Phonetic and Phonological Systems Analysis (PPSA)

User Notes for English Systems

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"A fully comprehensive analysis is not required for every child. A systematic, principled analysis is, however, necessary in all cases since it forms an integral part of the clinical decision-making process."

Bates & Watson (2012, p 105)

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N.B. We recommend that the reader has a blank copy of the 3 page PPSA to follow as they go through this guide. This is also available as a free download (PPSA Charting and Summary Form) under the same creative commons license conditions.

N.B. The phonetic fonts throughout the guide and the PPSA Form are Doulos SIL

Phonetic and Phonological Systems Analysis (PPSA)

Introduction

As clinicians and lecturers in speech and language therapy, we are always looking for efficient ways of marshalling data to best effect. The PPSA is the latest version of a tool designed to aid a straightforward and linguistically principled organisation of phonetic transcription data. We have found this approach helpful in our own clinical practice with children with Developmental Speech Disorders and in student teaching. It has also been used by SLT/P colleagues on an informal word-of-mouth basis. Their encouragement has lead to our sprucing it up and making it more widely available as a free downloadable resource. (The conditions of use are described under the Creative Commons License – an explanation is given at the end of this document.)

There is nothing intrinsically innovative about individual elements of the design (except the inclusion of the vowel system element adapted from CAV-ES, our Clinical Assessment of Vowels-English Systems) - rather its usefulness derives from the way in which the elements are arranged to support an at-a-glance appreciation of the child's phonetic repertoire and developing phonological system at the time of assessment.

The system can be used to organise data from any phonetically transcribed speech sample, including one or more of the following:

- single sound production following modelling
- picture naming
- real word repetition
- non-word repetition
- spontaneous speech

The value of the PPSA as an aid to diagnosis and intervention planning will therefore depend on the clinician's principled selection of stimuli to test their hypotheses and their success in eliciting the speech sample required.

To get started, overleaf, we show a completed PPSA Charting and Summary Form for Child 1. There are four components. Three allow analysis of:

- Singleton consonants and word structure
- Consonant clusters
- Vowels

The fourth is an Error Pattern Summary (this is found on page 2 of the form below the consonant cluster section)

Following this, we go through each component in turn, explaining its use and power to deliver clinically useful information (p 8 to 24). We follow with an interpretation of the completed PPSA for Child 1 (p 25-26) and one other case study, Child 5 (p 27-34), The guide concludes with a summary of the advantages of the approach and some discussion of what the PPSA does not deliver. References and more detail about the license covering the use of the material are given in pages 37 -38.

Child 1 Completed PPSA

Phonetic and Phonological Systems Analysis-English Systems (PPSA). Target accent: SBS

Name: Child 1 Date/Age: /4:10 Data used: Picture naming

PI	Target	Correct Realisation			Errored Realisation			Deletion			Place	Manner
		WI	WM	WF	WI	WM	WF	WI	WM	WF		
p	p	111	11	111							Front→Back	Oral Stops/Plosives
b	b	1111	11	1								
t	t	1--1-	1	11	ddd							
d	d	1	11	11								
k	k	- - - - -		1-1--1	tdttt		???					
g	g			-1---			?d??					
m	m	1		11							Front→Back	Nasals
n	n	11		1111111								
ŋ	ŋ			1-11			n					
	f	- - - - - - - -	- - -	----	ppbpb bbp	ppp	???			11	Front→Back	Fricatives
	v	-	-		b	b						
	θ											
	ð		-									
s	s	- - -		-1--1-- 1-	ttt		????			11		
	z	-		--	d		?			1		
	ʃ	- - - - -	-	- - - -	tdttt	t	?			111		
	ʒ											
h	h	1-						1				
	ʧ	---	--		ttt	dt						Affricates
	ʤ	-		-	d		d					
w	w	1									Front→Back	Approximants
	ɹ	--			ww							
	l			-			u					
	j											
	ɹ										Rhotic	

Other Errors (eg sequencing errors, consonant harmony)
N/A

Phonetic and Phonological Systems Analysis-English Systems (PPSA). Target accent: SBS

Name: Child 1 Date/Age: /4;10 Data used: Picture naming

Clusters (ʳ applicable for rhotic accents)

Word Initial		Word Medial	Word Final	
pl- *p*	fl- *p*		-mp ✓	-ks
pɹ- *pp*	fɹ-		-nt -n*t*	-gz
bl- *b*	θɹ- *d*		-nd	-pt
bɹ- *b*	sp- *bp*		-ŋk	-bd
tw-	sm- *m*		-ft	-kt -*t*
tɹ- *t*	sw- *w*		-sp	-pʳ
dw-	st- *t*		-st	-bʳ
dɹ- *d*	sn- *n*		-sk	-dʳ
kw-	sl- *d*		-lp	-ntsʳ
kl- *t*	sk-		-lt	-mʳ
kɹ- *t*	spl-		-lk	-vz -*b*
gl- *d*	spɹ-		-ps	
gɹ-	stɹ-		-bz	
	skw-		-ts	
	skɹ-		-dz	

Error Pattern Summary (shading denotes atypical error patterns)

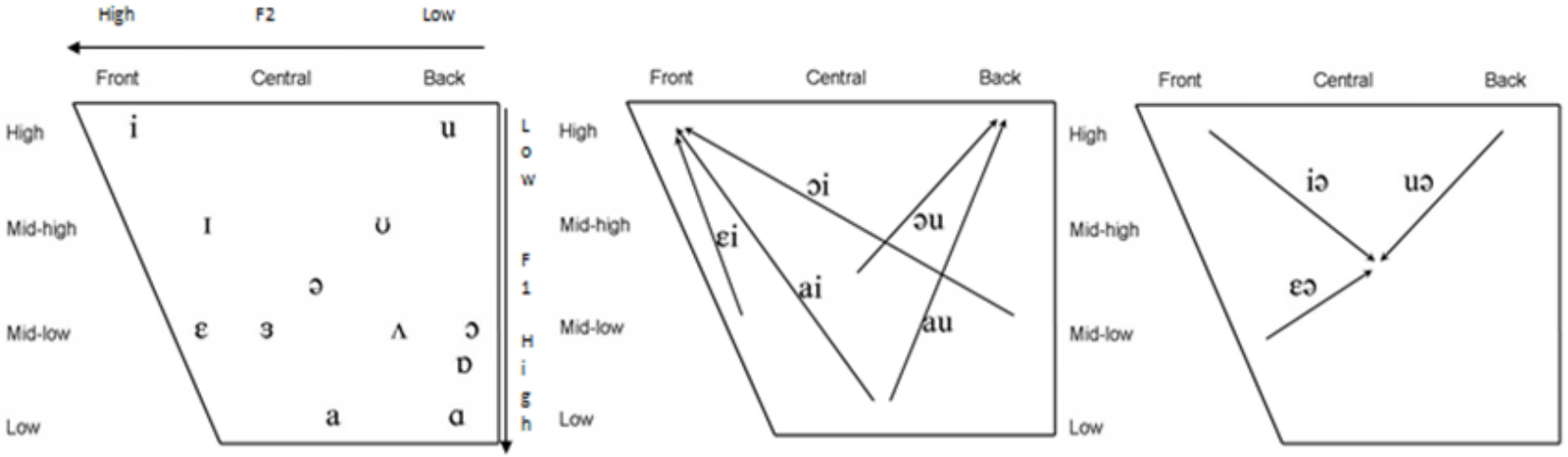
Structural	(✓)	Segmental	(✓)	Phonetic/Other	(✓)
Reduplication		Pre-vocalic voicing	✓	Dentalisation	
Weak syllable deletion		Post-vocalic devoicing		Lateralisation	
Final C deletion	✓	Velar fronting	✓	Palatalisation	
Initial C deletion		Alveolar backing		Ingressive air stream	
h-deletion	✓	Palatal fronting		Nasal emission	
Consonant insertion		Stopping of fricatives	✓	Clicks	
Vowel insertion (epenthesis)		Gliding of fricatives			
Cluster reduction	✓	Stopping of affricates	✓		
Coalescence		Deaffrication		**Other**	
Diphthong reduction		Gliding of liquids	✓	Fricative simplification	
Diphthongisation		Glottal replacement		l-vocalisation	✓
Linearisation of features		Excessive glottal replacement		/ɹ/ → [ʊ]	
Word level errors		Systematic sound preference		**Variability / Further ax required?**	**(✓)**
Consonant harmony		Vowel lowering		Progressive variability	✓
Transposition (metathesis)		Vowel raising		Context-conditioning	
Sequencing errors		Vowel fronting		Inconsistent production of same lexical items	
		Vowel backing		Multi-lingual influence	

Phonetic and Phonological Systems Analysis-English Systems (PPSA).

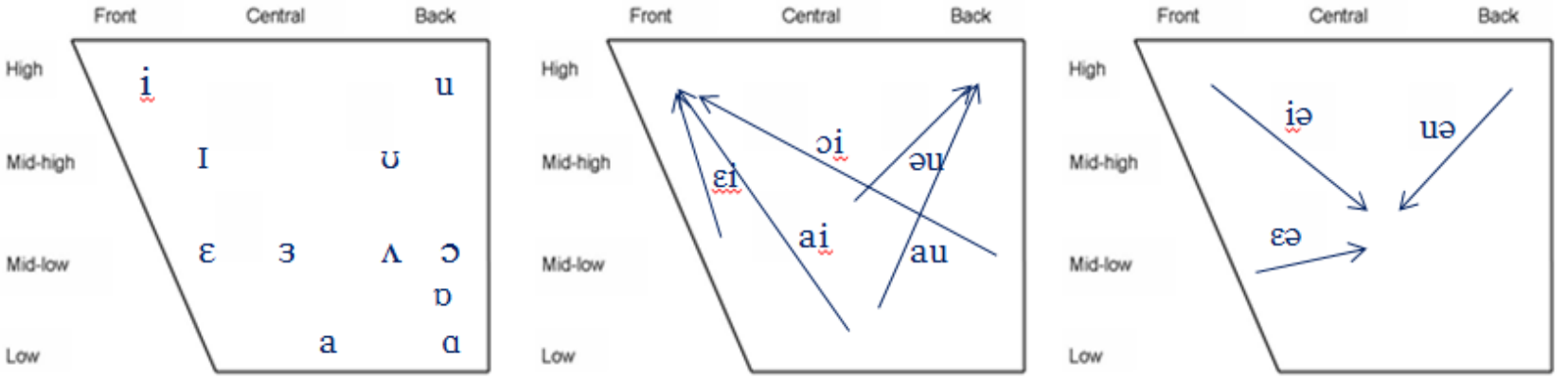
Name: Child 1 Date/Age: / 4;10 Data used: Picture naming

CAV- ES: Vowel Quadrilaterals Monophthongs and Diphthongs: Southern British Standard

Name:	CA:	Date:	SLT/P:



Complete the blank quads by first noting the vowels that are present in the system. Place any vowels produced in error in brackets beside the vowels used in their place.



Using the PPSA (Page 1)

Singleton Consonants and Word Structure

Providing a sufficiently representative data set is available, charting singleton consonant data on this form gives an at-a-glance summary of the speaker's phonetic inventory as well as their repertoire of contrastive phonemes at each word position. The data is systematically organised according to manner, place and voicing categories so that error patterns are easily identifiable. Variability and any gaps in the data are also clearly evident, guiding further investigation. The **Deletion** column captures errors in word structure. Further tips on the use of each section, including rationale and clinical notes, are provided below.

Phonetic Inventory (PI)

This column is used to note if the child is capable of making the sounds in the target phonetic inventory. The evidence can come from hearing the child use the sounds in one or more words as noted in *either* the **Correct Realisation** or **Errored Realisation** columns or by eliciting the sounds in isolation. N.B. it is worth checking the **Errored Realisation** columns because an inventory sound can sometimes be used in place of another target phoneme. For instance, a child may stop target alveolar fricatives pronouncing, for example, /sʌn/ as [tʌn], but nevertheless use [s] to realise the post-alveolar fricative /ʃ/, pronouncing, for example, 'sheet' /ʃit/ as [sit]. In this case, 's' would be noted in the **PI** column – even though it is not used to realise target /s/. While the production reflects an error, it shows that the child is capable of physically articulating [s].

It is for the clinician to set the criteria for inclusion of a sound within the phonetic inventory, for example, whether this is one, two or more occurrences within the speech sample. Sounds absent from the sample, either because the child has failed to produce them or because they have not been tested, can be elicited through modelling, with or without additional cues to see if they are stimulable.

Target

This column lists the target consonant phonemes in the adult system and reflects the inventory for Southern British Standard (SBS) English. We also include a separate final row for rhotic 'r' to assist clinicians working with rhotic accent systems such as Scottish and Northern Irish. Rhotic

speakers pronounce ‘r’ when it occurs following a vowel in words such as ‘car’ /kaɹ/ and ‘card’ /kaɹd/. Thus, in Scottish, for example, the inclusion of /ɹ/ following the vowel distinguishes between words such as ‘bid’ /bɪd/ and ‘bird’ /bɪɹd/. In Southern British Standard English the distinction rests on a difference in vowel quality alone /bɪd/ v /bɜd/. Note that we use the same symbol /ɹ/ for both rhotic and non-rhotic ‘r’ in the **Target** column, in accordance with the phonemic approach taken throughout the PPSA (see discussion below).

Where sounds are not permissible in certain word positions in English, a line is drawn through the cell: /ŋ, ʒ/ and rhotic ‘r’ word-initially and /h, w, j/ and non-rhotic ‘r’ word-finally.

Consonants are grouped according to the three key phonetic distinctions:

- **Manner** of articulation (each natural class is bounded by double lines and labelled in the final column)
- **Place** of articulation (ordered from most front to most back within each manner group – see penultimate column)
- **Voicing** (the rows for voiced sounds are shaded)

So, to illustrate - the first manner grouping is oral stops (or plosives). These are ordered according to place of articulation, progressing from bilabial (/p-b/), to alveolar (/t-d/), to velar (/k-g/). In each pair, the voiceless member is listed first.

Note that we have restricted the inventory to phonemes, i.e., those sounds that function contrastively within the system. We do not include phonetic variants, i.e., sounds that arise through principled variation which does not impinge on signalling meaning distinctions and hence intelligibility. These include:

Allophonic variation - where for example the speaker might use clear [l] or dark [ɬ], an allophonic variation conditioned by word position whereby clear [l] occurs word-initially or before a vowel and dark [ɬ] occurs word-finally or before a consonant.

Stylistic variation - where, for example, a child may use the glottal stop [ʔ] instead of /p, t, k/ as in 'butter' pronounced as [bʌʔə] in fast or casual speech but [bʌtə] in slower and/or more formal speech.

Lexical variation - where for example a Scottish child may use the labio-velar fricative [ʍ] to render orthographic 'w' in 'wh-words' such as 'where' and 'why' and the voiced velar approximant [w] elsewhere.

Accent variation - where children may use a particular phonetic variant of a phoneme, such as, for example, [ɹ, ʋ, ɾ] or [r] to render 'r', depending on the target accent. (N.B. we use the symbol /ɹ/, the alveolar approximant typically found in SBS, to denote any 'r'-like phoneme.)

Clinical Note

In view of this, in any one case, a judgement will need to be made about whether or not the child's responses reflect acceptable and principled variation (as outlined above) or immature or unusual pronunciation warranting intervention. For example, glottal replacement can be:

- a feature of fast or casual speech
- a feature of accents such as Estuary English
- a feature of very early typical development
- an intermediate progressive stage in the resolution of final consonant deletion within delayed systems
- when used excessively, a 'red flag' for phonological disorder

Correct Realisation

This section is subdivided into three columns indicating the position of the sound in the target word – **WI** (Word Initial), **WM** (Word Medial) and **WF** (Word Final). This three-way distinction usefully captures most patterns of breakdown that are influenced by word position and neatly sidesteps the theoretical debate concerning syllable boundary placement (see also the section on Consonant Clusters). However, a finer-grained analysis distinguishing between word-medial syllable-initial and word-medial syllable-final consonants may be warranted in more severe/complex cases.

WI refers to any singleton consonant which is the first sound pronounced in a word, for example, /t/ in 'tap'. The /t/ in 'trap' is the start of a WI cluster and is charted in section 2 (page 2).

WM refers to any singleton consonant which is not either the first or last sound in the word, for example, the /t/ in 'patty' /pati/, 'potato' /pətɛitəu/ and 'attack' /ətak/. Note that any sequence of consonants that occurs between two vowels, even where syllable boundaries are crossed, for example, 'umbrella' /ʌmbɹɛlə / or 'postman' /pəustman/, is treated as a WM cluster. In non-rhotic accent systems like SBS, the /t/ in 'party'/pɑti/ is a WM singleton but in rhotic accents such as Scottish, it would be treated as part of a WM consonant cluster /ɹt/ (/paɹti/) in the same way as, for example, /nt/ in 'lentil' /lɛntəl/.

WF refers to any singleton consonant which is the last sound in the word, for example, the /t/ in 'pat' /pat/ and 'plate' /plɛit/. The /t/ in 'past' /pɑst/ and 'paint' /pɛint/ would be charted as part of a WF cluster, /-st/ and /-nt/ respectively. Note that the PPSA treats final consonants such as /l/ in 'table' /tɛibəl/ and /n/ in 'button' /bʌtən/ which are often syllabified and hence transcribed as [tɛibl̩] and [bʌtn̩], as WF singletons and not WF clusters. This reflects the target phonemic representation.

Here is an example to show how we chart *singleton* consonant information. The target word is 'pip' /pɪp/, the child's pronunciation is [pɪp].

PI	Target	Correct Realisation			Errored Realisation			Deletion			Place	Manner
		WI	WM	WF	WI	WM	WF	WI	WM	WF		
p	p	1		1							Front	Oral
	b											

As /p/ is realised correctly both WI and WF, this is indicated by a 1 in both columns. (The numeral takes up less space than a tick and allows the clinician to keep a tally where there is more than one example.) We also note p (or a tick) in the PI column to indicate that [p] is part of the child's phonetic inventory.

Errored Realisation and Deletion

As in the case of **Correct Realisation** these components are divided into **WI, WM** and **WF** columns. The following data illustrates how we use these columns: The target word is 'pip' /pɪp/ - the child's pronunciation is [ɪb]

PI	Target	Correct Realisation			Errored Realisation			Deletion			Place	Manner
		WI	WM	WF	WI	WM	WF	WI	WM	WF		
	p	-		-			b	l			Front	Oral
b	b											

Here the first /p/ has been deleted. This is indicated by putting a dash (–) in the **WI Correct Realisation** column to indicate that the child has had an opportunity to say 'p' WI but has not achieved correct production. The deletion is then marked as a 1 in the **WI Deletion** column. The WF 'p' target has been pronounced as [b]. Again a dash is placed in the **WF Correct Realisation** column to indicate a failed attempt and the actual errored pronunciation is also charted in the **WF Errored Realisation** column. 'b' is charted in the **PI** column to indicate that this sound is within the child's phonetic inventory.

Note, while the use of a dash in the **Correct Realisation** columns to indicate a failed attempt may seem somewhat superfluous, in practice we find it very useful. Scanning the completed **Correct Realisation** columns gives an overall idea of the child's phonological strengths and weaknesses. It also clearly signals how many times sounds have been tested in a particular word position and the extent of any variability in realisation without the need to scan across all 9 columns. Potential areas for further testing where more data is required are clearly highlighted. Comparison of the two examples below charting the same data, respectively with and without the dashes, illustrates the usefulness of this notation. N.B. This notation also facilitates calculation of percent consonant correct (PCC) scores: (1) add up the tally marks (i.e., 1) in the first three columns to give the total number of correct tokens, (2) add up the dashes in the first three columns and add this to the number of correct realisations to give the total number of tokens sampled, (3) divide the number of correct tokens by the total number of tokens sampled and multiply by a 100 to give the PCC score.

PI	Target	Correct Realisation			Errored Realisation			Deletion			Place	Manne
		WI	WM	WF	WI	WM	WF	WI	WM	WF		
p	p	-l- - l		- - -	b		bbb	11			Place: Front→Back	Oral Stops/Plosives
b	b			11								
t	t			-			d					
d	d											
	k			- -			dd					
	g	-			t							

PI	Target	Correct Realisation			Errored Realisation			Deletion			Place	Manne
		WI	WM	WF	WI	WM	WF	WI	WM	WF		
p	p	11			b		bbb	11			Place: Front→Back	Oral Stops/Plosives
b	b			11								
t	t						d					
d	d											
	k						dd					
	g				t							

Below, we now chart a small speech sample to demonstrate the information which can be gained from this approach. For brevity we focus on the class of oral stops.

Target Word	**Adult Target / /**	**Child's pronunciation [ ]**
pip	pɪp	bɪp
dog	dɒg	dɒt
cat	kat	dat
bird	bɜd	bɜt
bed	bɛd	bɛt
boat	bəut	bəut
bat	bat	bat
pocket	pɒkɪt	pɒtɪt
cake	kɛik	gɛik
cap	kap	dap

PI	Target	Correct Realisation			Errored Realisation			Deletion			Place	Mann
		WI	WM	WF	WI	WM	WF	WI	WM	WF		
p	p	-1		11	b						Place: Front→Back	Oral Stops/Plosives
b	b	111										
t	t			1111								
d	d	1		-			t					
k	k	- - -	-	1	dgd	t						
g	g			-1			t					

Scanning the charted data immediately reveals the following take home points:

(1) There is no evidence of problems with word structure

(2) All 6 plosives are in the child's phonetic inventory

(3) There is some evidence of context-sensitive voicing

- /p/ → [b] word-initially
- /d/ → [t] word finally

and of an interaction between velar fronting and context-sensitive voicing:

- /k/ → [d] word-initially and /g/ → [t] word-finally

(4) There is some evidence to suggest that velar fronting may be resolving

- There is one correct token of /k/ WF
- There is one example of /k/ pronounced as the voiced velar [g] WI (also evidence of pre-vocalic voicing.)

(5) More data is needed to confirm the nature and extent of the error patterns:

- There are no examples of /b/ WF or /t/ and /g/ WI
- There are only single examples of /d/ WI and /k/ WF

Clinical Note

As demonstrated, one of the main advantages of the PPSA is that it clearly highlights variability in the system and also where further data collection is necessary in order for the clinician to feel confident in their understanding of the child's phonological strengths and weaknesses.

Crucially, enough data needs to be available to show variability in the first place and then sufficient to tease out which of the following factors, operating alone or in combination, might be causative:

- Phonological processes moving towards resolution, reflecting:
  - Facilitative or constraining effects of word position (e.g., as indicated above, the acquisition of velars in WF before WI or WM position)
  - Lexical conditioning (i.e., correct production for later acquired words / non-words reflecting good online processing skills as opposed to persisting earlier forms reflecting inaccurate representations that require updating) (see Stackhouse & Wells, 1997)
  - Context-conditioning (i.e., facilitative or constraining effect of vowel context) (see Bates, Watson & Scobbie, 2013)
- Word level error patterns such as Consonant Harmony
- Inconsistent production (often reflecting articulatory timing and co-ordination difficulties)
- Errors in transcription

For these reasons, a minimum of 5 tokens of the phonemes of interest in WI and WF position (and, ideally, particularly with older children, also in WM position) is recommended. (See **Child 5 Interpretation** (page 27) for further examples and discussion.) (See also the Child Speech Disorder Research Network's (CSDRN) *Good Practice Guidelines for Transcription of Children's Speech Samples in Clinical Practice and Research* for further guidance on sampling.)

Other Errors

We leave a space below the main singleton chart for noting those errors that cannot be readily described in terms of substitutions or deletions. These include error patterns such as:

- Consonant insertions, eg /apəl/ → [napəl], /ɛg/ → [jɛg]
- Vowel insertions, eg /glʌv/ → [gəlʌvˌ], /dwɔf/ → [dəwɔf]
- Sequencing errors, eg /paɹət/ → [taɹəp], /ʌmbɹɛlə/ → [bʌmɹɛlə]
- Linearisation of phonetic features, eg /fɛns/→ [psains], /fit/ →[swit]
- Coalescence of phonetic features, eg /klaun/ → [klam], /pʌɹpəl/ → [popəl]

Sequencing errors are typically associated with difficulty in the timing and co-ordination of articulatory gestures. Depending on the extent to which these occur in a speech sample, further

assessment of the child's ability to produce the *same* words consistently across three separate repetitions may be warranted (Dodd, Hua, Crosbie, Holm and Ozanne, 2006).

Consonant Harmony (CH) is another word-level error pattern which, ideally, should also be noted separately. However, in practice, instances of CH are often mistakenly described in process terms. We explore the implications of this in our discussion of Child 5.

Using the PPSA (Page 2)

Consonant Clusters

This section lists common consonant clusters found word-initially and word-finally in English. Space is left for clinicians to note word-medial clusters (see discussion below). As far as possible, clusters are ordered in a principled way to reflect shared manner, place and voicing features (see **WI Clusters** below). Clusters realised correctly are marked with a tick beside the target. (We use a tick here rather than a 'I' as this latter can sometimes be confused with an /l/ phoneme in this context.) Where clusters are realised incorrectly, the errored production is written alongside the target. The following data set illustrates the procedure:

Target	**Target / /**	**Child [ ]**
play	plɛi	plɛi
pram	pɹam	pam
spot	spɒt	bɒt
pesky	pɛski	pɛti
milk	mɪlk	mɪlt
slept	slɛpt	slɛp

Word Initial		Word Medial	Word Final	
pl- ✓	fl-	-sk- *t*	-mp	-ks
pɹ- *p*	fɹ-		-nt	-gz
bl-	θɹ-		-nd	-pt *p*
bɹ-	sp- *b*		-ŋk	-bd
tw-	sm-		-ft	-kt
tɹ-	sw-		-sp	-lk *lt*

Charting data in this way clearly reveals the nature and extent of any consonant cluster reduction and also any interaction of cluster reduction with processes such as velar fronting as, for example, in the case of 'skip' /skɪp/ produced as [dɪp] or [tɪp].

WI Clusters

The PPSA's WI list is fairly comprehensive due to the fact that English phonotactic rules constrain the number and type of elements that can be found in a cluster. Word-initially either 2 or 3 consonants are permitted and the particular combination of phonemes is also limited.

Two element clusters are either:

- Oral stops + subset of approximants depending on the place of articulation of the stop: /pl, pɹ, bl, bɹ, tw, tɹ, dw, dɹ, kw, kl, kɹ, gw, gl, gɹ/ and /pj, tj, kj/ as in 'pure', 'tune' and 'cute'
- Fricatives /f/ or /θ/ + /l/ or /ɹ/ ie /fl, fɹ, θɹ/
- /s/ + stops, nasals and approximants , ie /sp, st, sk, sm, sn, sw, sl/

Three element clusters all begin with /s/ and end in /l/ or /ɹ/, ie /spl, spɹ, stɹ, skl, skɹ/. Note that each of these sets may be expanded through inclusion of other clusters found in proper nouns, loan words, onomatopoeic words and 'slang'. For example, /gw/ occurs in Gwendolin, /vl/ in Vladimir, /vɹ/ in vroom, /sɹ/ or /ʃɹ/ in Sri Lanka and /sf/ in sphere. While these are relatively isolated instances, we do leave space for the clinician to add other target clusters of this kind that may occur in their data sample.

Clinical Note

- Cluster reduction typically involves the omission of the second element in /l, ɹ/ clusters and the first element in /s/ clusters. Clinicians will be aware, however, that this is not always the case.
- If a speaker realises a singleton as a sequence of two or more consonants, for example, /f/→ [ps] as in 'fence' /fɛns/ pronounced as [psɛns], this should be noted under **Other Errors** in the

singleton section. This type of pattern is best described as a linearization of phonetic features. The labiality and frication which are combined in a single time slot in /f/ are represented as a linear sequence of a bilabial plosive ([p]) followed by an alveolar fricative ([s]).

- Note that when the initial /s/ is omitted in /s/-stop-cluster reduction, the second voiceless stop element is typically perceived as a voiced stop, reflecting the fact that /p, t, k/ are unaspirated in this context and hence phonetically more similar to their voiced counterparts /b, d, g/. (However, we retain /p/ for the target /sp/, as [b] is still a variant form of the voiceless phoneme.) So in terms of assessment, the production of, for example, [bɒt] for /spɒt/ and [gɪp] for /skɪp/ are examples of cluster reduction alone and not cluster reduction and voicing. Similarly, /skɪp/ produced as [dɪp] reflects a combination of cluster reduction and velar fronting and not cluster reduction, velar fronting and voicing. Where a child produces [pɒt] for 'spot' or [kɪp] (or [tɪp]) for 'skip', this can be interpreted as an encouraging sign of progression towards achieving the target cluster. In producing an aspirated [p], the child is arguably trying to capture the percept of frication characteristic of the initial /s/. The error pattern might therefore be seen as a fusion (ie coalescence) of phonetic features associated with both /s/ (frication) and /p/ (labilality and stop).

WM Clusters

The PPSA takes a reductionist approach to clusters. As stated earlier, we define word-medial clusters as any sequence of consonants that occurs between two vowels. This means that the PPSA does not distinguish between 'true' WM clusters such as /-st-/ in 'bli<u>st</u>er' /blɪstə/ and abutting consonants such as /-st-/ in 'mistake' /mɪstɛik/ which span syllable and/or morpheme boundaries. Thus, for example, while the sequence /-mbɹ-/ in 'u<u>mbr</u>ella' /ʌmbɹɛlə / is most accurately described as a word-medial, syllable-final singleton (-m-) followed by a word-medial, syllable-initial cluster

(-bɹ-), here it is charted as a single WM cluster. We feel the PPSA approach strikes a useful balance between information gain and analytical effort. Identification of word-internal syllable boundaries is by no means a straightforward exercise, particularly given the differing theoretical stances in the literature and the variation that occurs among individual speakers. It may be that further sub-classification of word-medial sequences as either syllable-initial or syllable-final singletons and clusters could provide useful additional information in a particular case but this is not immediately supported by the PPSA form.

WM consonant *sequences* are, of course, not subject to the same phonotactic constraints as true clusters. This makes it difficult if not impossible to list even the most common or likely sequences. For this reason, the WM cluster section of the chart contains blank rows for the clinician to complete according to the particular sequences found in their data sample.

WF Clusters

The PPSA defines WF clusters as any sequence of consonants that occurs between a vowel and the end of the word as, for example, in 'hand' /hand/, 'milk' /mɪlk/ and 'stamp' /stamp/. Note this includes sequences which span a morpheme boundary as in the following examples: 'cats' /kats/, 'paints' /pɛints/, 'locks' /lɒks/, 'posts' /pəusts/, 'Beth's' /bɛθs/, 'Fred's' /fɹɛdz/, talked /tɔkt/, 'grabbed' /gɹabd/. Although, in English, word final consonant sequences of four and up to five consonants are permitted, for example: 'glimpsed' /glɪmpst/, 'sixths' /sɪksθs/and 'angsts' /aŋksts/, these are rare, even in adult speech.

The PPSA lists a selection of commonly occurring WF clusters. However, as for WI clusters, there are blank rows for clinicians to note any additional WF clusters found in their own data set.

Using the PPSA (Page 3)

Vowels

In our experience, the majority of vowel error patterns found in children with phonological impairment involve systematic substitutions of one vowel for another, e.g., [a] used in place of /ɛ/, rather than random phonetic 'distortions'. Our approach to charting vowel errors, therefore, rests on highlighting where vowel contrasts are reduced rather than trying to capture variations in precise phonetic quality. To provide an at-a-glance system summary we recommend that transcription data is charted onto vowel quadrilaterals, the approach we use in CAV-ES (Clinical Assessment of Vowels-English Systems). This has the advantage of:

- pinpointing missing vowel contrasts
- capturing (phonemic) variation in the realisation of individual vowels
- relating patterns of error to vowel articulatory and acoustic characteristics

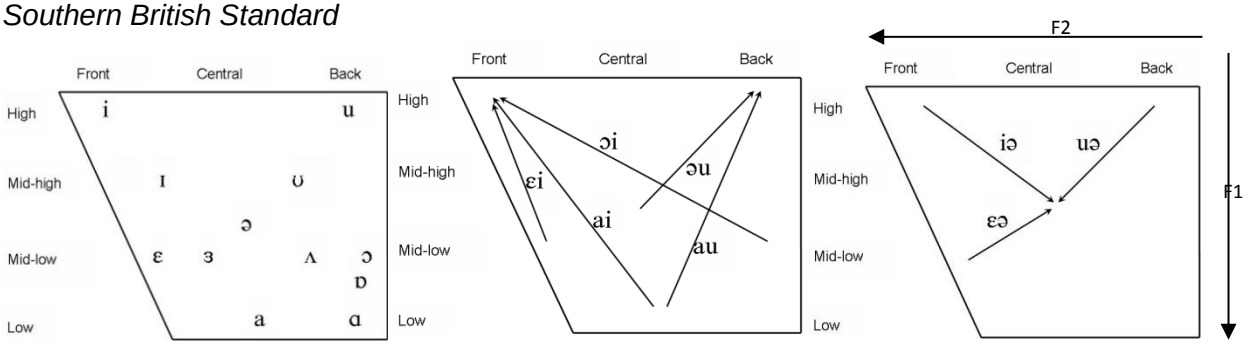
This mapping between vowel symbols and their *relative* articulatory and acoustic properties is supported by:

- the phonemic classificatory labels: Front , Central and Back and High, Mid-High, Mid-Low and Low to indicate the relative position of the tongue body during articulation
- arrows denoting first (F1) and second formant (F2) values. F1 is inversely related to vowel height while F2 reflects tongue front-backness and/or lip-rounding.

To explain the charting procedure, we now show completed quadrilaterals for three children presenting with phonological delay/disorder. Each child was referred for vowel difficulties as well as consonant problems and was assessed using CAV-ES. (N.B. The CAV-ES resource will also soon be free to download. It provides a user guide, pictorial stimuli and a comprehensive analysis framework for a range of different English vowel systems. The guide also includes a more comprehensive account of vowel error patterns than we provide here plus a theoretical rationale for the phonemic approach taken.)

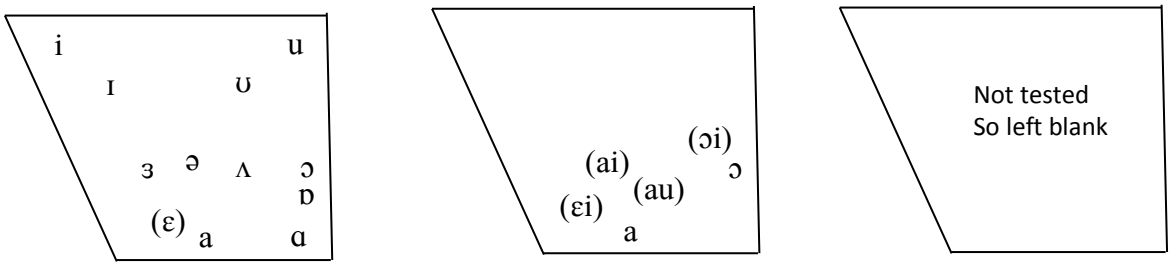
Child 2 has a target accent of Southern British Standard (SBS). As with all three cases described here, we preface the child's system with a schematic (phonemic) representation of vowels for the target accent to assist interpretation.

CAV-ES: Vowel Quadrilaterals, Monophthongs and Diphthongs
Southern British Standard



Monophthongs | Up-swinging Diphthongs | In-swinging diphthongs

Child 2's System



Charting the data immediately reveals two areas of difficulty:

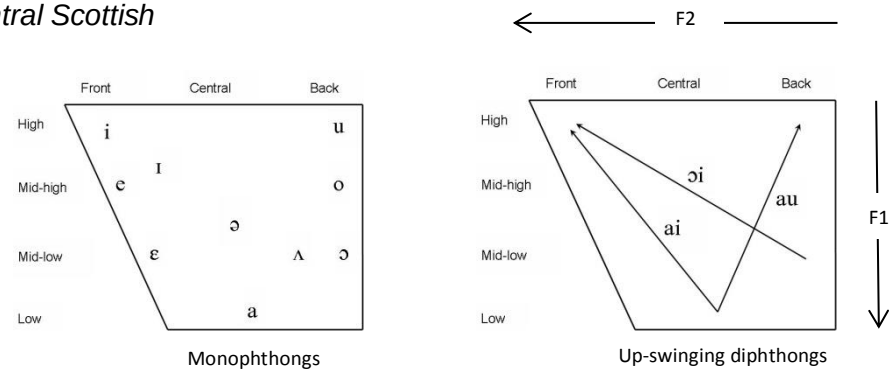
(1) The mid-low front vowel /ɛ/ is consistently pronounced as the low central vowel [a]. This error pattern is conventionally interpreted as a process of vowel lowering and is indicated on the monophthong quadrilateral by placing the symbol for 'ɛ' in ( ) brackets beside the one for 'a'. The position normally occupied by /ɛ/ is left blank to indicate that /ɛ/ is absent from the child's system.

(2) Up-swinging diphthongs are consistently reduced to their first element. (Note the first element in /ɛi/ is also lowered to [a].) This error pattern is conventionally described as a process of diphthong reduction and is signalled by placing the symbol for each diphthong affected beside the monophthong symbol used in their place. The diphthong movement

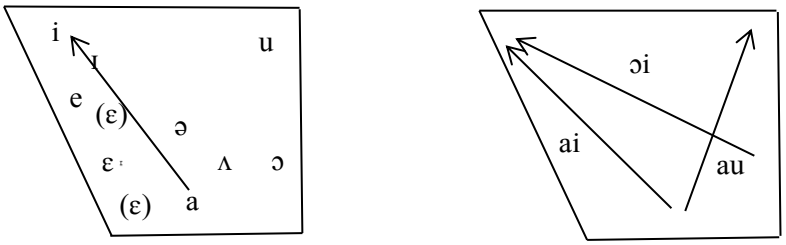
arrows are also omitted. As /əu/ and the in-swinging diphthongs have not yet been tested, these positions have been left blank.

Child 3 has a target accent of Central Scottish Standard. This is a rhotic accent system which has fewer monophthongs and diphthongs than SBS. (See CAV-ES for a more detailed comparison.)

CAV-ES: Vowel Quadrilaterals, Monophthongs and Diphthongs
Central Scottish



Child 3's System



Child 3 shows one area of difficulty - also a problem with /ɛ/. In this case, though, the data sample reveals variable treatment:

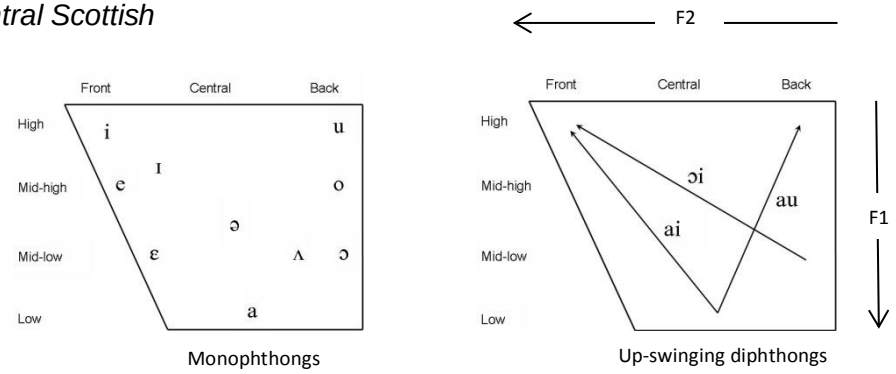
- correct pronunciation
- lowering to [a]
- diphthongisation to [ai]

Correct realisation of /ɛ/ and hence presence of this vowel within the child's system, is indicated by marking /ɛ/ in its target position on the quadrilateral. Lowering of /ɛ/ to [a] is indicated, as before, by placing the symbol for 'ɛ ' in brackets alongside the symbol for 'a'. Diphthongisation, i.e., realisation

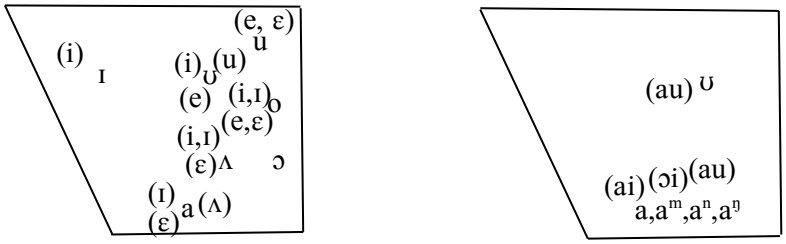
of /ɛ/ as [ai], is indicated by placing the symbol for 'ɛ' in brackets alongside an upswinging arrow indicating diphthongal movement from [a] to [i] .

Child 4 also has a Central Scottish Standard target system.

CAV-ES: Vowel Quadrilaterals, Monophthongs and Diphthongs
Central Scottish



Child 5's System



This child had a 68% overall vowel error score and was highly unintelligible. Although the system is severely compromised, charting the data nevertheless reveals systematic trends:

1. There is evidence of widespread 'backing' of front vowels
2. There is a great deal of variability with regard to the 'height' of the vowel used to replace the target
3. /ɛ/, /ʌ/ and /ɪ/ are lowered to [a]
4. The inventory includes [ʊ], a non-system vowel in Scottish
5. Diphthongs are typically reduced to the first element with the off-glide sometimes being replaced by a nasal

Clinical Note

Vowel error patterns in children acquiring English systems most commonly involve one or more vowels in the mid-low series. This is reflective of typical development and is perhaps hardly

surprising given the crowded nature of the vowel space in this region – arguably, auditory discrimination and articulatory positioning need to be particularly acute to perceive and execute the contrasts. It is more unusual for the corner vowels /i/, /u/, /a/ and /ɑ/ to be problematic. In the case above, the child has no high front vowel /i/ to anchor this corner of the system and, on occasions, the high back vowel /u/ is also compromised – a pattern suggesting disorder. The child's attempts at producing target vowels is, though, clearly not random and by carefully charting data on the quadrilaterals, principled therapy targets are immediately apparent.

Using the PPSA (Page 2) Error Pattern Summary

The fourth component of the PPSA is a table listing the most common natural phonological processes and atypical speech patterns found in children with Developmental Speech Disorders. These are grouped according to whether they are:

- **Structural**
- **Segmental**
- **Word-level error patterns**
- **Phonetic/Other error patterns**

The clinician can record which processes/ patterns are evident in the data by simply placing a tick in the box alongside the relevant heading. Atypical patterns, generally considered indicative of a phonological disorder (as opposed to phonological delay), are shaded.

Word level errors include patterns such as Consonant Harmony (CH), metathesis and sequencing errors. As the name implies, CH is an assimilatory process in which one consonant in a word changes its place or manner of articulation or voicing feature to that of another consonant within the same word, for example, /dɒg/ pronounced as [gɒg]. Realisation of /d/ as [g] in this case should not be confused with alveolar backing which is a systemic (or 'system-wide') process. Metathesis and other sequencing errors also reflect problems producing individual words rather than system-wide processes/patterns. These arguably reflect online difficulties with the timing and co-ordination of articulatory gestures which, in the case of CH, have become habitual or 'fossilised'.

Phonetic errors – also often described as non-system sounds - include, for example, the voiceless lateral fricative [ɬ] or voiceless palatal fricative [ç] produced in place of /s/, pervasive nasality, or use of clicks in place of oral stops. We have left some blank rows for any other unlisted patterns to be recorded.

There is also a space to note the presence of progressive variability within the system or evidence of multi-lingual influence. The clinician can also record here whether further investigation into context-conditioning is required or an inconsistency assessment warranted. Note that we use the term 'inconsistency' to refer to the inconsistent production of the *same* lexical item across different repetitions.

Using the PPSA - Interpretation

Charting the data on the PPSA facilitates a first pass/closer inspection approach. To illustrate this we provide an interpretation of data which is charted for Child 1 on pages 4 to 6 of this guide. We follow this with a phonetically transcribed speech sample, completed PPSA and interpretation for Child 5 (see pages 27 to 28).

Child 1 Interpretation: First pass

- The vowel system is complete
- The oral stops and nasal systems are almost complete, particularly in labial position
- The fricative system is heavily compromised
- There are no-affricates
- The only approximant is /w/ - but very little data
- There is final consonant deletion (fricatives) but also WF glottal replacement and correct realisation suggesting progression
- Consonant clusters are reduced WI. WF there is reduction but also evidence of progression

Child 1 Interpretation: Closer Inspection

Oral Stops

- Some evidence of context -sensitive voicing:

  WI /t/ → [d], although also /t/ also correct

  WI /k/ → [d] although /k/ → [t] also

- Some evidence of velar fronting

  No velars WI – but WI /g/ not tested

  WF velars correct or realised as a glottal. (WF /g/ also pronounced as [d] on one occasion suggesting resolution of context sensitive voicing – underlining the importance of collecting more data for /g/)

  Pattern of variability suggests progressive change but more data is needed to confirm.

Fricatives

- Widespread evidence of homorganic stopping WI and WM

  /f/ → [p], /v/ → [b], /s/ → [t], /z/ → [d], /ʃ/ → [t]

- Some interaction with pre-vocalic voicing WI (/f, ʃ/)
- WF Consonant deletion or glottal replacement. Some correct /s/ tokens – indications of progressive change
- 1 instance of h-deletion (dialectal?)
- Dental fricatives not tested

Affricates

- Widespread evidence of stopping
- Some indication that voicing contrast applies

Approximants (very little data)

- Gliding

  WI /ɹ/ → [w]

- WF l-vocalisation (dialectal?)

The general pattern reflects delay with evidence of progressive change. Note, however, that rate of change would need to be monitored through repeated regular assessment to inform diagnosis and therapy planning

Clinical Note

While excessive glottal replacement can indicate disorder, here the data suggests that glottal replacement of WF fricatives and plosives is an intermediate stage in the resolution of final C deletion. This observation is made possible by looking at the data for plosives and fricatives together.

Child 5 Transcribed Data Sample

Data Sample for Child 5 (4;6 yrs) Items 1-25
Target Accent: SBS **Data Used: Picture naming task**

	Orthographic gloss	Adult Target (Phonemic)	Child Realisation (Phonetic)
1	CAR	kɑ	gɑ
2	BUS	bʌs	bʌs
3	BOAT	bəut	bəut
4	FIVE	faiv	jaiv
5	TRAIN	tɹɛin	gɛin
6	TOY	tɔi	dɔi
7	ONE	wʌn	nʌn
8	SPACE ROCKET	spɛis ɹɒkɪt	bɛiç wɒʔɪt
9	PRAM	pɹam	bam
10	HOUSE	haus	jaus
11	DUCK	dʌk	dʌʔ
12	CHOO CHOO TRAIN	ʧu ʧu tɹɛin	gugu gɛin
13	RACING CAR	ɹɛisɪŋ kɑ	jɛiçɪn gɑ
14	BOOK	bʊk	bʊʔ
15	FORT	fɔt	jɔ
16	CHEESE	ʧiz	gi
17	GATE	gɛit	gɛit
18	SNAKE	snɛik	nɛik
19	FOUR	fɔ	ɔ
20	GREEN	gɹin	gin
21	TEDDY BEAR	tɛdi bɛə	dɛdi bɛə
22	PUSSY CAT	pʊsi kat	bʊçi gaʔ
23	TIGER	taigə	daidə
24	BUNNY	bʌni	bʌmi
25	SPIDER	spaidə	baibə

Data Sample for Child 5 (4;6 yrs) Items 26-50
Target Accent: SBS **Data Used: Picture naming task**

	Orthographic gloss	Adult Target (Phonemic)	Child Realisation (Phonetic)
26	PIG	pɪg	bɪ
27	FORK	fɔk	jɔʔ
28	FROG	fɹɒg	jɒ
29	PUDDLE	pʌdəl	bʌbəl
30	CUP	kʌp	bʌp
31	FARMER	fɑmə	mɑmə
32	TABLE	tɛibəl	bɛibəl
33	SUNSHINE	sʌnʃain	jʌnjain
34	RED	ɹɛd	jɛ
35	CAKE	kɛik	gɛiʔ
36	FEATHER	fɛðə	jɛjə
37	COAT	kəut	gəu
38	BREAD	bɹɛd	bɛ
39	LORRY	lɒɹi	jɒji
40	SAUSAGES	sɒsɪʤɪz	jɒçɪjɪ
41	BLUE	blu	bu
42	PHONE	fəun	jəun
43	LOLLY POP	lɒli pɒp	jɒji pɒp
44	KITCHEN	kɪʧən	gɪʔən
45	BIG	bɪg	bɪ
46	ANNE	an	jan
47	EGG	ɛg	jɛ
48	ORANGE	ɒɹɪnʤ	jɒjɪn
49	ELEPHANT	ɛlɪfənt	jɛjɪjənt
50	AEROPLANE	ɛəɹəplɛin	jɛjɪbɛin

Child 5 Completed PPSA

Phonetic and Phonological Systems Analysis-English Systems (PPSA). Target accent: SBS

Name: Child 5 Date/Age: /4;6 Data used: Picture/object naming

PI	Target	Correct Realisation			Errored Realisation			Deletion			Place	Manner
		WI	WM	WF	WI	WM	WF	WI	WM	WF		
p	p	---1		11	bbb						Front→Back	Oral Stops/Plosives
b	b	111111	1									
t	t	----		1-11--	dddb		ʔ			11		
d	d	1	1--	--		bb				11		
k	k	------	-	--1--	gggbgg	ʔ	ʔʔʔʔ					
g	g	1	-	----		d				1111		
m	m		1	1							Front→Back	Nasals
n	n		-	11111111		m						
	ŋ			-			n					
	f	-------	-		jjjmjj	j		1			Front→Back	Fricatives
	v			1								
	θ											
	ð		-			j						
s	s	--	---	1-1	jj	ʕʕʕ	ʕ					
	z			--						11		
	ʃ											
	ʒ											
	h	-			j							
	ʧ	---	-		ggg	ʔ						Affricates
	ʤ		-			j						
w	w	-			n						Front→Back	Approximants
	ɹ	---	---		wjj	jjj						
l	l	--	--	11	jj	jj						
j	j											
	ɹ										Rhotic	

Other Errors (eg sequencing errors, consonant harmony)
/an/ →[jan], /ɛg/ →[jɛ], /ɛlɪfənt/ →[jɛjɪfənt]
/tɛibəl/ →[bɛibəl], /spaidə/ →[baibə], / pʌdəl/ →[bʌbəl]
/kʌp/ →[bʌp], /taigə/ →[taidə], / bʌni/ →[bʌmi]
/fɑmə/ →[mɑmə], /wʌn/ →[nʌn]

Phonetic and Phonological Systems Analysis-English Systems (PPSA). Target accent: SBS

Name: Child 5 Date/Age: / 4;6 Data used: Picture / object naming

Some Clusters (ᴿ applicable for rhotic accents)

Word Initial		Word Medial	Word Final	
pl-	fl-	-nʃ- -mj-	-mp	-ks
pɹ- *b*	fɹ- *j*	-pl- -*b*-	-nt ✓	-gz
bl- *b*	θɹ-		-nd	-pt
bɹ- *b*	sp- *bb*		-ŋk	-bd
tw-	sm-		-ft	-kt
tɹ- *gg*	sw-		-sp	-spᴿ
dw-	st-		-st	-bᴿ
dɹ-	sn- *m*		-sk	-ndʒ -*m*
kw-	sl-		-lp	
kl-	sk-		-lt	
kɹ-	spl-		-lk	
gl-	spɹ-		-ps	
gɹ- *g*	stɹ-		-bz	
	skw-		-ts	
	skɹ-		-dz	

Error Pattern Summary (shading denotes atypical error patterns)

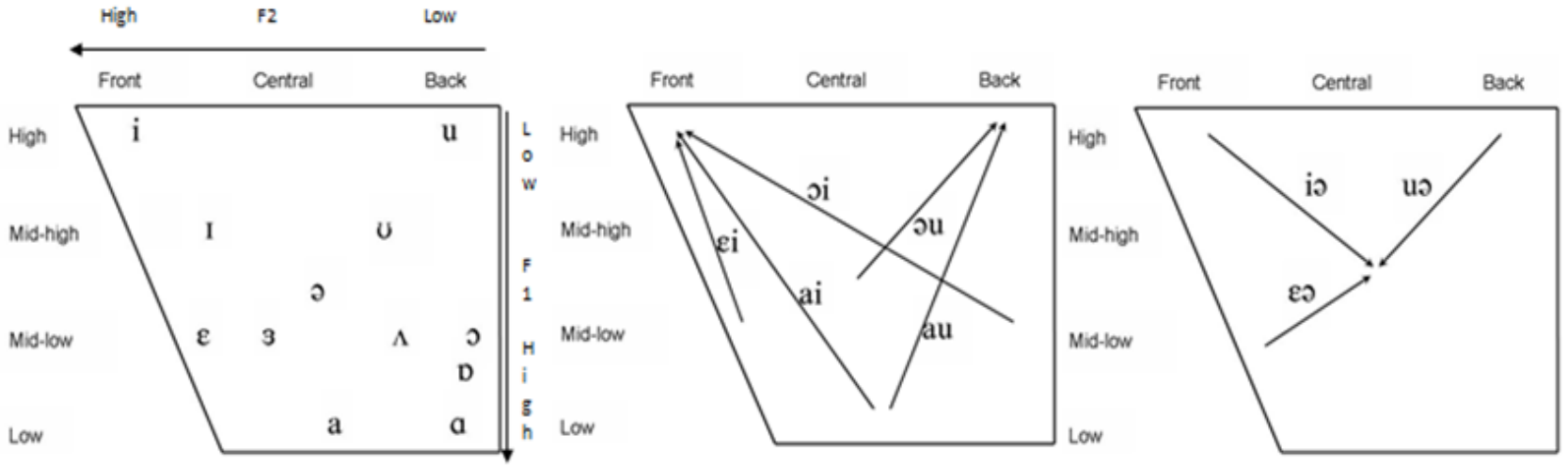
Structural	(✓)	Segmental	(✓)	Phonetic/Other	(✓)
Reduplication		Pre-vocalic voicing	✓	Dentalisation	
Weak syllable deletion		Post-vocalic devoicing		Lateralisation	
Final C deletion	✓	Velar fronting		Palatalisation	✓
Initial C deletion	✓ˢ	Alveolar backing		Ingressive air stream	
h-deletion		Palatal fronting		Nasal emission	
Consonant insertion	✓	Stopping of fricatives		Clicks	
Vowel insertion (epenthesis)		Gliding of fricatives	✓		
Cluster reduction	✓	Stopping of affricates	✓		
Coalescence		Deaffrication		**Other**	
Diphthong reduction		Gliding of liquids	✓	Fricative simplification	
Diphthongisation		Glottal replacement	✓	l-vocalisation	
Linearisation of features		Excessive glottal replacement		/ɹ/ → [ʊ]	
Word level errors		Systematic sound preference	(?)	**Variability / Further ax required?**	(✓)
Consonant harmony	✓	Vowel lowering		Progressive variability	✓
Transposition (metathesis)		Vowel raising		Context-conditioning	
Sequencing errors		Vowel fronting		Inconsistent production of same lexical items	
		Vowel backing		Multi-lingual influence	

Phonetic and Phonological Systems Analysis-English Systems (PPSA).

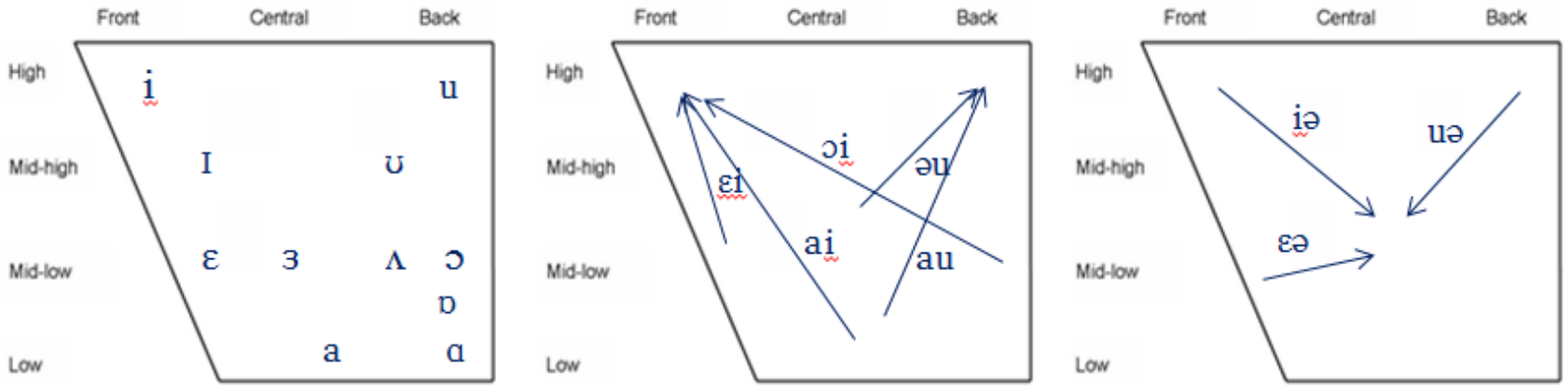
Name: Child 5 Date/Age: / 4;6 Data used: Picture/object naming

CAV- ES: Vowel Quadrilaterals Monophthongs and Diphthongs: Southern British Standard

Name:	CA:	Date:	SLT/P:



Complete the blank quads by first noting the vowels that are present in the system. Place any vowels produced in error in brackets beside the vowels used in their place.



Child 5 Interpretation

First Pass

- The vowel system is complete
- The nasal system is almost complete WF but not tested WI
- Oral stops – productive phonological knowledge evident for each stop, but widespread variability. Some WF deletion or glottal replacement
- The fricative system is heavily compromised and has non-system realisations – little data available across the class
- There are no-affricates – 2/3 tokens from same word 'choo choo train' [gu gu gɛin] (fossilised form?)
- Approximants – some evidence of productive phonological knowledge of /w/ and /j/. /j/ mainly used. Little data
- Where tested WF, stops and fricatives are deleted, glottalised or correct indicating progressive change
- Cluster reduction WI, no data for WF

Closer Inspection

- Evidence of widespread pre-vocalic voicing across stop, fricative and affricate manner classes:

  WI /p/ → [b], /t/ → [d], /k/ → [g], /ʧ/→ [g], (*/f/ → [j, m], /s/ → [j], /h/ → [j])

  *Unusual variability in terms of place and manner (not phonetically principled) – e.g., 'b', 'j', 'm' 'g'– warrants further investigation
- Widespread palatal replacement with [j] palatal approximant predominantly used WI for fricatives, and approximants, and WM for approximants and the palatal voiceless fricative [ç] used WM and WF for fricatives – where tested warrants further investigation.

Further investigation

- WI and WM place and manner variation

  Many of these errors appear anomalous – they are relatively isolated incidences and (with the exception of initial voicing in the case of /t, k/) do not lend themselves to a description in

process terms. While it might be tempting to describe them as examples of fronting to /b/ or /m/, this pattern is not phonetically principled and a description in these terms could throw the clinician off-course in terms of diagnosis and intervention.

It is always possible that the odd anomalous production can reflect a transcription error - further justification for transcribing and analysing multiple rather than single tokens. However, in this case we have four anomalous errors to account for. Revisiting the transcription data shown below provides an explanation:

Target Word	Adult Target / /	Child pronunciation
table	tɛibəl	bɛibəl
spider	spaidə	baibə
puddle	pʌdəl	bʌbəl
cup	kʌp	bʌp

In each case, the errored realisation can be described as an instance of consonant harmony whereby the target consonant assimilates to the place of articulation of either the preceding bilabial consonant (as in the case of 'spider' [baibə] and 'puddle' [bʌbəl]) or following bilabial consonant (as in the case of 'table' [bɛibəl] and 'cup' [bʌp]).

Note that the one example of /g/ realised as [d] WM occurs in the word 'tiger' /taigə/ pronounced as [taidə], and so could also be explained as CH with /g/ assimilating to the place of articulation of the initial /t/.

- Consonant harmony (CH) also affected other manner classes as shown in the data below.

Target Word	Adult Target / /	Child pronunciation	CH pattern
bunny	bʌni	bʌmi	/n/ → [m]
farmer	fɑmə	mɑmə	/f/ → [m]
one	wʌn	nʌn	/w/ → [n]

CH is found in the speech of very young typically developing children and is therefore considered to be a characteristic of phonological delay when it occurs in the speech of older children. There is a danger, however, of misdiagnosis if such word-level, assimilatory patterns are described in process

terms. For example, /d/ produced as [g] in 'dog' [gɒg] and 'duck' [gʌk] could suggest the atypical process of backing which is associated with phonological disorder. Description of /k/ → [b] in 'cup' as a combination of voicing and fronting or /f/ → [m] in 'farmer' as a combination of voicing, stopping and (dare we say it) nasalization, might similarly suggest idiosyncratic and hence disordered development. Without investigating the source of the variability, there is the further danger that it can contribute to a misdiagnosis of *inconsistent* phonological disorder or DVD.

By grouping phonemes in natural classes, the PPSA highlights relatively isolated and anomalous errors such as these and where it is therefore advisable to revisit the transcription data. Provided sufficient tokens are charted, the PPSA can also help differentiate between instances of CH and genuine instances of, for example, alveolar backing. For example, where there is a general pattern of alveolar backing, then /d/ produced as [g] in 'dog' [gɒg] could reasonably be described as backing. However, in cases where this is a single isolated example of 'backing', then it is more likely to represent an instance of CH, particularly, in cases where there is also a pattern of velar fronting.

Advantages of the PPSA – Why we like this approach

The PPSA is designed to capture information across the whole system – consonants and vowels – and represent this in an economical format. This supports an at-a-glance appreciation of the system's profile of strengths and weaknesses and also highlights gaps in the data. The structure means data 'automatically' falls into linguistically meaningful groupings as it is being charted. This facilitates identification of systematic error patterns, suggesting principled therapy targets and stimulus sets.

The PPSA is generic in the sense that it can be used to analyse data from any client group or from any transcribed data sample, at the clinician's discretion. Samples of data collected within the same time frame, for example, from a standard screen and from follow-up specific probing can be charted together on the same form to give a rich, meaningful profile.

Data from different sampling conditions can be charted separately to highlight the effect of, for example, real v non-word stimuli or isolated single word v spontaneous production. Profiles from data taken at different time points can be easily compared to establish where progress towards the adult system has been made.

Variability (where sufficient data is available), is immediately apparent indicating where further investigation is required.

Charting an appropriate data sample on the PPSA gives the clinician confidence that they have:

- a useful overview of the child's system (phonetic inventory and productive phonological knowledge) at a particular point in development,
- a solid evidence base for principled clinical decision-making with regard to diagnosis, identifying intervention targets, justifying therapy approach and measuring outcome.

What the PPSA doesn't do

- The PPSA can be used with any transcribed data including words produced in natural, spontaneous speech. Sampling spontaneous production is important for gaining insight into a child's functional speech, i.e., the child's performance in real time under increased processing demands. However, it will not capture longer domain assimilatory phenomena or the difficulties some children show negotiating syntactic boundaries within sentences. This requires a different analytical approach (see Howard, 2004).

- The PPSA does not set out to provide Percentage Correct scores – for consonants or vowels. While a percentage score can easily be derived from the charting procedure for any single phoneme or for all phonemes across the system, the value of these scores depends crucially on the original data set. Percentage Consonant Correct (PCC) scores, as originally conceived, were intended as a measure of the extent to which the consonant system was complete, i.e., all possible targets pronounced at adult level. The measure pre-supposed that the data sample would either be perfectly balanced or so large that one could assume a balanced representation of all consonants in all possible word contexts. When used as outcome measures, this is necessary so as to ensure that the scores reflect changes in the developing sound system rather than differences in the distribution of consonants / word contexts within the samples used.

  To illustrate the potential problems of sample bias - compare two picture naming tasks, each, if completed, delivering a sample of 100 consonants. The first task has 5 words with velars: 'kick', 'key', 'car', 'leg', 'bang' – delivering 6 velar tokens to the total sample of 100 sounds. A

child with a velar fronting problem which applies universally i.e., to all velar targets but who has an otherwise intact phonological system would have a PCC of 94%. The second naming task has 12 words with velars: 'cone', 'cave', 'camera', 'corn', 'cornet', 'cap', 'cup', 'gap', 'gorilla', 'game', 'guard', 'gourd' (12 velar sounds). Here the same child would have a PCC of 88%. (If the sample had 30 velars then the PCC would be 70% and so on.).

If the child progresses to a situation where he can pronounce velars in word final position but not word initially then a PCC measure of sample 1 would now be 97% as 3/6 possible examples have a velar in word final position. If the second sample were used though no progressive change would be shown as there are no examples of word final velars in this picture naming task - so no opportunity to demonstrate change. The PCC score would remain the same at 88% - despite the fact that we as clinicians know that a significant progressive change has taken place. In sum, we know that velar fronting can apply universally but also that at different stages in a developing system its occurrence may be conditioned by word position, by whether the target is a singleton or part of a cluster or by the nature of the following vowel. If the PCC sample does not take these possibilities into account, its value as an instrument for measuring change is questionable.

- The PPSA does not provide any guidelines linking the acquisition of a particular phoneme to age norms. There is some agreement in the literature with respect to general groupings of early, middle and late acquired sounds (see Bowen, 2014). However, for any one individual, the way in which a system of contrasts is built can depend on factors such as their frequency of exposure to particular lexical items, second languages or bouts of otitis media (see CDSRN's *Good Practice Guidelines for the Analysis of Child Speech* for a more detailed discussion). With this in mind, the emphasis here is on obtaining a linguistically meaningful profile of the child's system of sound contrasts at the time of assessment which can be used to inform diagnosis and target selection and against which future development can be measured.

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