Clinical Assessment of Vowels–English Systems (CAV-ES)

User Guide

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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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Introduction

CAV-ES (Clinical Assessment of Vowels - English Systems) is a FREE, downloadable and photocopiable resource for use by Speech and Language Therapists/ Pathologists (SLT/SLPs). The picture stimuli provided are chosen to be appropriate for working with children but the method of approach can be used to analyse and summarise any equivalent data set. Conditions of use under a Creative Commons Licence are described below.

CAV-ES was originally developed as a research tool to investigate disordered vowel systems in a group of children from Scotland[1]. It is designed to help SLT/SLPs derive a clinically useful profile of a child's contrastive vowel system. The full assessment facilitates identification of systematic vowel error patterns and highlights where there is variability within the system, guiding further exploration. It also probes the consonant contexts most likely to condition vowel errors and, to a lesser extent, the vowel contexts most likely to condition consonant errors.

> *Note: Doulos SIL fonts are used throughout CAV-ES for transcription data. These are freely downloadable. We have, however, embedded fonts and saved as a PDF – so hopefully you should not experience any problems with printing.*

In designing CAV-ES we have been conscious of the particular challenges that vowel assessment presents to the clinician. Frequently asked questions include the following:

- How do I capture relevant accent features of the speaker?
- How narrow or broad does my transcription need to be in order to obtain an effective picture?
- How much data do I need to analyse?
- When is a vowel 'distorted'?
- How are vowel error patterns best described?
- How can variability within the system be captured?
- How far is vowel variability conditioned by consonantal context?

[1] The authors would like to thank Queen Margaret University, Edinburgh, who supported the research and development of CAV-ES with two 'small project' grant awards.

- How can understanding of the articulatory and/or acoustic properties of vowels inform management?

We have tried to address these concerns by:

- Providing data collection and analysis sheets which cover a representative range of English accent systems.
- Taking a phonemic rather than a phonetic approach to data analysis.
- Including 50 pictures which can be flexibly arranged to provide:
    - a screen,
    - further probing,
    - a comprehensive data set of over 180 vowel tokens,
    - a range of consonant contexts plus analysis forms which highlight common conditioning contexts.
- Including worked examples of cases to illustrate different types of vowel error pattern.
- Providing a single page Vowel Quadrilateral aummary sheet which schematically captures the child's vowel system and links this explicitly to the articulatory and acoustic properties of vowels.

Accent systems

We currently include packs for three exemplar accent systems:

- Non-rhotic (Southern British Standard)
- Rhotic (Standard Scottish)
- Rhotic (Ulster English)

We also have packs covering a selection of regional accents: Cornish, Yorkshire, East Coast Southern Irish. The materials for other accent systems will be posted to the CAV-ES website as they become available.

Phonemic approach

CAV-ES is designed to help the SLT/P identify and monitor vowel error patterns which compromise speech intelligibility. It will, for example, reveal if a child consistently pronounces /ɛ/ as [a], consistently pronounces /ɛ/ as [i] or treats /ɛ/ variably, pronouncing it as either[a] or [ai]. In the first case, the distinction between words like 'bed' and 'bad' is compromised – both words sounding like 'bad'. In the second, both 'bed' and 'bead' would sound like 'bead'. In the third case, /ɛ/ might be pronounced as [a] proceeding [l] but as [ai] elsewhere - as we found for one child in our Scottish study. Inability to distinguish vowels *sufficiently* in terms of vowel height as in these examples or along the other key phonetic parameter - vowel front-backness, results in reduced ability to signal meaning distinction and, hence, reduced intelligibility.

CAV-ES' focus, therefore, is the child's system of vowel contrasts and the nature and extent to which this is compromised from the listener's perspective. It is not directly concerned with fine phonetic differences in the way in which an individual vowel is pronounced, for example, whether the /a/ in 'bad' is pronounced as [a, æ, å, ã, a:]. A speaker using a variant form differing slightly from the 'target' accent vowel quality may sound unusual but a listener is unlikely to misunderstand their meaning. That is, the subtle phonetic differences in /a/ production do not lead to a percept which is of either:

- another vowel from within the same target system, or
- a vowel that is completely outside the target system

Similarly, CAV-ES is not concerned with identifying instances of covert contrast. That is, subtle but consistent differences in the phonetic realisation of two vowels which indicate that the child is aware of the phonological contrast but which, from the general listener's point of view, are insufficient to signal a reliable or consistent meaning distinction **or** which are insufficient to generate a distinct percept. Information about a child's tacit phonological knowledge is undoubtedly of high clinical relevance. However, we would argue that this can be obtained through assessment of the child's perceptual skills once 'problem' contrasts have been identified.

A broad phonetic transcription is thus typically sufficient to pinpoint where, from the listener's perspective, vowel contrasts are reduced. For speech problems where a narrow phonetic analysis is warranted, as might be the case for example with a speaker who is deaf or who has marked cerebral palsy, the clinician may find that CAV-ES provides a useful first step in capturing the phonological strengths and weaknesses of the system.

In the following sections we:

- describe each of the CAV-ES components and how they are can be used to provide clinically useful information about a child's vowel system,
- provide worked examples of cases to illustrate some of the more common vowel error patterns that have been reported in the literature.

How to use CAV-ES

Like most speech assessments that are based on transcription data, CAV-ES provides:

- Picture stimuli designed to elicit a representative data sample.
- Transcription sheets or 'word lists' which give the phonemic or 'target' transcription for the accent system in question.
- Analysis sheets to assist in the identification of vowel error patterns.
- Vowel quadrilateral sheets which, when completed, provide an at-a-glance summary of both the speaker's monophthongal and diphthongal vowel systems.

Picture Stimuli

We provide 50 black and white line-drawings in a Powerpoint format for maximum flexibility of use. The clinician can present the stimuli (one picture per slide) on-line or use the 'hand-out' facility within Powerpoint to make a paper-based assessment tool, customized to include between 1-9 pictures per page (see Figure 1 below). The 'hand-out' facility also allows the clinician to develop therapy materials such as lotto boards or battleship co-ordinate games.

Following common practice, the pictures are ordered so as to avoid successive productions of the same vowel, minimising the possibility of a child suddenly becoming aware of a difficulty during the course of assessment. The full set allows for an in-depth analysis, yielding multiple tokens of

each vowel phoneme across an extensive range of phonetic contexts. The first 15 pictures (and the first three pages of the transcription sheet) will elicit tokens for the full range of vowels (within most English accent systems) and so may be used as an initial screen. Individual vowels identified as warranting further investigation can then be probed in more depth by selecting an appropriate sub-set from the full picture set. A listing of the pictures that can be used to elicit each vowel is provided for guidance in the Data Analysis sheet (see below).

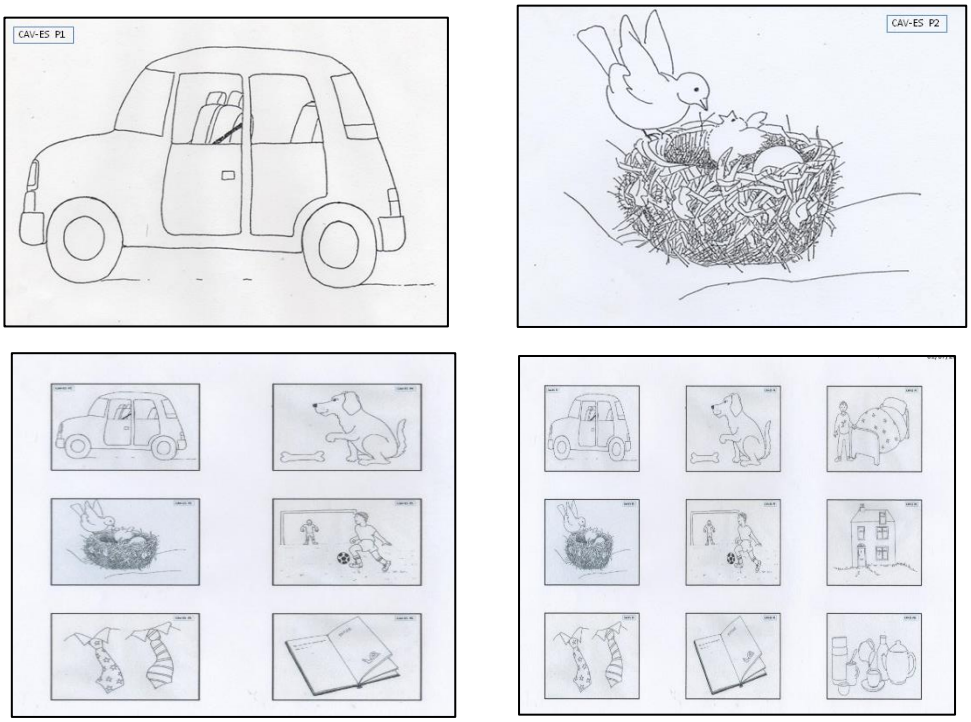

Figure 1 Pictorial stimuli format: single slide, 6 and 9 slides to a page

Data Collection and Analysis Packs

These are accent specific and contain a/an:

- Accent Inventory,
- Data Collection or 'Transcription' sheet.
- Data Analysis sheet.
- Vowel Quadrilateral summary sheet.

Accent Inventory

This is intended to give the clinician a quick overview of the key features of the accent system to be assessed. The inventory gives the number of monophthongs and diphthongs in the system, exemplar words, the phonetic symbols we use in the CAV-ES phonemic interpretation of the system and some possible phonetic variants.

Transcription Sheet

Accent specific transcription sheets are provided for the clinician to phonetically transcribe the child's responses to the stimulus pictures. We include an example (Table 1) taken from the first page of the SBS pack.

The first column (**No**) gives the number of the CAV-ES picture used to elicit each word. The orthographic gloss is given in column 2 (**Word**) and the phonemic or adult 'target' transcription in column 3 (**Target**). We felt this would be particularly beneficial when the SLT is working with an unfamiliar accent system. The child's production is noted in column 4 (**Response**). Column 5 (**Additional response**) is available to note any repetitions of the target word or other words produced that may be of interest. The sixth, final column (**Error pattern**) is used to summarise how any vowels produced incorrectly are realised.

Superscripts can be used to indicate where more than one example has been collected. In the section below three examples of the target word 'purple' have been transcribed. In each case the target /ʌ / vowel is pronounced as [a] so the error pattern is captured as /ʌ/ → [a]^{111}.

Table 1 Transcription sheet example

No	Word (e) elicitation	Target	Response	Additional response	Error pattern
1	car	kɑ	*kɑ*		
	wheel	wil	wal		i→a
	seat	sit	*sit*		
	purple	pɜpəl	*papəl*	*papəu, papəu*	ʌ→a[111]
2	bird	bɜd	*bɜd*	*ə bak bad*	ɜ→a[11]
	wing	wɪŋ	wɪŋ		
	nest	nɛst	*nast*		ɛ→a

Data Analysis Sheet

Once the data has been transcribed it is useful to record the results obtained for each vowel under separate headings. This facilitates identification of patterns of error within and across vowels and any variability in the realisation of individual vowels. We provide a Data Analysis sheet for this purpose. An extract from page one of the SBS pack is shown below (see Table 2). The numbers in the first column (**No**) refer to the potential number of tokens that may be elicited across the full assessment. The second column (**Pic**) specifies the picture used to elicit the data. Column 3 gives the vowel target and the adjacent (**Rz**) column is used to note the child's pronunciation of the target in this context. Note that the vowel targets are ordered in a principled way across the page. In this example which shows the first sheet of the SBS Data Analysis Form, the high vowels are listed from the most front to a back articulation: /i, ɪ, ʊ, u/. A similar front-back pattern is followed for the mid-high vowels, the mid-low vowels and the low vowels.

Table 2 Data Analysis sheet example

No	Pic	/i/	Rz	Pic	/ɪ/	Rz	Pic	/ʊ/	Rz	Pic	/u/	Rz
1	1	wheel	a	2	wing	✓	5	football	✓	8	roof	✓
2	1	seat	ɪ	7	pillow	✓	13	sugar	✓	23	spoon	✓
3	4	doggie	✓	7	pyjamas	✓						
4	5	knees	✓	8	windows	✓						
5	7	sheet	ɪ	8	chimney	✓						

If the target vowel is realised correctly (as, for example, in the case of 'doggie' and 'wing') a tick is placed alongside the word in the '**Rz**' column. If the target vowel is realised incorrectly (as, for example, in the case of 'wheel' and 'seat'), the errored pronunciation is noted. When all the data has been entered the clinician can quickly scan the columns to see whether a given vowel is:

- always pronounced correctly
- sometimes pronounced correctly
- never pronounced correctly

and, where a vowel is produced incorrectly, how it is pronounced and whether there is any variation in how it is pronounced.

If considered useful by the clinician, this analysis also provides the basis for determining percentage vowel correct (PVC) scores. The total number of errors for each vowel can be calculated and expressed as a percentage of the total number of tokens elicited for that vowel. This figure is entered in the appropriate column at the bottom of the page. Note that where a vowel has more than one errored pronunciation (as, for example, in the case of /i/, the percentage error occurrence for each variant pronunciation is noted (eg /i/ → [a] 1/7 = 14%, /i / → [ɪ] 2/7 = 29%).

NB. Variability in the realisation of a given vowel may reflect the influence of adjacent consonants, most typically the following consonant. For example, lowering of the mid-low front

vowel /ɛ/ to [a] in the context of a following velarized lateral [ɬ] is a commonly reported pattern (Pollock & Keiser, 1990; Reynolds, 1990; Gibbon, Shockey & Reid, 1992). (Please see Bates, Scobbie and Watson, 2013 for a more in-depth discussion of consonant-vowel interactions in disordered systems.)

Vowel Quadrilateral Summary Sheets

An understanding of how the substituted vowel differs from the target vowel in terms of its articulatory and acoustic properties is essential for planning remediation and designing appropriate stimuli. This relationship is demonstrated by charting the transcribed data directly onto vowel quadrilaterals - the main goal of the CAV-ES approach. To support the process, CAV-ES provides accent specific target quadrilaterals for guidance as well as blank vowel quadrilaterals for the clinician to complete.

A note on the traditional vowel quadrilateral
The vowel quadrilateral as devised by Daniel Jones (see Ashby 1989) is a schematic way of representing the relative articulatory and acoustic properties of vowels. From the articulatory point of view, the corners of the quadrilateral represent the extreme points of vowel articulation when looked at from the perspective of a mid-sagittal section of the oral cavity. The vowel systems of all languages and accents must therefore, by definition, lie inside the boundary defined by these points. We capture this concept in the diagram below (see Figure 2) where we superimpose a mid-sagittal view of the oral tract on the quadrilateral. The red line (loosely!) represents the tongue in the /i/ and /a/ positions. The position of other vowels within the space can be usefully described using the vertical co-ordinates High, Mid-high, Mid-low and Low[2] and the horizontal co-ordinates Front, Central and Back.

[2] CAV-ES consistently uses the vertical co-ordinate labels **high**, **mid-high**, **mid-low** and **low** to reflect tongue position. Some systems instead use the terms close, mid-close, mid-open or open to reflect jaw position. The two sets of labels may be used inter-changeably.

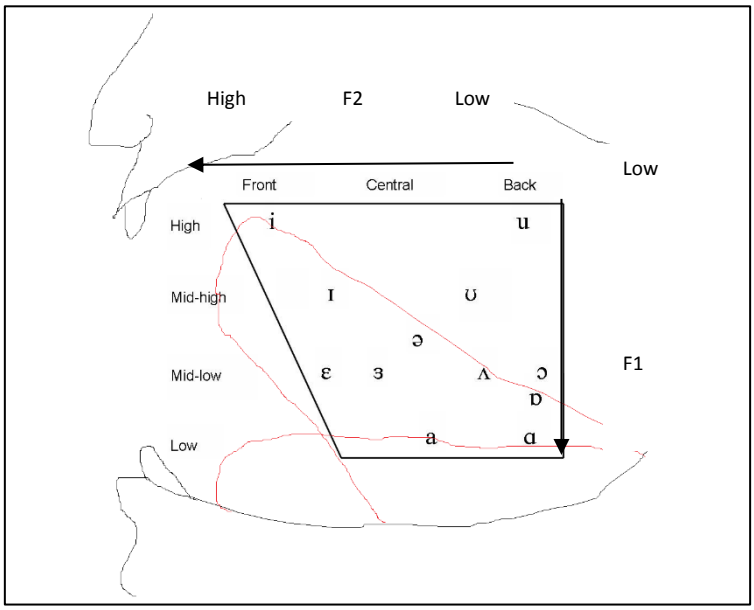

Figure 2 Vowel quadrilateral superimposed on a mid-saggital view.

A vowel described in articulatory terms as a 'high front vowel' captures the information that the typical tongue posture required is one which is raised towards the palate towards the front of the mouth. The most high and front vowel in English is the /i/ vowel as in, for example, 'bee' and 'bean'. Contrast this with the /a/ vowel as in, for example, words like 'bat' and 'man'. In this case, the tongue body is much lower in the mouth although still towards the front of the mouth as compared with the low back vowel /ɑ/.

The vowel quadrilateral is also a schematic representation of the acoustic vowel space. We provide reference lines to indicate the relationship between first and second formant values (respectively F1 ad F2) alongside the vowel quadrilateral for quick reference. A description of /i/ in acoustic terms is of a vowel with a relatively low F1 and high F2. In comparison /a/ has a relatively high F1 value and an F2 value in the mid-range.

In CAV-ES we take a reductionist approach, paring down description to the minimum required to deliver a clinically useful profile. We take the view that the position of the vowel in the quadrilateral i.e., relative tongue position and corresponding spectral characteristics (F1 and F2) are a sufficient 'first pass' description for most cases. In English the distinction between vowel pairs which differ along the tense v lax dimension, for example, /i/ v /ɪ/ and / ɯ/ v /ʊ/ is also successfully captured by placing the vowels in different locations within the quadrilateral (i.e.,

capturing their spectral differences). It is also reflected in the use of different phonetic symbols. Lip-spreading and rounding is linked to vowel front-ness and back-ness respectively. Essentially rounding the lips makes them protrude more, thus increasing the length of the resonating tube before the main tongue constriction - so again we argue that this information is already captured by the place specification.

The CAV-ES Vowel Quadrilateral Summary Sheet for SBS is shown in Figure 3.

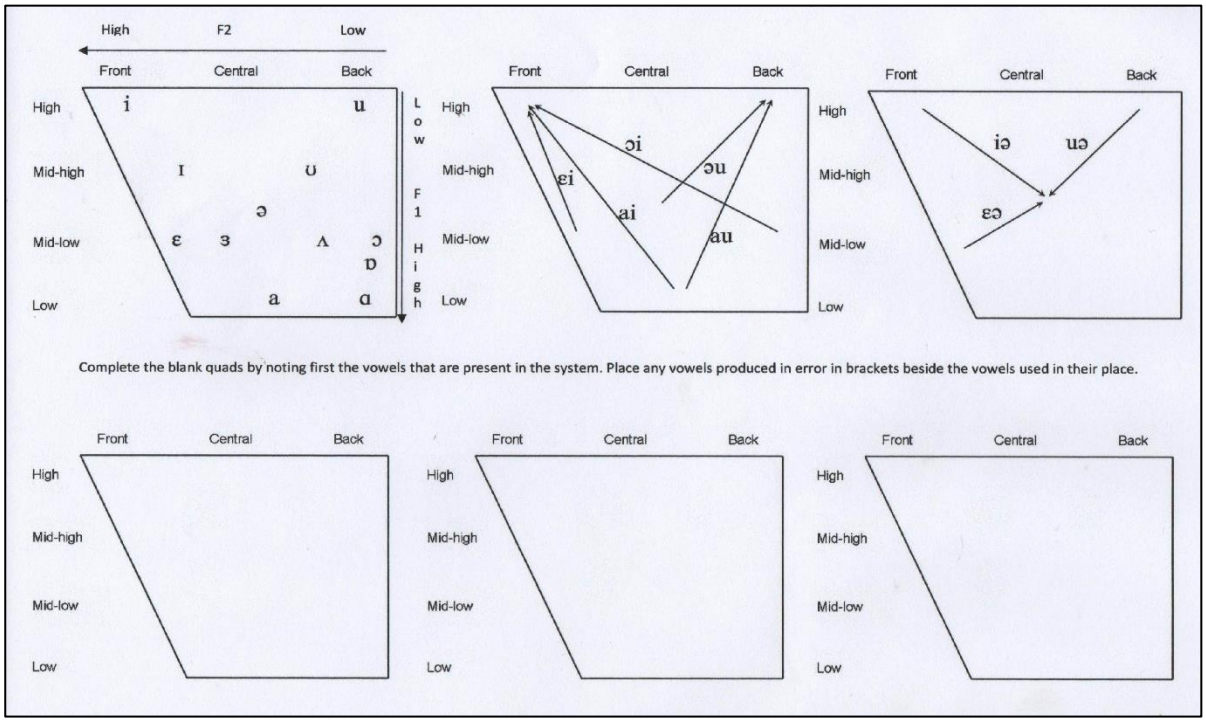

Figure 3 Vowel Quadrilateral summary sheet (SBS)

The target accent system is provided for guidance in the top row of quadrilaterals. Blank quadrilaterals are then provided below for the clinician to complete. In this example taken from the Southern British Standard (SBS) pack, the first quadrilateral captures the 12 contrastive monophthongs, the second the five contrastive 'up-swinging' (or closing) diphthongs – 3 towards the high front /i/ position and 2 towards the high back /u/ position and the third, the three contrastive 'in-swinging' (or centering) diphthongs.

Note on diphthongs
As is traditional, we include arrows to indicate the change in tongue movement during the diphthong and corresponding change in vowel quality. So, for example, the diphthong /ai/ as in 'mind' or 'eye' has an arrow which starts from a relatively low- central /a/ position and swings up to a higher more front /i/ position. Speakers across and within accent systems vary with respect to where exactly they 'jump on' or 'off' this trajectory and different symbols, for example, [ai], [aɪ], [æi], [æɪ] may be used to capture these variations in phonetic detail. As with the monophthongs, in CAV-ES we are interested in identifying where there is a loss of phonological contrast between vowels rather than in capturing subtle differences in phonetic quality. We are interested firstly in establishing whether the child can contrast diphthongs with monophthongs, i.e., achieve both elements within the diphthong, or whether they reduce the diphthong to one element, most typically the first, e.g., pronounce /ai/ as /a/. Reduction to one element results in a loss of contrast between the diphthong and corresponding monophthong, e.g., /ai/ vs /a/ (so that 'eye' and 'a' are both pronounced as [a]). Secondly, where two elements are preserved, we are interested in the relative start and end point of the diphthong in question and whether the movement path between these is sufficient to distinguish it from other diphthongs within the system, e.g., /ai/ v /au/ (as in 'cow') or/au/ v / əu / (as in 'boat'). For this reason, we represent the diphthongs using those phonetic symbols which capture the most extreme end points of the target trajectory (see Table 3).

Table 3 Symbols used for diphthongs

Exemplar words	Symbols used in CAV-ES for up-swinging diphthongs in SBS English	Potential phonetic variants
buy	ai	ai, aɪ, æi, æɪ
bay	ɛi	ɛi, ɛɪ, ei, eɪ,
boy	ɔi	ɔi, ɔɪ, ʌi
bough	au	au, aʊ
bow (as in ribbon)	əu	əu, əʊ

Completing the blank quadrilaterals

The CAV-ES approach is designed to reflect three different possible scenarios with respect to how a target vowel is realised: (1) consistently correctly, (2) consistently in error and (3) sometimes

correctly and sometimes in error. The procedure for each scenario is described below and illustrated with reference to the mid-low front vowel /ɛ/ (see Figure 4).

(1) If a vowel is realised correctly in all production opportunities it is placed on the blank quadrilateral in the same position it occupies in the target quadrilateral shown above.

(2) If a vowel is never produced correctly, the position it should occupy on the quadrilateral is left blank and it is placed in brackets beside the vowel (or vowels) by which it is realised, in this case /a/.

(3) If a vowel is produced correctly on one or more occasions it retains its position on the vowel quadrilateral and is also placed in brackets beside the vowel used in its place. Thus, in our example, /ɛ/ is charted twice, in its own position to and in brackets beside the symbol for 'a'.

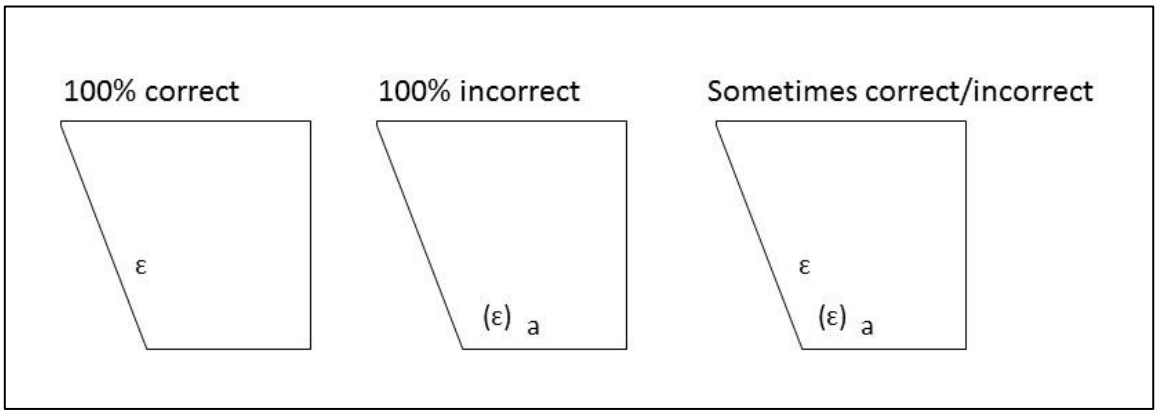

Figure 4 Testing /ɛ/

If a vowel has more than one variant pronunciation, it is placed in brackets beside each variant pronunciation. It is also charted in its own position if it is sometimes also produced correctly.

Clinical note
For the purposes of our research a given error pattern had to occur in 15% or more productions in order for it to be considered a systematic error and charted on the quadrilateral. It is for the individual clinician to set their own criterion for deciding what constitutes a significant pattern or not. We would, though, always advise against including an 'error' based on a single occurrence.

Vowel error patterns

Consonant error patterns are usefully described in articulatory process terms which capture the difference between the target and the sound produced in its place, along one or more phonetic dimensions, most commonly place of articulation, manner of articulation and voicing. So, for example, production of /k/ as [t] is described as 'velar fronting' capturing the contrast between [k] and [t] along the place dimension. The use of phonological process terms like this highlights the fact that typically the difficulty lies with a particular phonetic contrast rather than with an individual sound. Thus, in the case of velar fronting, /g/and /ŋ/ are also likely to be fronted to [d] and [n] respectively and not just /k/ → [t].

It is encouraging to note from the literature that a similar classificatory framework can be applied to vowel error patterns, although here the relevant phonetic dimensions are tongue height (or its corollary jaw opening), tongue front-backness and lip rounding (see for example Reynolds, 1990; Pollock, 2013). In the following section we provide worked examples of completed Vowel Quadrilateral summary sheets for three children. These capture four of the more common patterns reported in the literature: vowel lowering, vowel raising, vowel backing and diphthong reduction.

Worked examples

Child 1

Child 1's vowel system – monophthongs and diphthongs, is shown in Figure 5. The completed quadrilaterals reveal two areas of difficulty:

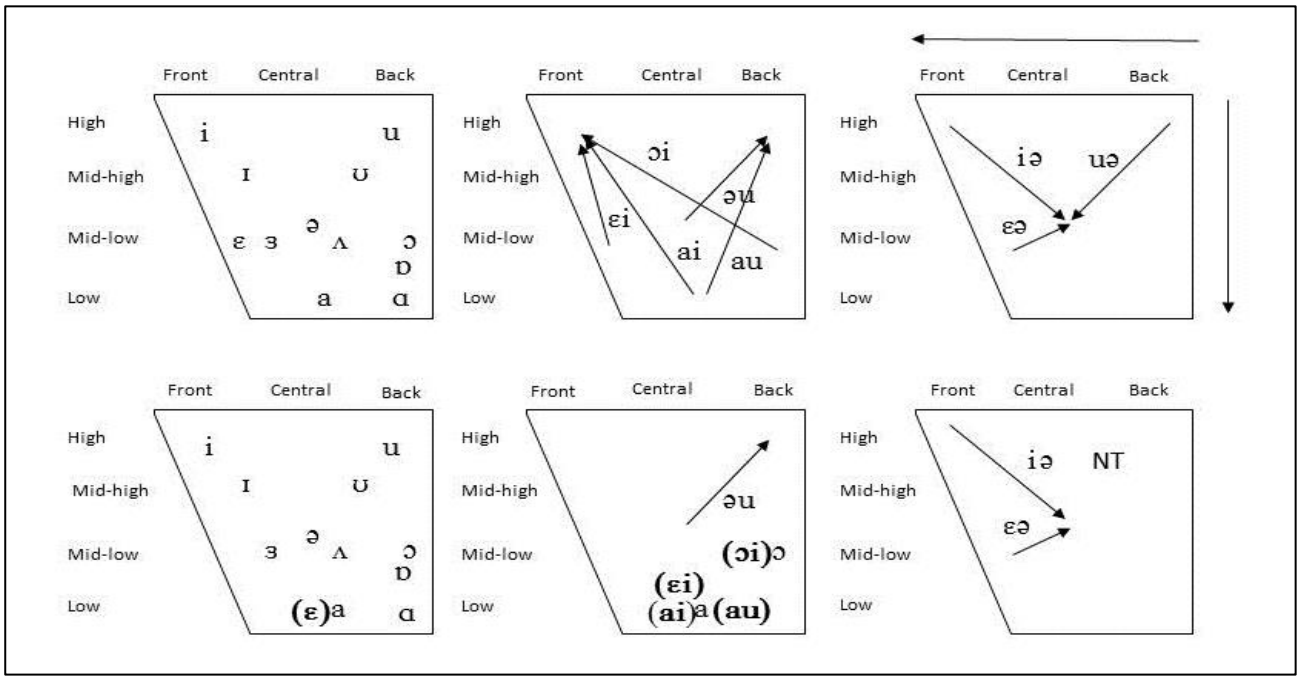

Figure 5 Completed Vowel Quadrilaterals for Child 1

(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 this child's system. Examples from the transcription data would include: 'bed' [bad], 'fence' [fans], 'pen' [pan], 'bread' [bwad], 'egg cup' [ag kʌp]. 'melting' [maltɪŋ] and nest [nast]. Note that all the other monophthongs are present in the system.

(2) The up-swinging diphthongs (with the exception of /əu/), 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 in () brackets beside the symbol for the monophthong used in their place. The diphthong movement arrows are also omitted. Realisation of /ɛi/ as [a] may be described as an interaction of diphthong reduction and vowel lowering. Examples from the transcription data would include: 'goat' [gəut], 'face'

[fas], 'kite' [kat], 'brown' [bwan], 'boy' [bɔ]. Note that this child has no difficulty with the in-swinging diphthongs /iə/ and /ɛə/. The diphthong /uə/ was not tested in the current sample. This is indicated using the abbreviation 'NT',

Child 2

Child 2's system is also characterised by lowering (see Figure 6). In this case, however, three vowels are affected. The mid-low vowels /ɛ/, /ɜ/ and /ʌ/ are all consistently lowered to [a]. The first element of the diphthong /ɛi / is also lowered to [a]. (Note that in this case, the child does not reduce the diphthong, i.e., they achieve diphthongal movement.) This pattern points to a possible articulatory or perceptual constraint underpinning the errored vowel production and allows ready identification of candidates for inclusion in a feature approach to therapy. For example, here the SLT might want to raise the child's awareness of the phonetic feature of vowel height by contrasting one or all the mid-low vowels with high vowels as well as the low vowel [a]. Stimuli sets might include, for example:

/bad/ v /bɛd, bɜd, bʌd/, /baθ/ v /bɛθ, bɜθ/, /batə/ v /bɛtə, bʌtə/ (contrasting low vs mid-low) /nit/ v /nɛt, nʌt/, /pis/ v /pɜs, pʌs/, /bin/ v /bɛn, bɜn, bʌn/ (contrasting high v mid-low)

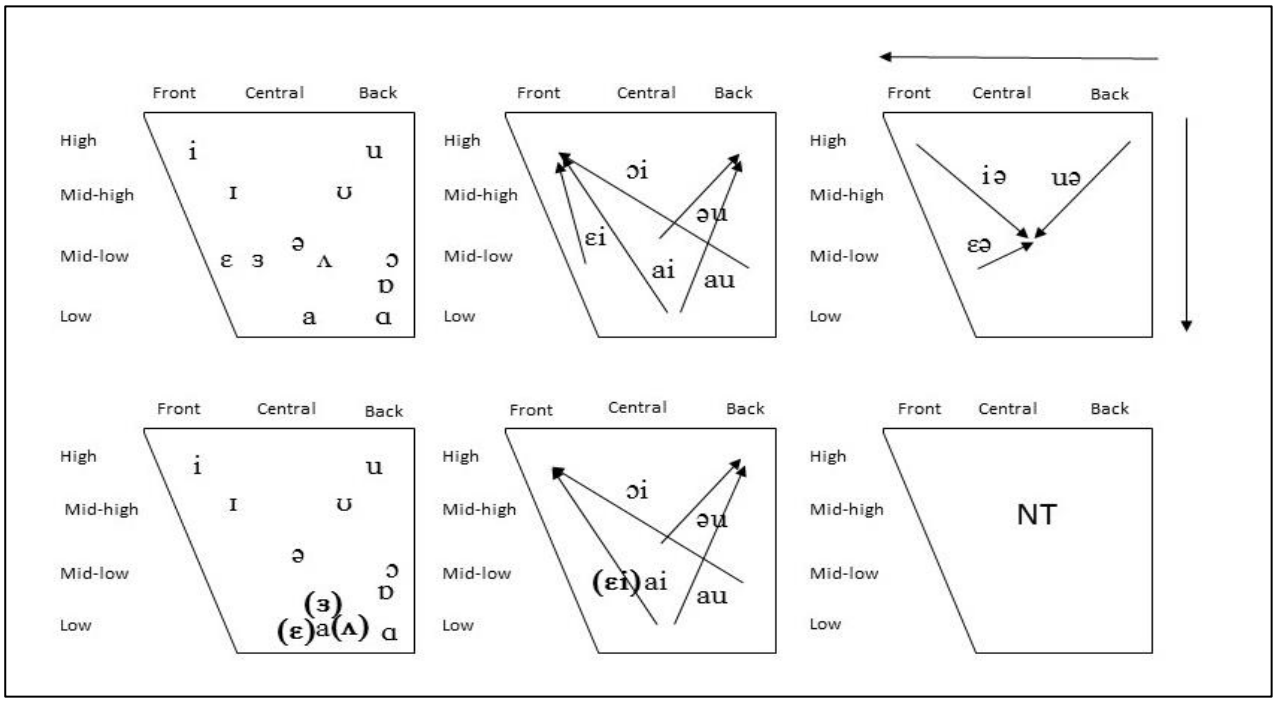

Figure 6 Completed Vowel Quadrilaterals for Child 2

Child 3

Child 3's system is characterised by **vowel backing**. The mid-low front vowel /ɛ/, the long central vowel /ɜ/ and the mid-low central vowel /ʌ/ are all backed to [ɔ]. Examples from the transcription data include: 'bed' [bɔ], 'bird' [bɔd] and 'cup' [kɔp]. The mid-high front vowel /ɪ/ is also backed to [ʊ] as in, for example, 'pin' [pʊn]. Note that /ɜ/ is realized variably, sometimes it is backed and sometimes it is backed and lowered to [ɑ], e.g., 'bird' [bɔd] but 'curl' [kɑl]. This child's diphthong system is complete with the exception of /ɛi/ which is backed to [ɔi] mirroring the pattern observed for the monophthong /ɛ/. As in the previous case, the in-swinging diphthongs have not been tested.

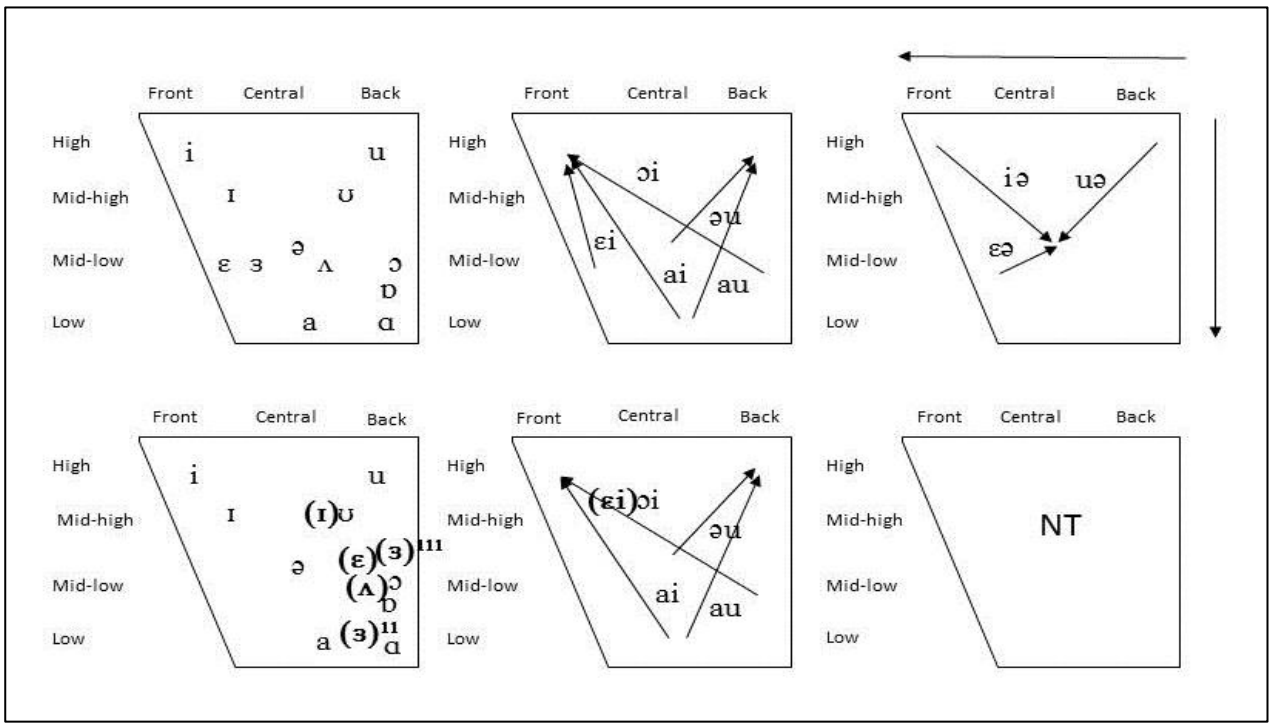

Figure 7 Completed Vowel Quadrilaterals for Child 3

As these examples demonstrate, when completed, the Vowel Quadrilateral Summary sheets provide the clinician with an 'at-a-glance' appreciation of the child's system of vowel contrasts and how this deviates from the adult target system. It highlights where there is a loss of contrast between vowel phonemes and facilitates identification of systemic processes such as lowering, backing and diphthong reduction. It also highlights any variability in the treatment of given vowel

across different words. This information supports the principled selection of therapy targets and intervention approach and may also assist differential diagnosis, for example, between phonological disorder and developmental verbal dyspraxia (see Pollock, 2013). For a more in-depth consideration of intervention for vowel disorders see Gibbon (2013).

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Note - If you are working with an accent which is not yet included in CAV-ES – you might still find the procedure of data capture and analysis useful. If you would like to contribute an accent then please contact us on sbates@marjon.ac.uk *and* jwatson@qmu.ac.uk.