	plash	pl	a	sh	pl	ă păt	sh
16	trub	tr	o	b	tr	ŏ pot	b
17	chog	ch	u	g	ch	ŭ putt	g
18	bemp	b	e	mp	b	ĕ pet	mp
19	slind	sl	i	nd	sl	i pĭt	nd
20	grat	gr	a	t	gr	ă păt	t

	Target	Spell,r CCVCC			Read,r CCVCC		
11	hack	h	a	ck	h	ă păt	k
12	drip	dr	i	p	dr	i pĭt	p
13	stub	st	o	b	st	ŏ pot	b
14	clot	cl	u	t	cl	ŭ putt	t
15	pest	p	e	st	p	ĕ pet	st
16	rash	r	a	sh	r	ă păt	sh
17	blip	dr	i	p	bl	i pĭt	p
18	flop	fl	u	p	fl	ŭ putt	p
19	mend	m	e	nd	m	ĕ pet	nd
20	chum	ch	u	m	ch	ŭ putt	m

	Target	Spell,n CCVCCe			Read,n CCVCCe		
21	nide	n	i	de	n	i bite	d
22	gute	g	u	te	g	ŭ butte	t
23	moze	m	o	ze	m	ō boat	z
24	hake	h	a	ke	h	ā bāt	k
25	vone	v	o	ne	v	ō boat	n
26	sime	s	i	me	s	i bite	m
27	fute	f	u	te	f	ŭ butte	t
28	bipe	b	i	pe	b	i bite	p
29	bave	b	a	ve	b	ā bāt	v
30	wode	w	o	de	w	ō boat	d

	Target	Spell,r CCVCCe			Read,r CCVCCe		
21	dime	d	i	me	d	i bite	m
22	mute	m	u	te	m	ŭ butte	t
23	hose	h	o	se	h	ō boat	z
24	fake	f	a	ke	f	ā bāt	k
25	cone	c	o	ne	c	ō boat	n
26	vine	v	i	ne	v	i bite	n
27	fume	f	u	me	f	ŭ butte	m
28	kite	k	i	te	k	i bite	t
29	jade	j	a	de	j	ā bāt	d
30	tote	t	o	te	t	ō boat	t



P-O-S-E © DIAGNOSTIC SUMMARY

LNAME: Caulfield FNAME: Holden

I.D. 330101 DATE: 9/20/2009

POSE SHORT VOWEL SCORES (CVC+CCVCC)

Parameter	N items	ratio o.k	%o.k.
Total SPELL + READ, n+r	80	54/80	68%
Correl R,S	Correl R,S²	40,40	0.97	0.95
SPELL n+r	40	25/40	63%
READ n+r	40	29/40	73%
nonsense S+R	40	26/40	65%
real S+R	40	28/40	70%

PRE-VOWEL , POST-VOWEL ERRORS

	S+R,r n	SPELLr n	READr n
Pre-only	0/80	0/40	0/40
Post-only	0/80	0/40	0/40
Pre&Post	0/80	0/40	0/40

VOWELS OK w/ PRE- , POST- ERRORS

S+R,r n	SPELLr n	READr n
0/80	0/40	0/40

TARGET SHORT VOWELS

	SPELL +READ, n+r				SPELL n+r		READ n+r	
	ratio o.k	%o.k	corr. R,S	correl sig	ratio o.k	%o.k	ratio o.k	%o.k
target vowel = (i) pr[i]t	16/16	100%	1.00	1.00	8/8	100%	8/8	100%
target vowel = (e) pr[e]t	16/16	100%	1.00	1.00	8/8	100%	8/8	100%
target vowel = (a) pr[æ]t	16/16	100%	1.00	1.00	8/8	100%	8/8	100%
target vowel = (o) pr[o]t	2/16	13%	0.95	0.90	0/8		2/8	25%
target vowel = (u) pr[ʌ]t	4/16	25%	0.92	0.84	1/8	13%	3/8	38%

POSE "SILENT E" ERROR SUMMARY

SPELLING n+r

intrusive in cvc/ccvc error ratio	intrusive in cvc/ccvc % errors	ccvce errors error ratio	ccvce errors % errors	avg errors weighted %
0/40		0/20		

READING n+r

intrusive in cvc/ccvc error ratio	intrusive in cvc/ccvc % errors	ccvce errors error ratio	ccvce errors % errors	avg errors weighted %
0/40		0/20		

SPELL+READ, n+r

intrusive in cvc/ccvc error ratio	intrusive in cvc/ccvc % errors	ccvce errors error ratio	ccvce errors % errors	avg errors weighted %
0/80		0/40		

b:d CONFUSION

SPELLING n+r

b,d errors	b,d ratio	%b,d
	0/18	

READING n+r

b,d errors	b,d ratio	%b,d
	0/18	

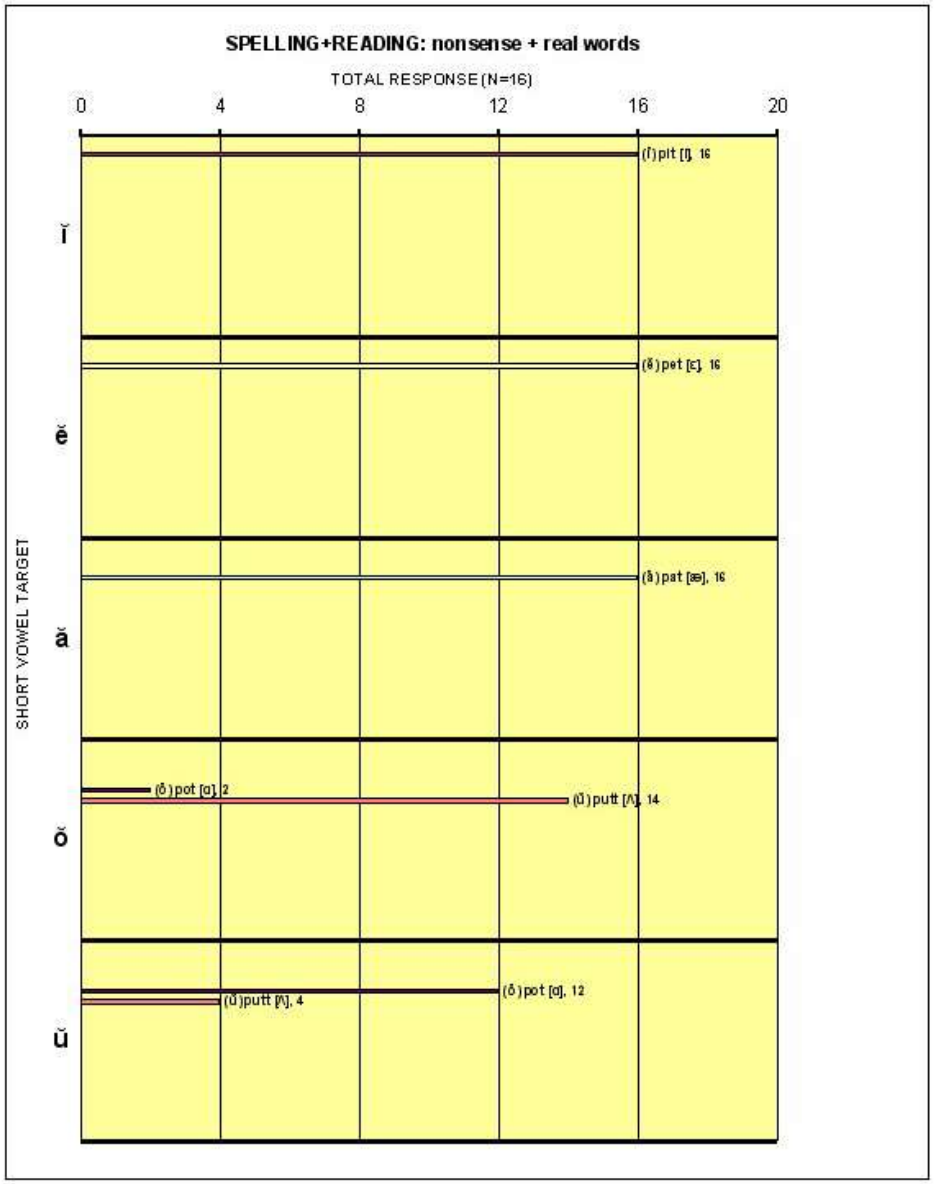
SPELL + READ n+r

b,d errors	b,d ratio	%b,d
	0/36	

P-O-S-E © DIAGNOSTIC SUMMARY

LNAME: Caulfield FNAME: Holden

I.D. 330101 DATE: 9/20/2009

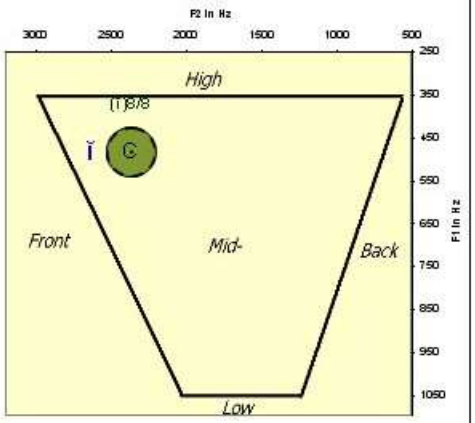


P-O-S-E © DIAGNOSTIC SUMMARY (ĭ)

LNAME: Caulfield FNAME: Holden

I.D. #: 330101 DATE: 9/20/2009

POSE: SPELLING
SHORT VOWEL IDENTITY / SUBSTITUTION PLACEMENT (ĭ)

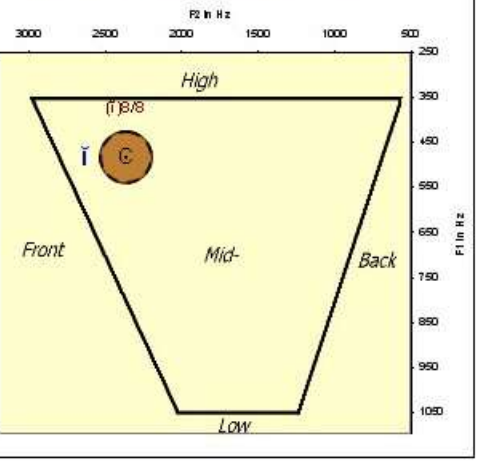


Mean Spelling Error Distance to Target	
0.00	Bark
Error Dispersion (SD) re Response Centroid	
0.00	Bark

Centroid	F1	F2
kHz	488	2365
Bark	4.77	14.13

OTHER ERRORS	
DIPHTHONGS	
ī	0
oi	0
ou	0
yōō	0
VOWEL OMITTED	
	0
OTHER	
	0

POSE READING
SHORT VOWEL IDENTITY / SUBSTITUTION PLACEMENT: (ĭ)



Mean Reading Error Distance to Target	
0.00	Bark
Error Dispersion (SD) re Response Centroid	
0.00	Bark

Centroid	F1	F2
kHz	488	2365
Bark	4.77	14.13

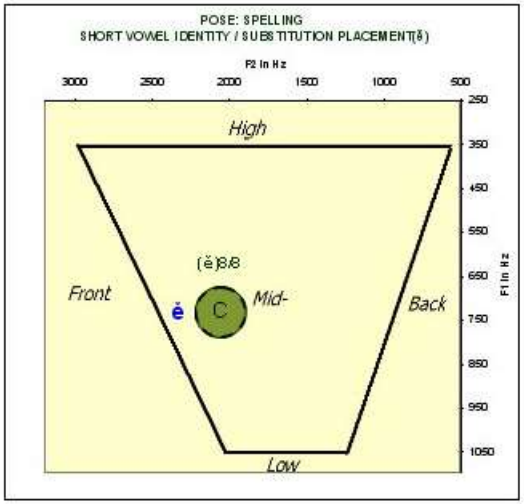
OTHER ERRORS	
DIPHTHONGS	
ī	0
oi	0
ou	0
yōō	0
VOWEL OMITTED	
	0
OTHER	
	0

P-O-S-E © DIAGNOSTIC SUMMARY (ĕ)

LNAME: Caulfield FNAME: Holden

I.D. #: 330101 DATE: 9/20/2009

POSE: SPELLING
SHORT VOWEL IDENTITY / SUBSTITUTION PLACEMENT(ĕ)

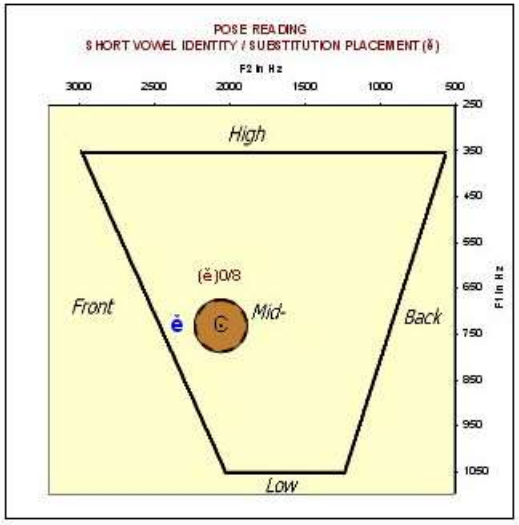


Mean Spelling Error Distance to Target	
0.00	Bark
Error Dispersion (SD) re Response Centroid	
0.00	Bark

Centroid	F1	F2
kHz	731	2058
Bark	6.75	13.20

OTHER ERRORS	
DIPHTHONGS	
ī	0
oi	0
ou	0
yōō	0
VOWEL OMITTED	
	0
OTHER	
	0

POSE READING
SHORT VOWEL IDENTITY / SUBSTITUTION PLACEMENT (ĕ)



Mean Reading Error Distance to Target	
0.00	Bark
Error Dispersion (SD) re Response Centroid	
0.00	Bark

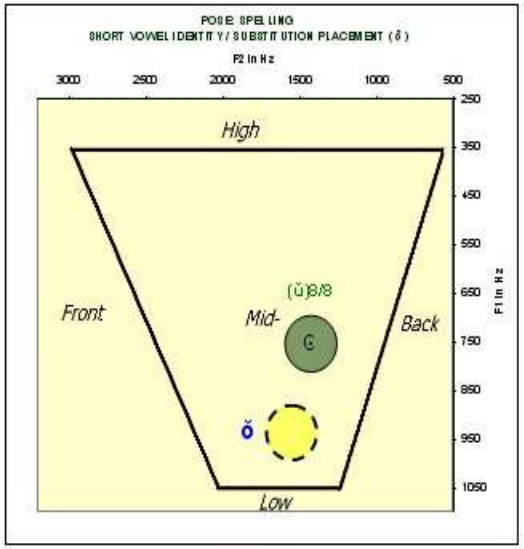
Centroid	F1	F2
kHz	731	2058
Bark	6.75	13.20

OTHER ERRORS	
DIPHTHONGS	
ī	0
oi	0
ou	0
yōō	0
VOWEL OMITTED	
	0
OTHER	
	0

P-O-S-E © DIAGNOSTIC SUMMARY (ŏ)

LNAME: Caulfield FNAME: Holden

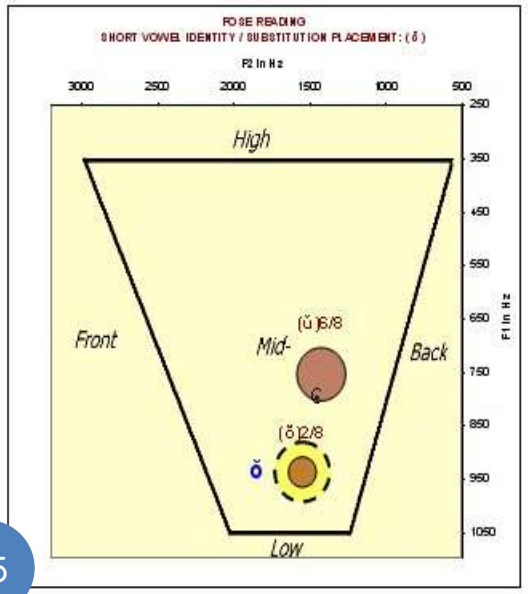
I.D. #: 330101 DATE: 9/20/2009



Mean Spelling Error Distance to Target	
1.34	Bark
Error Dispersion (SD) re Response Centroid	
0.11	Bark

Centroid	F1	F2
kHz	753	1426
Bark	6.91	10.76

OTHER ERRORS	
DIPHTHONGS	
ī	0
oi	0
ou	0
yōō	0
VOWEL OMITTED	0
OTHER	0



Mean Reading Error Distance to Target	
1.01	Bark
Error Dispersion (SD) re Response Centroid	
0.34	Bark

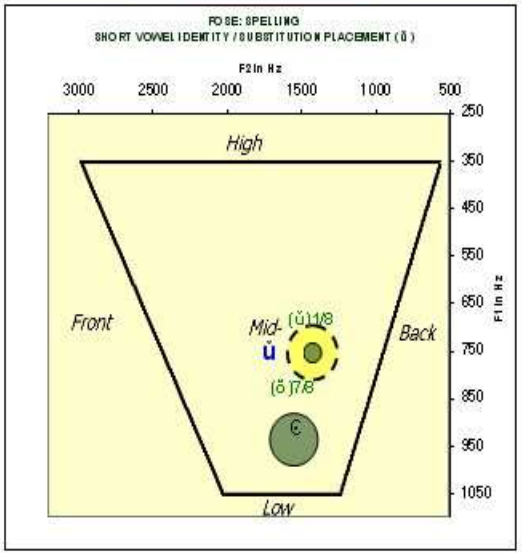
Centroid	F1	F2
kHz	797	1456
Bark	7.22	10.90

OTHER ERRORS	
DIPHTHONGS	
ī	0
oi	0
ou	0
yōō	0
VOWEL OMITTED	0
OTHER	0

P-O-S-E © DIAGNOSTIC SUMMARY (ŭ)

LNAME: Caulfield FNAME: Holden

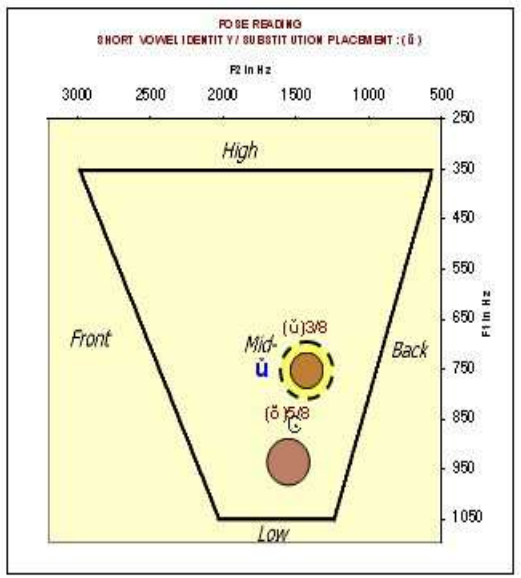
I.D. #: 330101 DATE: 9/20/2009



Mean Spelling Error Distance to Target	
1.18	Bark
Error Dispersion (SD) re Response Centroid	
0.31	Bark

Centroid	F1	F2
kHz	912	1535
Bark	7.98	11.24

OTHER ERRORS	
DIPHTHONGS	
ī	0
oi	0
ou	0
yōō	0
VOWEL OMITTED	0
OTHER	0



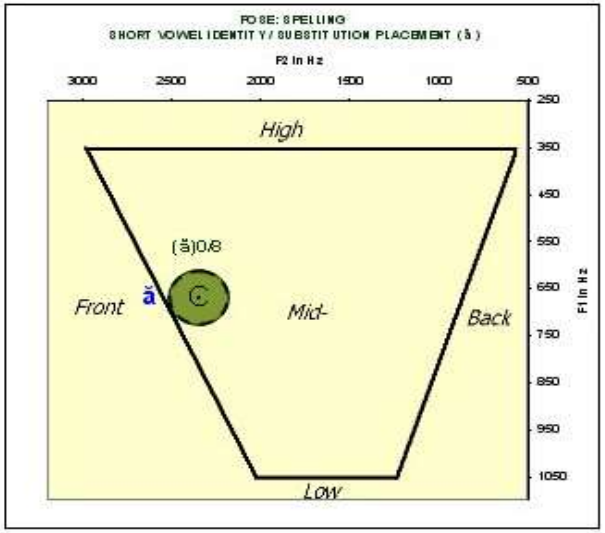
Mean Reading Error Distance to Target	
0.84	Bark
Error Dispersion (SD) re Response Centroid	
0.42	Bark

Centroid	F1	F2
kHz	865	1503
Bark	7.68	11.11

OTHER ERRORS	
DIPHTHONGS	
ī	0
oi	0
ou	0
yōō	0
VOWEL OMITTED	0
OTHER	0

P-O-S-E © DIAGNOSTIC SUMMARY (ă)

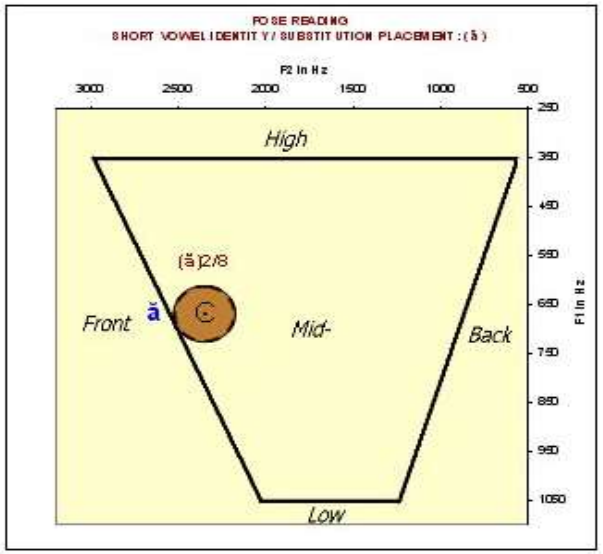
LNAME:	Caulfield	FNAME:	Holden
I.D. #:	330101	DATE:	9/20/2009



Mean Spelling Error Distance to Target	
0.00	Bark
Error Dispersion (SD) re Response Centroid	
0.00	Bark

Centroid	F1	F2
kHz	669	2349
Bark	6.29	14.09

OTHER ERRORS	
DIPHTHONGS	
ĭ	0
oi	0
ou	0
yōō	0
VOWEL OMITTED	
	0
OTHER	
	0



Mean Reading Error Distance to Target	
0.00	Bark
Error Dispersion (SD) re Response Centroid	
0.00	Bark

Centroid	F1	F2
kHz	669	2349
Bark	6.29	14.09

OTHER ERRORS	
DIPHTHONGS	
ĭ	0
oi	0
ou	0
yōō	0
VOWEL OMITTED	
	0
OTHER	
	0

Analyzing results

- Phonological rule patterns
  - Are there consistent vowel error patterns?
    - Phonological/Orthographic Displacement (POD)
    - Can range from an adjacent vowel on the vowel quadrangle to a remote vowel widely removed from the target location
    - Mirrored vowel means the same short vowel displacement is reflected on all responses

      If yes, provides information on phonological orthographic connection
    - If no, may indicate poor phonological development or other problems

POSE results

- Results are analyzed and sorted into a classification to determine remediation of vowel error patterns.

  Classification system:

  1. No or few errors
  2. Classroom
  3. Classroom with Support
  4. Team

- Results are the basis for formulating a remediation program.

Understand underlying concepts of vowel training

- Goal is to change **auditory** storage of error vowel to correct vowel
- Vowels are produced within the mouth-no visual cues
- Vowels have close phonological relationships-acoustic wave form
- Important to complete the auditory-articulatory loop
- Classroom conditions with noise can create difficult listening to differences

POST- Phonological Orthographical Substitution Therapy

- Remediation begins with vowel error patterns
- Select target phonemes based on items most frequently missed
- Are errors on reading, spelling or both tasks
- Set up phonemic input/ output matrix

Vowel Matrix

a	e

Vowel Matrix

a	e
o	u

CASE STUDIES

- John S
  - 11 years of age
  - 6th grade
  - Referred for an auditory processing evaluation due to poor reading scores and written language scores
  - An analysis of overall pattern of results indicate normal auditory processing skills except in the area of phonemic synthesis (17/25 correct- norm 21 correct on the Phonemic Synthesis tests)
  - IQ- 117 overall

John S

- Reading scores
  - Woodcock Test of Reading Mastery- 2.3 grade
  - WIAT 12th percentile
  - Spelling 12th percentile
  - Pseudo word decoding 12th percentile
  - Listening comprehension 99th percentile
- Classification- learning disabled
- Placed in self contained class in 7th grade

POSE results

Error patterns on 4 out of 5 vowels

- Flap for flop
- Yum for yam
- Han for hen

Error patterns on diagraphs

- Wis for wish
- Bliss for flesh
- S vs sh

John

- 14 months of phoneme remediation
- Results
  - Reading
    - Woodcock Reading Mastery-
    - Pre treatment grade 2.3
    - Post treatment grade 6.5
- Placed in collaborative class
- Following year, placed in regular class without support
- Declassified

Jane

- 14 years of age
- 9th grade
- IQ 110
- History of reading decoding and spelling problems

Jane

- Reading scores
  - Woodcock Test of Reading Mastery
    - Word identification 5.8 grade level
    - Word attack 5.8 grade level
    - Word comprehension 7.1 grade level

Jane

- One school year of remediation
- Results
  - Word identification 10.5 grade level
  - Word attack 12.3 grade level
  - Word comprehension 12.2 grade level

P-O-S-E and students with hearing impairment

Summary

- Audiologists have a role as a member of a literacy team since it has been shown that there is a "significant link between subcortical ***auditory*** function and reading."
- Audiologists often see children for auditory processing evaluations whose primary complaint is a weakness in reading decoding.
- Recommendations should include referral back to SLP for an analysis of phonology, reading and spelling.
- Phonology underpinning reading can be changed at any age