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Diagnosing inconsistent phonological disorder: quantitative and qualitative measures

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ABSTRACT

Studies of children's consistency of word production allow identification of speech sound disorder. Inconsistent errors are reported for two groups of children: *childhood apraxia of speech* (CAS) due to difficulty with the motoric precision and consistency of speech movements; and *inconsistent phonological disorder* (IPD) attributed to impaired phonological planning. This paper describes the inconsistent productions of children with IPD in comparison to typically developing children. In two studies of suspected SSD ($N = 135$), 22 children pronounced ≥40% of 25 words inconsistently on three repeated trials. No participant had symptoms of CAS. They were monolingual and spoke Australian- or Irish-English. Assessment determined the proportions of words said consistently (i.e. the same across productions: all correct or with the same error) or inconsistently (i.e. differently across productions: at least one correct and one error or different errors in productions). Qualitative analyses examined error types and explored the effect of target words' characteristics on inconsistency. Children with IPD produced 52% of words with different errors. While 56% of all phoneme errors were developmental (age appropriate or delayed), atypical errors typified inconsistency: default sounds and word structure errors. Words with more phonemes, syllables and consonant clusters were vulnerable to inconsistency, but their frequency of occurrence had no effect. TD children and those with IPD had different quantitative and qualitative error profiles, confirming IPD as a diagnostic category of SSD. Qualitative analyses supported the hypothesised deficit in phonological planning of words' production for children with IPD.

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Introduction

When children produce many words inconsistently, it is considered a marker for speech sound disorder (SSD). One approach to classifying distinct subgroups of SSD relies on the description of types of phonological errors made, combined with a comparison of subgroups' performance on phonological processing abilities (for summary see Dodd, 2014). In contrast, Stackhouse and Wells, (1997) psycholinguistic framework focuses on input and output processing skills and Shriberg et al.'s (2010) classification uses a medical model. Two independent reviews (Ttofari Eecen et al., 2019; Waring & Knight, 2013) support the salience of children's phonological errors for understanding subgroups of

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SSD. Consequently, this study examined the types of speech errors made when children with SSD produce words inconsistently.

Clinicians often consider inconsistent errors as evidence for childhood apraxia of speech (CAS), a neurogenic speech disorder typified by 'lengthened and disrupted co-articulatory transitions' with 'prosody and stress errors' and consonant and vowel distortions (American Speech-Language-Hearing Association [ASHA], 2007). Children with inconsistent phonological disorder (IPD) also make many inconsistent errors despite having no segmental or supra-segmental signs of impaired planning or programming of articulation (Broomfield & Dodd, 2004; McNeill et al., 2022). While 3.6% of the children with SSD are identified with CAS (ASHA, n.d.), IPD was diagnosed in 10% of 320 SSD cases referred to a UK paediatric speech and language therapy service (Broomfield & Dodd, 2004) and 15% of 126 four-year-olds with SSD in an Australian community cohort study (Early Language in Victoria, Ttofari Eecen et al., 2019). This paper describes the number and type of errors made by children with IPD. It explores qualitative measures of inconsistency by comparing the speech of children with IPD and typically developing (TD) children (Holm et al., 2022). Phonological error data are examined for evidence about the nature of inconsistency.

Previous studies have focused on the proportion of words pronounced inconsistently on repeated trials. Normative data indicate that children aged over 3.5 produced fewer than 10% of words inconsistently, while 3.0–3,5-year-olds show 13% inconsistency (Holm et al., 2007). In contrast, the reported mean inconsistent productions of the same word were 58–64% for CAS groups (Iuzzini-Seigel et al., 2017; McCormack & Dodd, 1996) and 56–58% in IPD groups (McCormack & Dodd, 1996; McNeill et al., 2022). While measuring percent inconsistency differentiates TD children from those with speech difficulties, it fails to distinguish SSD groups. Analyses of IPD participants' inconsistent error types might provide clinical markers for differential diagnosis that guide assessment and intervention. Few studies, however, provide examples of inconsistent errors made by children with SSD.

Acquisition of word production consistency by typically developing children

While TD toddlers' speech is characterised by inconsistent production of the same word (Grunwell, 1982; Sosa & Stoel-Gammon, 2012), most studies of 3.0–5.0-year-olds report that around 80% of words are produced consistently in picture naming tasks sampling words two or three times, across languages (see Table 1). Older children are more consistent than younger ones, and girls are sometimes more consistent than boys. Words vulnerable to inconsistency had more consonant clusters and syllables (Holm et al., 2022; Macrae, 2013).

Qualitative characteristics of word consistency (e.g. phonemic analyses) were reported for 96 TD Australian-English speaking preschool children (Holm et al., 2022) who were part of a large normative study of speech development. To measure consistency, children named 15 pictures twice, in separate trials, in the same assessment session. The mean consistency of production was 82% (59% same correct; 23% same error). Different (inconsistent) productions of the same word occurred either when one was correct and one in error (8.7%: *sheep* [ʃi:p, si:p]), or when there were two different errors (9.6%: *elephant* [ɛflənt, ɛfənt]).

Inconsistently produced words were analysed for evidence about the nature of word production in TD children (Holm et al., 2022). There were 130 examples of word pairs produced correctly on one trial and in error on the other. Only one of an inaccurate words'

Table 1. Percent consistency reported for typically developing children.

Study	Age	N	Population	Mean % consistency: Overall and by approximate age group						Gender effect
				Overall	~2;6	~3;0	~3;6	~4;0	~4;11	
Sosa (2015)	2;6–3;11	32	English (USA)	32%	23%	32%	43%			Not tested
Jones (2020)	1;2 to 3;8	5	English (USA)	78%						Not tested
Ha (2020)	2;6–6;11	209	Korean	79%	44%	70%	82%	88%		Not tested
Burt et al. (1999)	3;10–4;10	57	English (UK)	82%				77%	86%	Girls = Boys
Zarifian et al. (2020)	3;0–6;0	317	Persian	84%		81%		87%	89%	Girls = Boys
Martikainen et al. (2021)	3;0–6;11	80	Finnish	89%		81%		89%	96%	Not tested
Holm et al. (2007)	3;0–6;11	409	English (UK)	92%		87%	88%	93%	95%	Girls > Boys
Holm et al. (2022)	3;0–4;11	96	English (Australia)	81.7%		76%		86%		Girls > Boys

[a]A longitudinal study: 1811 words analysed with two scoring methods over age range. Phonemic consistency: 78%; Phonetic consistency: 17%.

phonemes was likely to be in error. Atypical errors were rare (e.g. additions and backing). Errors were most frequently age-appropriate according to normative data (e.g. gliding and cluster reduction) or delayed (e.g. fronting, Dodd et al., 2003). Waring (2019) argues that the executive function of inhibition plays an important role in suppressing error patterns. Children sometimes fail to inhibit a phonological pattern when marking an emerging contrast (e.g. alveolar vs velar), particularly in multisyllabic words (e.g. *kangaroo* correct in one trial but [tændəɹu:] in another). This type of inconsistency was interpreted as evidence for a resolving error pattern, rather than being a marker for SSD.

In Holm et al.'s (2022) study, there were 143 examples of a word produced differently with both in error. Words most vulnerable to inconsistent production had complex word structures. Word frequency and neighbourhood density had less effect. Three subcategories of this type of inconsistency were identified (see Holm et al., 2022 for further discussion of these error types):

(i) 56% of the inconsistent productions were alternate uses of age-appropriate or delayed developmental errors (e.g. *witch* [wɪt, wɪts], *frog* [fɒg, fwɒg]). This category included errors like *screwdriver* [skɹu:daɪvə, sku:dɹaɪvə] demonstrating the ability to articulate phoneme sequences in complex syllable onsets.
(ii) 22% of the inconsistent productions were characterised by the use of atypical errors (e.g. *strawberry* [tʃɔ:bɹi, stɔ:bɛwi]; *sprinkles* [fɪŋkəlz, swɪŋkəlz]). One production often had developmental errors, the other being atypical (e.g. af/frication of clusters).
(iii) 22% of the inconsistent productions affected word structure (addition and deletion of syllables) and phoneme sequencing errors (e.g. *helicopter* [hɒktətɛlə, hetətɒktə], [kɒjəkɒwə, kɒkə]; *octopus* [ɒptəkʊpʊs, ɒptəkʊs]). These errors plausibly reflect poor planning of the sequence of phonemes in syllables, and syllables in words.

Inconsistent phonological disorder (IPD)

A review of SSD cases treated at a UK speech therapy clinic identified a subgroup making inconsistent errors despite having no motor-speech difficulty (Dodd, 1982). Subsequent research reports that between 8% and 16% of children with SSD pronounce 40% or more of words inconsistently on repeated trials of picture naming tasks, across languages (e.g. Danish: Clausen & Fox-Boyer, 2022; Korean: Pi & Ha, 2020; Cantonese: So & Dodd, 1994; Mandarin: Hua & Dodd, 2000). In one study of English-speaking four-year olds, controls ($n = 28$) and children with SSD ($n = 86$) named 25 pictures, three times (McCormack & Dodd, 1996). The typically developing children produced 14% of words inconsistently, while different homogenous subgroups of children with SSD varied: delayed development 29%; consistent atypical errors 33%; and children with IPD, 58% inconsistency.

Studies seeking to explain the inconsistent errors of children with IPD have examined their profile of associated abilities. A review of the findings suggests they perform within normal limits on most speech processing and executive function tasks (Dodd et al., in press). Tasks eliciting poor performance were as follows: syllable awareness but no other phonological awareness tasks, spelling but not reading comprehension (Holm et al., 2008); and, expressive, but not receptive, learning of non-words (Bradford-Heit & Dodd, 1998). Standardised vocabulary measures provide contradictory findings, with studies reporting either receptive (McNeill et al., 2022), or expressive impairment (Macrae & Sosa, 2015), or deficits on both measures (Dodd & McCormack, 1995). Incomplete or erroneous lexical representations of words, or difficulty accessing these representations, might account for inconsistent word production in IPD (Macrae & Sosa, 2015), although the ability to access the phonological structure of words needs to be distinguished from knowing a word's meaning. For example, some children with IPD describe a picture they cannot name (e.g. 'bird that comes out at night' for 'owl', Dodd & McCormack, 1995).

Levelt et al.'s (1999) speech production model provides an alternative account. It has two separate speech output processing stages: a linguistic stage leading to a phonological plan for the sequence of phonemes of an utterance (Laganaro, 2019); and a motor programming stage that provides the blueprint for articulatory gestures for selected words (J. Duffy et al., 2021; Haley et al., 2013). Two speech difficulties acquired by adults lend support for this dichotomy: paraphasias characterised by inconsistent speech errors in the absence of motor speech difficulties (Butterworth, 1992; Laganaro, 2019); and, acquired articulatory apraxia described as an 'impaired capacity to plan or program sensorimotor commands necessary for normal speech' (J. R. Duffy, 2013, p. 4).

A similar speech processing deficit may underlie inconsistent productions in adult paraphasia and paediatric IPD, as neither of these groups have motor-speech impairments. Supporting evidence comes from the finding that children with IPD make fewer speech errors when imitating words than in spontaneous production (Bradford-Heit & Dodd, 1998) and from intervention case studies of children with IPD. These studies provide examples of phoneme sequencing difficulties (e.g. *zebra* [zribrʌ, zibʌ, ribʌ], Hemsley & Holm, 2017), and use of default sounds (e.g. syllable initial [w] and final [k]: *lighthouse* [wa:wak], *giraffe* [bikwak]; all word final consonants are replaced with a schwa: *push* [pʊə], *boat* [boʊə], McIntosh & Dodd, 2008). Such error types motivated the development of *core vocabulary therapy* that targets whole words (rather than speech sounds or error patterns), establishing a consistent production of 70 highly functional lexical items selected by children and their families. As long as a range of word shapes and speech sounds are included, the actual words selected do not affect the clinical outcome. Therapy provides information about each target's sequence of speech sounds, syllable by syllable. Consistency and improved accuracy generalise to non-treated words after around 8 hours of therapy (for review see Crosbie et al., 2021).

The clinical challenge of inconsistent word production

Children's inconsistent speech errors pose clinical challenges for assessment, intervention, and clinical management. Normative data on consonant acquisition and phonological patterns assume children's speech production is consistent as most standardised assessments require children to name a picture only once. Intervention for SSD (e.g. minimal pair therapy) also assumes consistency by contrasting specific errors with the correct production. Similarly, articulation therapy focusing on single speech sounds discounts the possibility of a phoneme sequencing deficit. For clinical management, children with IPD are often referred early by carers due to concern about their unintelligible speech (Fox, 2000). A clinical opportunity is lost if intervention is delayed, as an RCT found that 'children with IPD made most progress in therapy when they were three years old' (Broomfield & Dodd, 2005, p. 227). As quantitative scores fail to distinguish between at-risk groups, qualitative data might better identify children's specific clinical needs as well as inform theoretical accounts of inconsistent speech errors.

In this paper, inconsistent productions of children with IPD are quantitatively and qualitatively evaluated, as they are the largest homogenous SSD group with inconsistent productions. Diagnosis of IPD excludes inconsistency due to motor planning and programming deficits. Data from 22 children with no motor-speech symptoms, scoring ≥40% inconsistency on 25 words said at least twice, addressed these research questions:

- What proportion of words were pronounced *the same* (both correct or the same error) *or differently* (at least one correct and one in error or different errors)?
- Do proportions of phoneme error types (age appropriate, delayed, and atypical of normative data) differ for consistently and inconsistently produced words?
- Do target words' frequency of occurrence, number of phonemes and syllables, and syllable shape (e.g. CVC and CCVCC) affect consistency?
- Words pronounced inconsistently have specific phoneme differences (e.g. alternate developmental errors occur in *witch* [wɪs, wɪʃ]). In what proportions do specific types of phoneme changes occur when words are pronounced differently, both in error?
- Does the performance of children with IPD and TD differ on these measures?

Method

Speech data from 22 children diagnosed with IPD in two previous studies (Dodd & McIntosh, 2008, Australian children; Dodd et al., 2009, Irish children) were analysed to address the research questions. Parents signed informed consent forms approved by the University of Queensland Human Research Ethics Committee (2004000722).

Participants

The Australian study (Dodd & McIntosh, 2008) recruited 275 children (with or without speech difficulties) through advertisements in preschools, child-care centres and community newsletters to a study evaluating the role of input processing, executive function and motor–speech skills in preschool children's speech development. Of these parent referrals, 89 children had a SSD (i.e. performed >1 standard deviation below the mean on the

Table 2. Participants' mean (M), standard deviation (SD) and range: age, percent consonants correct (PCC), percent vowels correct (PVC), oro-motor standard scores, number of phones missing for age and inconsistency score on the DEAP.

	Age months	Phonology Assessment		Oro-Motor SS*				
		PCC	PVC	DDK	IM	SM	Phones missing	% Inconsistency
Australian sample: N = 11 (10 male, 1 female)								
M	49.7	39	81.4	10	10.2	10.5	2.4	59.3
SD	6.1	14.3	12.6	1.4	1.3	1.7	2.6	11.4
range	37–60	22–59	53–97	8–12	7–12	8–13	0–8	40–72
Irish sample: N = 11 (8 male, 3 female)								
M	52.4	45.6	83.2	9.3	9.6	9.6	1.9	56
SD	8.5	13.4	10.5	1.7	1.7	1.9	2.0	7
range^	40–66	25–66	65–96	6–13	8–13	7–14	0–6	44–72
Combined data: N = 22 (18 male, 4 female)								
M	51.1	42.3	82.3	9.6	9.9	10	2.1	57.6
SD	7.3	13.6	11	1.7	1.6	1.8	2.3	9.3
range	37–66	22–66	53–97	6–13	7–13	7–14	0–8	40–72

*DDK: diadochokinesis; IM: isolated movements; SM: sequence movements. Normal SS range 7–13.
^One child participant refused DDK testing, SS 6 while other scores within normal limits, so not excluded.

phonology subtest of the *Diagnostic Evaluation of Articulation and Phonology*, DEAP, Dodd et al., 2002). All children were monolingual English-speakers, had age-appropriate language comprehension, and no hearing, neurological or cognitive impairments. Eleven of the 89 children (aged 3.1–5.0) with SSD made inconsistent speech errors (i.e. scored ≥40% on the DEAP Inconsistency Assessment) and were excluded from the main study. Their speech data, analysed in the present study, has not been previously published (see Table 2).

The Irish study (Dodd et al., 2009) assessed 57 monolingual children attending speech and language therapy clinics in Dublin. They were either currently receiving intervention or attending a review appointment. Case history information revealed no sensory, cognitive or physiological explanation for their speech difficulty. While language comprehension was not formally assessed, the children were identified by their speech therapist with SSD as their primary difficulty. This sample was assessed to evaluate the clinical validity of normative data collected from typically developing 3 to 7-year-old Irish children on all subtests of the DEAP. Table 2 presents a summary of the characteristics of the 11 children (aged 3.4–5.6 years) scoring ≥40% on the DEAP Inconsistency Assessment. Qualitative analysis of the data from these 11 children has not been previously described.

Procedure

The procedure was the same in both studies. Children were assessed at home, preschool, childcare or speech therapy clinics in a quiet environment. Experienced speech-language clinicians (the first two authors) engaged children in two 30-min assessment sessions, separated by a play break. Parents sat near their children during the assessments and received a written report on their child's performance.

All subtests of the DEAP were administered:

- *Diagnostic Screen*: 10 pictures named; speech sounds in error elicited to check stimulability; pictures renamed to check consistency.

- *Articulation and Oro-motor Assessment*: 30 CV/VC words elicited all speech sounds in picture naming; stimulability of speech sounds in error was tested in isolation, using appropriate cues. Diadochokinesis repetitions of 'pat-a-cake' scored for accuracy, intelligibility, and fluency; Isolated movements of tongue elevation and lateral movement, lip rounding and spreading; and, imitation of sequenced movements (e.g. kiss and blow).
- *Phonology Assessment*: 50 pictures named (1–4 syllables, 22 clusters) measured phoneme and phonological error pattern use, and percent consonants correct (PCC) and percent vowels correct (PVC); a picture description task assessed continuous speech.
- *Inconsistency Assessment*: Children named 25 words in three separate trials. If 10 or more of the 25 words were pronounced differently (≥40%) the IPD criterion was met. Semantic cues were offered for unknown words; if necessary, a model for imitation was provided for all three trials of an unknown word. In this study, a total 16 (of 550) target words (3%) were imitated, between 1 and 5 words for each of the six children.
- Each trial of 25 words was separated by another activity (e.g. one of the oro-motor tasks). Words were transcribed on-line and audio-recorded for checking and reliability. When the third trial of the 25 words was not completed, available data were analysed. Each child's inconsistency score was the total of words produced differently divided by total words produced at least twice multiplied by 100.

Analyses

Analyses determined the proportions of words said consistently (i.e. the same production of the target word) and inconsistently (i.e. different productions of the target word) for each child. Each word was then classified as *same correct; same error*; *differently* with at least *one correct; or differently* with *different errors*. Differences due to phonetic variability were not categorised as inconsistent (e.g. same correct: *parrot* [pæɹət, pæɹɪt]; *same error: helicopter* [hɛlitɒptə. hɛlitɒptʌ]) as this reflects normal variation in word production (Bürki, 2018). Irish participants' data evaluated the clinical validity of normative data collected from typically developing 3- to 7-year-old Irish children on all subtests of the DEAP's Irish standardisation (Dodd et al., 2009). While Irish-English and Australian-English accents differ, each group was compared against normative data from their language background peers to identify speech errors. To measure consistency, each individual child's sequence of phonemes in a word was compared across trials. Differences between Australian and Irish groups were tested using non-parametric Mann–Whitney U tests, due to the small number of participants in each clinical group. Paired t-tests compared performance of the combined groups on different measures.

Qualitative analysis described all phonemic changes in differently pronounced words. Participants' speech errors were compared with DEAP normative data. Identified error patterns were classified as age appropriate (used by ≥10% of the children in the same 6 months age group); delayed (used by ≥10% of the children in a younger age group); or atypical (not used by ≥10% of the children in the normative data in any age band between 3 and 7 years).

Appendix 1 summarises DEAP normative data. It shows that children's phonological errors change during development to more nearly match the spoken language(s) they hear. The errors they make are thought to reflect children's knowledge of the contrasts and constraints of their language-specific phonology (Clark et al., 2007; Smith, 2010). Every language has its own set of speech sounds to contrast lexical meaning (e.g. lay/ray are two words in English but/l/and/r/do not contrast word meaning in some Asian languages). Phonological constraints place limits on how speech sounds may be sequenced to make words (e.g. *bridge* [bvɪdz],/bv/is an illegal cluster in English; only nasals occur word finally in Japanese). Children need to work out the contrasts and constraints of the languages they are learning from the words they have in their mental lexicon. The use of age-appropriate developmental errors provides evidence for largely intact phonological representations of words in their mental lexicon as well as the cognitive linguistic ability to derive the phonological contrasts and constraints of the language(s) of exposure (Clark et al., 2007; Smith, 2010).

Additional analyses examined the effect of target words' characteristics on consistency. This was calculated using Pearson's correlation coefficient between the number of children making inconsistent errors on each of the 25 target words and each word's (i) number of phonemes (to measure word length); (ii) number of syllables and consonant clusters (to measure syllable complexity); and (iii) frequency of occurrence (ZipfUS, Brysbaert et al., 2019). Different error forms occurring in multiple productions of the same word were examined for recurring patterns of change across children.

Two criteria were used to identify default sequences of speech sounds for the 18 children using this word production strategy (see Appendix 2). A default sequence of speech sounds needed to occur in at least five different lexical items from DEAP assessment data, irrespective of same or different error response (for the 18 children identified as using this strategy: $M = 8.9$, SD 4.0, *range* 5–23). The only errors counted as default sequences were those that could not be explained by known developmental or atypical phonological error patterns (see Appendix 1). For example, one default sequence was *[d] marked within word syllable initial consonants* (*zebra* [ɛdʌ]; *parrot* [pædi]; *umbrella* [ʌbɛdə]; *vacuum* [ædi]; *elephant* [ɛdɪl]); but *dinosaur* [daɪdɔ] was not counted because it might reflect assimilation.

Results

Participants from the two studies were compared on measures of age, number of speech errors, DDK, oro-motor skills, and inconsistency on DEAP subtests (see Table 2). A Mann-Whitney U-test showed that the Australian and Irish samples were matched for age ($U = 50$, $z = 0.6596$, $p = 0.509$). There were more boys (82%) than girls in both samples. Most children had PCC and PVC standard scores (SS) of 3 (the lowest score possible), although three children had one score in the lower average range (SS 7–9). DDK and oro-motor scores clustered around SS 10 (average), indicating no symptoms typical of children with CAS. Phones most often missing for age were/tʃ, dʒ/(usually acquired by 4 years, Dodd et al., 2003). An inconsistency score of ≥40% was an inclusion criterion for the study, with nine participants producing ≥60% of target words inconsistently (i.e. saying at least 15 of the 25 words differently). The Irish and Australian children were matched for inconsistency ($U = 39.5$, $z = 1.3461$, $p = 0.177$) allowing participants' data to be combined for further analyses.

The 25 word inconsistency assessment provided the 22 participants with 550 opportunities to name target words on three trials. Two preliminary scans of the data base were done. Thirty-five target words were not elicited at least twice due to 27 refusals and eight wrong word choices (e.g. cockatoo for parrot). Of the 515 target words attempted, 61% were elicited three times and 39% twice. These data were used to analyse the effect of target word's characteristics on consistency in Table 3.

To maximise the number of words included in qualitative analyses of inconsistent errors, when a child did not provide two productions of the Inconsistency test's 25 target words, that child's assessments were inspected for replacement data. Words included were drawn from other DEAP subtests requiring two productions of words (i.e. the screener and continuous speech tasks) and wrong word choices on all three trials. Only 26 of 35 missing target words could be replaced from the children's other data. The number of replacements in each response category was as follows: one same correct; 13 same error; one correct trial with another in error; and 11 different errors. Data from repetitions of 541/550 words, then, were included in the data base. Another scan identified word form constraints, focusing on syllable shapes and the number of syllables in words. Seventeen children produced four syllable words; two only produced two syllable words, while three added syllables to produce some five syllable words (e.g. *helicopter* [hɛlitɒpətʌ]). A syllable shape count indicated that all children produced

Table 3. Number of 22 participants producing each word the same and differently plus word characteristics: number of phones per word, syllable structure and frequency of occurrence.

Words	Missing data	Same Correct	Same Error	Correct/ Error	Different Errors	Number phonemes	Syllable Structure	Word Frequency
boat	0	7	8	4	3	3	1	5.0
rain	0	5	10	2	5	3	1	4.7
girl	2	5	8	2	5	3	1	5.8
tongue	2	3	7	1	9	3	1	4.5
shark	1	2	11	2	6	3	1	4.2
witch	2	2	11	0	7	3	1	4.4
five	1	1	8	3	9	3	1	5.5
scissors	0	1	6	2	13	5	2	3.8
chips	2	1	12	0	7	4	2	4.3
parrot	2	0	6	2	12	5	2	3.5
ladybird	2	0	8	3	9	7	3	2.2
fish	0	0	10	1	11	3	1	4.9
thank you	1	0	5	1	15	6	3	5.8
dinosaur	2	0	12	1	7	6	3	3.6
helicopter	0	0	3	1	18	9	4	4.2
teeth	0	0	16	0	6	3	1	4.7
slippery slide	1	0	12	0	9	10	5	3.7
jump	2	0	10	0	10	4	2	4.8
vacuum cleaner	10	0	2	0	10	11	6	1.3
kangaroo	1	0	7	0	14	7	3	3.4
zebra	1	0	7	0	14	5	3	3.4
birthday cake	2	0	5	0	15	8	3	5.0
bridge	0	0	6	0	16	4	2	4.7
umbrella	0	0	2	0	20	7	4	3.9
elephant	1	0	2	0	19	7	4	4.1
Total	35	27	194	25	269			
M (SD)			7.8 (4)		10.8 (5)			
Replacements		1	13	1	11			

Syllable structure score derived by adding number of syllables and consonant clusters; Word Frequency: ZipfUS (Brysbaert et al., 2019).

Table 4. Same and different productions for 25 words said more than once for 22 children with inconsistent phonological disorder.

	Mean (SD)	Range	% (of 25 words)
Same	10.7 (2.3)		**43.4%**
Same: *both correct*	1.2 (1.3)	0–4	5.2%
e.g., witch [wɪtʃ, wɪtʃ]			
Same: *same error*	9.4 (2.5)	6–15	38.2%
e.g., shark [gat, gat]			
Phoneme errors per word	2.0 (0.7)	1.2–3.3	
e.g., jump [dʌk] = 3			
Types of phoneme errors			
Age appropriate	22.9 (27)	0–89	
e.g., strawberries [tɔbiz] at 3;4			
Developmentally delayed	36.7 (23)	0–81	
e.g., shark [tak] at 4;4			
Atypical	40.4 (24)	0–100	
e.g., elephant [ɛləŋ]			
Different	13.9 (2.4)		**56.6%**
Different: *correct/error(s)*	1.2 (1.4)	0–5	4.8%
e.g., five [faɪv, faɪk]			
Different errors	12.7 (2.8)	7–18	51.8
e.g., five [baɪv, faɪk]			
Phoneme errors per word	2.7 (0.5)	(1.9–3.9)	
e.g., strawberries [sɔbiz] = 3			
Types of phoneme errors			
Age appropriate	20.5 (21)	0–74	
e.g., umbrella [ʌmbɛlʌ, bɛlə] at 3;4			
Developmentally delayed	30.1 (19)	2–63	
e.g., jump [dʌmp, tʌmp] at 5;5			
Atypical	49.3 (16)	23–92	
e.g., bridge [fɹɪd, fɹɪ]			

CVC syllables (e.g. *fish* [kɪʃ]), while 91% produced at least one consonant cluster (e.g. CCVC, *bridge* [fɹɪd]; CVCC, *jump* [kʌmp]).

One research question focused on the proportion of words pronounced consistently and inconsistently. Table 4 shows that 43% of the words were produced consistently, with 5% being consistently correct and 38% having the same error across productions. The proportion of words produced inconsistently across trials was 57%, with 5% of words produced correctly on at least one trial but in error on others, and 52% of words having different errors across productions. Children pronounced more words differently than the same ($t(21) = 3.3535$, $p < 0.01$), and fewer words were said with the same error than with different errors ($t(21) = 3.3743$, $p < 0.01$). Words had multiple phoneme errors, but more errors occurred in words said differently ($t(21) = 5.452$, $p < 0.0001$).

Qualitative analyses of each of the four error categories are described below.

Same correct

Fifteen participants produced a total of 28 words correctly on all trials ($M = 1.2$, $SD = 1.3$, *range* 1–4). Only 9 of the 25 Inconsistency Assessment words, all with a CVC syllable shape, (e.g. boat, rain and girl), were produced consistently correctly (see Table 3).

Same error

The data included 207 words with the same error ($M = 9.4$, $SD = 2.7$ *range* 6–15). There was a mean of two phoneme errors per word (see Table 4). These phoneme errors were classified according to the DEAP norms as follows: age appropriate (AA; e.g. *zebra* [dɛbʌ] stopping and cluster reduction at age 3.2 years is age-appropriate); developmentally delayed (e.g. *zebra* [dɛbʌ] stopping and cluster reduction at age 4.7 years); or, errors atypical of normative data (e.g. *zebra* [ɛbʌ] initial consonant deletion at any age was classified as atypical). The mean proportions of error types shown in Table 4 indicate that 40% of phoneme errors were atypical, while 60% reflected typical development.

Developmental error patterns used age appropriately were deafffrication, cluster reduction, gliding, and fronting. Delayed error patterns used by more than five children were stopping, cluster reduction, fronting, specific final consonant deletion, assimilation and weak syllable deletion. Atypical error patterns included vowel errors, initial consonant deletion, backing, and default substitutions (e.g. [w] for word initial fricatives).

The effect of age on type of errors made was analysed using Pearson's correlation co-efficient calculations between age (in months) and the number of each of the three types of errors made. A significant negative correlation indicated that younger children made more AA errors ($r = -.748$, $p < 0.001$). A significant positive correlation indicated that older children made more delayed errors ($r = .7103$, $p < 0.001$). The number of atypical errors was not correlated with age ($r = .1501$, $p = 0.959$).

Table 3 shows the effect of target word characteristics (length, number and shape of syllables, and word frequency) on production consistency, measured by the number of children producing each target word in each of the four error categories. The mean number of children making the *same error* on target words was 7.8 ($SD = 4$). Using a criterion of >1 standard deviation from the mean revealed that only 2–3 children produced consistent errors for *vacuum cleaner, elephant, umbrella*, and *helicopter*, while *chips, slippery slide, dinosaur* and *teeth*, were produced with consistent errors by 11–16 children. A significant negative Pearson's correlation coefficient calculation indicated that fewer children made consistent errors on words with more phonemes ($r = -.5113$, $p < 0.01$). Similarly, another significant negative correlation indicated that fewer children made consistent errors on words with more syllables and consonant clusters ($r = -.5325$, $p < 0.01$). There was no relationship between words' frequency of occurrence (Brysbaert et al., 2019) and number of children making consistent errors ($r_{23} = 0.2221$, $p = 0.286$).

Correct/error

Thirteen children produced 26 words correctly on at least one trial but in error on others ($M = 1.2$, $SD = 1.4$, *range* 1–5). Two of these words were correct in two trials and in error in one (*rain* [ɹeɪn, wan, ɹeɪn]); and five had one correct and two words with the same errors (*fish* [fɪʃ, wɪs, wɪs]. Only one phoneme in a word changed between correct and error forms in 10 responses (*boat* [boʊt, bɒt, bɒt]), while 16 words had two or three differences (*helicopter* [hɛlikɒptə, hɛdipɒpə, hɛlipɒtə]). Half of the words only had developmental errors (*scissors* [sɪzəz, sɪzəd, sɪdəz]); six words only had atypical errors (*five* [faɪv, fwaɪv]); and seven had both (*spider* [spaɪdə, paɪdə, spaɪdəl]). Half the words in this category had CV(C) syllable shapes (see Table 3).

Different errors

Children said 280 words with different errors across trials (*bridge* [dɹɪdz, wɪdz, fɹɪdʒ]) ($M = 12.7$, $SD = 2.8$, *range* 7–18). Their mean phoneme errors per word was 2.7 (see Table 4). Just over half of these errors were developmental (either AA 20% or delayed 31%), while 49% of the errors were atypical. Bonferroni corrected paired *t*-tests (criterion $p = 0.017$) indicated that children made more atypical errors when saying words differently than the same ($t(21) = 2.85$, $p < 0.01$), but the same proportion of AA ($t(21) = 1$, $p = 0.35$) and delayed ($t(21) = 2.4$, $p = 0.03$) errors. Pearson's correlations, exploring the relationship between age and types of different errors found that younger participants made more AA errors ($r = -.7745$, $p < 0.001$), while older children made more delayed errors ($r = .6413$, $p < 0.01$). The proportion of atypical errors was not correlated with age ($r = .2289$, $p = 0.306$).

Table 3 shows the number of children saying each target word inconsistently in the different error category ($M = 10.8$, $SD = 4.6$, *range* 3–20). Using a criterion of >1 standard deviation from the mean revealed that only 2–4 children made different errors on *boat, rain* and *girl* while 16–20 children made different errors on *helicopter, bridge, elephant* and *umbrella*. Pearson's correlations confirmed that children made more inconsistent errors when saying words with more phonemes ($r = 0.5062$, $p < 0.01$); and more syllables and clusters ($r = 0.5445$, $p < 0.01$), but there was no effect of word frequency ($r = -0.1208$, $p = 0.565$).

Types of errors associated with inconsistent word production

Qualitative analyses of phoneme changes in inconsistently produced words might provide insight into children's word production strategies or identify speech processing deficits. The 280 items produced with different errors across productions were analysed. Four types of inconsistency were identified (see Table 5).

(1) *Alternative developmental error patterns* (e.g. *fish* [pɪt, fɪt, pɪs]) accounted for 58 (21%) of words said with different errors. Children produced a mean of 2.7 target words (*SD* 1.7, *range* 0-5) where inconsistency reflected the use of different typical developmental error patterns.
(2) *Atypical errors* previously reported as markers for SSD contributed 69 (25%) of children's different errors ($M = 3.1$, *SD* 1.6, *range* 0-6). The atypical error was usually only evident in one of a target word's productions. Three patterns identified affected consonants: backing (e.g. *jump* [k:ʌmp, dʌmp]); affrication (e.g. *shark* [tʃak, sak]); and initial consonant deletion (e.g. *thankyou* [ætu, tætu]). Fifteen vowel errors, alone, led to inconsistency (e.g. *fish* [faɪs, fʌs, fɪs]; *five* [faɪ, fi]). Other inconsistently said words also had vowel errors as 18% of all vowels were in error (see PVC, Table 2).
(3) *Default speech sound substitutions*, implemented inconsistently, contributed 64 (23%) of different errors made by 18 children ($M = 2.9$, *SD* 3.2 *range* 0–15). For example, one child marked most syllable initial consonants with [h] (*dinosaur* [haɪnəhɔ, haɪhəhɔ]; *cake* [heɪ, neɪk, heɪk]); final consonants were often deleted but sometimes marked (*witch* [hɪt, hɪ]; *zebra* [hiha, hɛbhɛ]). Other children showed a more limited default sound use: [w] for initial fricatives (*sheep* [wip]; *fish* [wɪs]

scissors [wɪsəz]); and default word endings (*chips* [ʃɪpiə, pæʃiə], *witch* [wiə, wɪ:iə]; *bridge* [bɪ, bɪk], *chips* [tɪk ti]). Syllable final consonants were deleted by 14 children. Only eight marked all final consonants, often using different errors (*teeth*: [tis, tits, tit]), Final consonants were often deleted in one production but marked in others (*fish*: [fɪ, vɪʃ, ɹɪt]).

Word structure sequencing errors

The remaining 89 (32%) of words with different errors could not be assigned to any of the above categories. However, productions often reflected the target's phonemes, syllables, or word structure: e.g. *birthday cake* [bɛ:ədi di, keɪ:ə:bɜdi] (syllable metathesis); *elephant* [ɛtətən, ɛlə, fa] (one production captured word structure, while the other two captured sounds in syllables); [ɛli:æt, ɛlɔntət, ɛleɪ:ɛt] (initial and final sounds marked). Data in Table 5 suggest that length and types of syllable shape affect phoneme selection and sequencing; errors rarely break phonological constraints of the target system (only one exception [bvɪdz] *bridge*); and that repeated productions show knowledge of different aspects of a word's phonological structure (e.g. [k:æɹət] [pʌɹɪt] [pæwɪt] *parrot*).

Data from children with typical development (reported in Holm et al., 2022, see Appendix 3 for summary of methodology and word classification) and IPD were compared, revealing differing quantitative and qualitative profiles (see Table 6). While the TD study sampled 15 words twice, rather than 25 words three times, its quantitative findings fit with previous research (see Table 1). A chi-square test found that there was a statistically significant difference between TD and IPD children's proportions of words

Table 5. Children with IPD: Examples of individual children's inconsistent productions.

wɪs wɪʃ *witch*	bɪdʒ bɪd bɪdz *bridge*	tæŋkju sæŋkju *thankyou*
Different word productions associated with developmental errors		
dʌmp tʌmp *jump*	s:ɪs bɪs f:ɪs *fish*	ʌpwɛwə bɛwə *umbrella*
ti si *sheep*	paɪb paɪ *five*	slipi sɪpli *slippery*
tif tis *teeth*	dʌm dʌp dʌ *jump*	kæŋwu kæŋʌwu *kangaroo*
ʃɪps sɪps *chips*	daɪsɔ daɪnoʊzɔ *dinosaur*	tæŋawu tænʌɹu *kangaroo*
**Different word productions associated with atypical errors*		
tis tits tit *teeth*	æŋku jæŋkju *thankyou*	k:ʌmp dʌmf kəʌmp *jump*
tʃa ʃa *shark*	eɪdibɔd ædbɔd *ladybird*	kʌŋ dʌn *tongue*
dʒaɪ daɪ *slide*	ɔdə paɪdə haɪdə *spider*	faɪ aɪd *five*
fɹɪd fɹɪ *bridge*	pæwət tæɹət æɹət *parrot*	k:æɹət pʌɹɪt pæwɪt *parrot*
tʃip sip *sheep*	æŋ ju æ:u æŋkju *thankyou*	ʌnbɛ:ə ʌmbɛ:ə *umbrella*
Different productions associated with default errors: sounds, word endings, word forms		
waɪv faɪz waɪz *five*	kʌ tʌ ti:ə *tongue*	zɛgə zɛzə *zebra*
wɪsəz kwɪdəl *scissors*	bʌ:iə bibʌi *umbrella*	waɪbɔ waɪbɔbɔ *ladybeetle*
slɛvə lɛvə zɛvə *zebra*	kʌiə tʌiə tʌi *umbrella*	hʌmp pʌmp *jump*
vɪz vɪdz bvɪdz *bridge*	fɛbiə fwɛbi *zebra*	hæŋhu hæŋhuhu *kangaroo*
Different productions due to phoneme sequencing and word structure errors		
bɪ ɪf faɪ *fish*	ʌmgɛbə ʌmbɛbə *umbrella*	ɛzpənt ɛlənt ɛləŋ *elephant*
bɹɪ bɪʒ bi *bridge*	hʌmwədə ʊnwɛlə *umbrella*	ɛbʌpət ɛbupɪt ɛlabɛt *elephant*
zɛbʌ dɛzʌ zɛdʌ *zebra*	juɹeɪjʌ ɹeɪjʌ bɹeɪjʌ *umbrella*	ɛli:æt ɛlɔntət ɛleɪ:ɛt *elephant*
slɪfi sɪfi sɪpfi *slippery*	ʌmiʌŋbi ʌmbiwɛlʌ *umbrella*	ɛnəpə ɛl ɛnəli *elephant*
faɪd haɪd tɹaɪ *slide*	pɪpihaɪd pɪsisaɪd *slippery slide*	bɜpiz i bɜsbiz *birthday cake*
bɛ:ədi di keɪ:ə:bɜdi *birthday cake*		

*See also Appendix 2.

Table 6. Percentage scores: Comparison of TD and IPD children's quantitative and qualitative consistency of word production.

Measures	Typical Development $N = 96$* Age: 3;2–5;0	Inconsistent Phonology $N = 22$ Age: 3;1–5;6
Percent words produced consistently	81.7	43.4
Percent correct	58.8	5.2
Percent same error	22.9	38.2
Percent words produced inconsistently	18.3	56.6
Percent one right/one wrong	8.7	4.8
Different errors	9.6	51.8
Qualitative analysis of errors in words pronounced inconsistently		
Alternative developmental errors	56	20.7
Recognised atypical errors (including vowel errors alone)	21 (0.6)	24.6 (5.4)
Default substitutions	0	23
Word structure errors	21.6	32

*from Holm et al. (2022).

pronounced correctly across trials with words pronounced with different errors ($\chi^2(2) = 73.53$, $p < 0.001$). The TD children most frequently produced both words correctly, while children with IPD most often made different errors. Comparison of the most frequently used category of error associated with inconsistency was also significant ($\chi^2(2) = 13.48$, $p < 0.001$). TD children's inconsistency mainly resulted from alternative developmental errors, while children with IPD most often made word structure errors. None of the TD children produced default speech sounds, while 23% of the IPD group's errors fell in this category.

Discussion

This paper explored data from 22 children with IPD who made inconsistent errors despite having no segmental or suprasegmental signs of CAS. When naming 25 pictures on three trials, more than half the words had different errors. Few words were produced correctly across trials, so most words said consistently had the same error. Over 50% of phoneme errors were developmental (i.e. age appropriate or delayed). Words with more phonemes, syllables and consonant clusters were vulnerable to inconsistency. Qualitative analyses of inconsistent errors categorised 55% of target words pronounced with different errors as having default substitutions or word structure errors, reflecting inaccurate phoneme sequencing. Quantitative and qualitative performance profiles of TD children (Holm et al., 2022) and children with IPD differed. The findings are discussed in terms of the research questions posed.

Proportions of words pronounced the same and differently

The IPD sample said 5% of words consistently correctly and 38% with the same error. Only 5% of words were correct in some trials but in error on others, while 52% had different errors. Mean inconsistency (57%) scores replicated previous studies of IPD for English (51–62%: Bradford-Heit & Dodd, 1998; Crosbie et al., 2005; McNeill et al., 2022) and other languages (e.g. Mandarin, 58%: Hua & Dodd, 2000; Korean, 68%: Pi & Ha, 2020). Low mean PCC scores (range 30–57%) reported by these studies fit with the current participants' mean

PCC of 42.3% and 2.4 errors per word. This profile differs from TD children's performance means: inconsistency 9.2%; PCC 90 (range 85–93); errors per word 1.8 (Holm et al., 2022).

High inconsistency, low PCC and multiple errors per word often make children's speech unintelligible. Furthermore, children identified with IPD at 4 years have persistent speech difficulties at 7 years (Morgan et al., 2017). McNeill et al. (2022) followed-up 39 children with IPD five times over two years and found that intervention led to little change in consistency or accuracy. The identification and treatment of children with IPD is, then, challenging. Information from qualitative measures of inconsistency might better support these children's clinical management by allowing more reliable identification of subgroups of SSD and better understanding of their phonological strengths and weaknesses.

Proportions of error types for words said the same and differently

Although more atypical errors were made in words said inconsistently than consistently, most IPD speech errors (56%) reflected typical phonological development. Clinically, if preschool children's speech errors are often developmental, they may be considered a low priority for intervention. It might also explain why therapy would target error patterns (e.g. final consonant deletion) or speech sound articulation, especially if consistency had not been assessed and identified as an issue. Theoretically, developmental errors demonstrate that children with IPD are aware of the contrasts and constraints of their phonological system, suggesting that their phonological representations of words are largely intact (Crosbie et al., 2005).

This conclusion fits with previous research indicating that children with IPD often have phonological awareness abilities within the normal range and better than those of most other children with SSD on tasks assessing detection of phonological legality, rhyme, alliteration, and phoneme deletion. For example, many children with IPD acquire age-appropriate reading comprehension and sound-letter correspondence (Dodd et al., 1995) although spelling is at risk (Holm et al., 2008). They also outperform others with SSD on executive function tasks (rule derivation and cognitive flexibility) that underpin phonological learning (Crosbie et al., 2009). Most importantly, intervention targeting phonological planning skills, by teaching production of a core vocabulary of 70 words, leads to generalisation of consistency and better accuracy in untreated words (Crosbie et al., 2021). Furthermore, therapy focusing on phonological planning has been shown to be more effective than intervention focusing on rule abstraction of phonological contrasts (Crosbie et al., 2005). These outcomes require intact phonological representations of words, suggesting that the deficit causing IPD affects post-lexical processing: the ability to assemble a phonological plan for speech output.

Target word characteristics and consistency of production

For TD children, words with more syllables and consonant clusters are at risk for inconsistency (Holm et al., 2022; Macrae, 2013) and high-frequency words are said more accurately and consistently (Sosa & Stoel-Gammon, 2012). This study of children with IPD found that the number of phonemes in a word, and syllables with clusters, posed a greater risk to consistent production than low frequency of occurrence. This may be due to target word choice of high-frequency words, many of which are multisyllabic (see Table 3).

Types of phoneme changes when words are said differently

Holm et al. (2022) categorised 96 TD children's 143 inconsistent errors into three categories: alternate developmental errors (56%, *frog* [fɒg, fwɒg]); atypical patterns (21%, *screwdriver* [sudɹaɪvə, sugaɪvə]); and word structure errors attributed to poor planning of the sequence of phonemes in words (22%, *octopus* [ɒptəkʊpʊs, ɒptəkʊs]). In contrast, 22 children with IPD made 280 inconsistent errors categorised as follows: alternate developmental errors (21%); atypical patterns (25%) and word structure/phoneme sequencing errors (32%). An additional error category, not apparent in TD children's speech, was default sound substitutions (23%, see Table 5). Three error categories giving rise to inconsistency were then shared between the two groups, although the proportion of errors in categories varied (see Table 6).

Alternate developmental errors reflect knowledge of the contrasts and constraints of the phonological system being acquired. Since children with IPD often have intact phonological awareness skills (Dodd et al., 1995), the finding that they made many fewer alternate developmental errors than the TD group seems odd. It can, however, be explained if the deficit giving rise to inconsistency, is post-lexical phonological planning. While the proportion of inconsistencies due to atypical errors was similar for the two groups, vowel errors contributed more of the IPD group's atypical errors reflecting their low PVC score. Their vowel errors might reflect a focus on consonant selection or default vowel word endings (see Table 5).

The IPD group's high proportion of word structure and phoneme sequencing errors is consistent with a hypothesised deficit in phonological planning. For example, repeated productions of a lexical item often reflected different aspects of a word's phonological structure (e.g. *elephant* [ɛtətən, ɛlə, fa]; *helicopter* [hʌnədɒlətə, hɛlɪtɒptə]). These are not random errors but rather seem to be attempts to match the production plan to the adult form. In contrast, the use of a default sound sequence may be a strategy to mark a segment of a word, when the correct segment cannot be accessed. Both default errors and word structure errors lead to an incorrect phonological plan for word production. When productions of a word differ, it is important to examine each production for clues about what aspects of the representation are included, omitted, or changed in the construction of a phonological plan for output.

Evidence that accuracy and consistency of production is promoted by intervention cueing the order of a word's phonemes supports that explanation (Crosbie et al., 2021). For example, previous treatment case studies of IPD report the use of word templates as a strategy for assembling a phonological plan for a word's production (see McIntosh & Dodd, 2008). For example, Dodd and Poole (2017) reported a child who had previously deleted all syllable final consonants, began, mid-therapy, to mark them with/n/, 'reducing the effort involved in selecting and sequencing the correct sounds in words' (p. 234). Default sound substitutions were used by 81% of children with IPD, often for specified phonetic contexts (e.g. syllable initial and word final). Such default sound substitutions were not observed in the TD study and might provide an important marker for identification of IPD.

Limitations

Interpretation of speech errors from a small group of children with IPD, on a limited data set, must be cautious. Although error data are symptomatic of impaired speech processing, deficit identification is inferential, requiring further investigation. No previous studies, however, have qualitatively analysed inconsistent errors of children with IPD. Future studies might compare these data to the inconsistent errors of children diagnosed with CAS, as McNeill et al. (2022) argued that ‘inconsistent speech errors should not be used as the sole diagnostic feature of CAS’ (p.13). This initial attempt to qualitatively describe the inconsistent errors of children with IPD, plus Holm et al.’s (2022) study of TD children, provide preliminary data relevant for theory and clinical management of all children making inconsistent errors.

Conclusions: theoretical and clinical implications

Inconsistent errors pose a challenge for theory of speech development and disorder, classifications of SSD subgroups and intervention practice. For example, consider a child who spontaneously says *helicopter* as [hɛlikɒptə, hɛdipɒpə, hɛlipɒtə] in three separate picture naming trials in one assessment session and yet has adequate speech perception, motor-speech and cognitive-linguistic abilities. How can such inconsistency, affecting more than half the words the child produces, be explained? Levelt et al.’s (1999) speech output model can account for paediatric IPD: it includes a linguistic stage for planning the sequence of words’ phonemes that is separate from a second stage that encodes phonetic motor-speech gestures for word production (Laganaro, 2019). The major clinical implication of the quantitative and qualitative profiles reported is that children with IPD differ from those of TD children (Holm et al., 2022), and require specific assessment protocols and intervention, described by Crosbie et al. (2021).

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References

American Speech-Language-Hearing Association. (2007). *Childhood apraxia of speech* [Position Statement]. https://www.asha.org/policy/ps2007-00277/

American Speech-Language-Hearing Association. (n.d.). *Childhood apraxia of speech: Signs and symptoms*. https://www.asha.org/practice-portal/clinical-topics/childhood-apraxia-of-speech

Bradford-Heit, A., & Dodd, B. (1998). Learning new words using imitation and additional cues: Differences between children with disordered speech. *Child Language Teaching and Therapy*, *14* (2), 159–179. https://doi.org/10.1177/026565909801400203

Broomfield, J., & Dodd, B. (2004). Children with speech and language disability: Caseload characteristics. *International Journal of Language and Communication Disorders*, *39*(3), 303–324. https://doi.org/10.1080/13682820310001625589

Broomfield, J., & Dodd, B. (2005). Clinical effectiveness. In B. Dodd (Ed.), *Differential diagnosis and treatment of children with speech disorder* (pp. 211–230). Whurr.

Brysbaert, M., Mandera, P., McCormick, S. F., & Keuleers, E. (2019). Word prevalence norms for 62,000 English lemmas. *Behavior Research Methods*, *51*(2), 467–479. https://doi.org/10.3758/s13428-018-1077-9

Bürki, A. (2018). Variation in the speech signal as a window into the cognitive architecture of language production. *Psychonomic Bulletin & Review*, *25*(6), 1973–2004. https://doi.org/10.3758/s13423-017-1423-4

Burt, L., Holm, A., & Dodd, B. (1999). Phonological awareness of 4-year-old British children: An assessment and development data. *International Journal of Language and Communication Disorders*, *34*(3), 311–335. https://doi.org/10.1080/136828299247432

Butterworth, B. (1992). Disorders of phonological encoding. *Cognition*, *42*(1–3), 261–286. https://doi.org/10.1016/0010-02779290045-J

Clark, J., Yallop, C., & Fletcher, J. (2007). *An introduction to phonetics and phonology* (3rd ed.). Wiley-Blackwell.

Clausen, M., & Fox-Boyer, A. (2022). Diagnostic validity, accuracy and inter-rater reliability of a phonological assessment for Danish-speaking children. *Journal of Communication Disorders*, *95*, 106–168. https://doi.org/10.1016/j.jcomdis.2021.106168

Crosbie, S., Holm, A., & Dodd, B. (2005). Intervention for children with severe speech disorder: A comparison of two approaches. *International Journal of Language and Communication Disorders*, *40*(4), 467–491. https://doi.org/10.1080/13682820500126049

Crosbie, S., Holm, A., & Dodd, B. (2009). Cognitive flexibility in children with and without speech disorder. *Child Language Teaching and Therapy*, *25*(2), 250–270. https://doi.org/10.1177/0265659009102990

Crosbie, S., Holm, A., & Dodd, B. (2021). Core vocabulary intervention. In A. Williams, S. McLeod, & R. McCauley (Eds.), *Intervention for speech sound disorders in children* (2nd ed., pp. 225–249). Brookes.

Dodd, B. (1982). Subgroups of phonologically disordered children. *Neurolinguistics and Speech Pathology Conference*, University of Newcastle upon Tyne, UK.

Dodd, B. (2014). Differential diagnosis of pediatric speech sound disorder. *Current Developmental Disorders Reports*, *1*(3), 189–196. https://doi.org/10.1007/s40474-014-0017-3

Dodd, B., Gillon, G., Oerlemans, M., Russell, T., Syrmis, M., & Wilson, H. (1995). Phonological disorder and the acquisition of literacy. In B. Dodd (Ed.), *Differential diagnosis and treatment of children with speech disorder* (pp. 125–148). Whurr.

Dodd, B., Holm, A., & Crosbie, S. (in press). Clinical phonology and phonological assessment. In M. Ball (Ed.), *Handbook of clinical linguistics* (2nd ed.). Wiley.

Dodd, B., Holm, A., Hua, Z., & Crosbie, S. (2003). Phonological development: A normative study of British English-speaking children. *Clinical Linguistics and Phonetics*, *17*(8), 617–643. https://doi.org/10.1080/0269920031000111348

Dodd, B., Hua, Z., Crosbie, S., Holm, A., & Ozanne, A. (2002). *Diagnostic evaluation of articulation and phonology (DEAP)*. Pearson.

Dodd, B., & McCormack, P. (1995). A model of speech processing for differential diagnosis of phonological disorders, Chapter 4. In B. Dodd (Ed.), *Differential diagnosis and treatment of children with speech disorder* (pp. 65–89). Whurr.

Dodd, B., & McIntosh, B. (2008). The input processing, cognitive linguistic and oro-motor skills of children with speech difficulty. *International Journal of Speech-Language Pathology*, *10*(3), 169–178. https://doi.org/10.1080/14417040701682076

Dodd, B., McIntosh, B., Leahy, M., & Murphy, N. (2009). Atypical speech in Irish children: Identification and differential diagnosis of speech sound disorder in a clinical population. *Journal of Clinical Speech and Language Studies*, *17*, 4–24.

Dodd, B., & Poole, M. (2017). A case of inconsistent phonological disorder: A three year follow-up. In B. Dodd & A. Morgan (Eds.), *Intervention case studies of speech impairment* (pp. 223–246). J&R Press.

Duffy, J. R. (2013). *Motor speech disorders: Substrates, differential diagnosis, and management*. Mosby.

Duffy, J., Utianski, R., & Josephs, K. (2021). Primary progressive apraxia of speech: From recognition to diagnosis and care. *Aphasiology*, *35*(4), 560–591. https://doi.org/10.1080/02687038.2020.1787732

Fox, A. (2000). *Acquisition of phonology and classification of speech disorders in German-speaking children* [Unpublished PhD Thesis]. University of Newcastle-upon-Tyne.

Grunwell, P. (1982). *Clinical phonology* (2nd ed.). Croom Helm.

Ha, S. (2020). Variability and inconsistency in children with and without speech sound disorders. *Communication Science and Disorders*, *25*(2), 431–440. https://doi.org/10.12963/csd.20714

Haley, K., Jacks, A., & Cunningham, K. (2013). Error variability and the differentiation between apraxia of speech and aphasia with phonemic paraphasia. *Journal of Speech, Language, & Hearing Research*, *56*(3), 891–905. https://doi.org/10.1044/1092-43882012/12-0161

Hemsley, G., & Holm, A. (2017). Intervention for a bilingual child with a speech disorder. In B. Dodd & A. Morgan (Eds.), *Intervention case studies of speech impairment* (pp. 319–336). J&R Press.

Holm, A., Crosbie, S., & Dodd, B. (2007). Differentiating normal variability from inconsistency in children's speech: Normative data. *International Journal of Language and Communication Disorders*, *42*(4), 467–486. https://doi.org/10.1080/13682820600988967

Holm, A., Farrier, F., & Dodd, B. (2008). The phonological awareness, reading accuracy and spelling ability of children with inconsistent phonological disorder. *International Journal of Language and Communication Disorders*, *43*(3), 467–486. https://doi.org/10.1080/13682820701445032

Holm, A., van Reyk, O., Crosbie, S., De Bono, S., Morgan, A., & Dodd, B. (2022). Preschool children's consistency of word production. *Clinical Linguistics and Phonetics*, *37*(3), 223–241. https://doi.org/10.1080/02699206.2022.2041099

Hua, Z., & Dodd, B. (2000). Putonghua (modern standard Chinese)-speaking children with speech disorder. *Clinical Linguistics and Phonetics*, *14*(3), 165–191. https://doi.org/10.1080/026992000298814

Iuzzini-Seigel, J., Hogan, T., & Green, J. (2017). Speech inconsistency in children with childhood apraxia of speech, language impairment, and speech delay: Depends on the stimuli. *Journal of Speech, Language, & Hearing Research*, *60*(5), 1194–1210. https://doi.org/10.1044/2016_JSLHR-S-15-0184

Jones, S. (2020). Accuracy and variability in early spontaneous word production: The effects of age, frequency and neighbourhood density. *First Language*, *40*(2), 128–150. https://doi.org/10.1177/0142723719894768

Laganaro, L. (2019). Phonetic encoding in utterance production: A review of open issues from 1989 to 2018. *Language, Cognition and Neuroscience*, *34*(9), 1193–1201. https://doi.org/10.1080/23273798.2019.1599128

Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, *22*(1), 1–75. https://doi.org/10.1017/S0140525X99001776

Macrae, T. (2013). Lexical and child-related factors in word variability and accuracy in infants. *Clinical Linguistics and Phonetics*, *27*(6–7), 497–507. https://doi.org/10.3109/02699206.2012.752867

Macrae, T., & Sosa, A. V. (2015). Predictors of token-to-token inconsistency in preschool children with typical speech-language development. *Clinical Linguistics & Phonetics*, *29*(12), 922–937. https://doi.org/10.3109/02699206.2015.1063085

Martikainen, A.-L., Savinainen-Makkonen, T., & Kunnari, S. (2021). Speech inconsistency and its association with speech production, phonological awareness and nonword repetition skills. *Clinical Linguistics & Phonetics*, *35*(8), 743–760. https://doi.org/10.1080/02699206.2020.1827296

McCormack, P., & Dodd, B. (1996). A feature analysis of speech errors in subgroups of speech disordered children. In P. McCormack & A. Russell (Eds.), *Proceedings of the sixth Australian international conference on speech science and technology* (pp. 217–221). Australian Speech Sciences and Technology Association.

McIntosh, B., & Dodd, B. (2008). Evaluation of core vocabulary intervention for treatment of inconsistent phonological disorder: Three treatment case studies. *Child Language Teaching and Therapy*, *24*(3), 307–327. https://doi.org/10.1177/0265659007096295

McNeill, B., McIlraith, A., Macrae, T., Gath, B., & Gillon, G. (2022). Predictors of speech severity and inconsistency over time in children with token-to-token inconsistency. *Journal of Speech, Language, & Hearing Research*, *65*(7), 2459–2473. https://doi.org/10.1044/2022_JSLHR-21-00611

Morgan, A., Eecen, K. T., Pezic, A., Brommeyer, K., Mei, C., Eadie, P., Reilly, S., & Dodd, B. (2017). Who to refer for speech therapy at 4 years of age versus who to "watch and wait"? *Journal of Pediatrics*, *185*, 200–204. https://doi.org/10.1016/j.jpeds.2017.02.059

Pi, M., & Ha, S. (2020). Classification of subgroups of children with speech sound disorders: A preliminary study. *Communication Sciences and Disorders*, *25*(1), 113–125. https://doi.org/10.12963/csd.20685

Shriberg, L. D., Fourakis, M., Hall, S. D., Karlsson, H. B., Lohmeier, H. L., McSweeny, J. L., Potter, N. L., Scheer-Cohen, A. R., Strand, E. A., Tilkens, C. M., & Wilson, D. L. (2010). Extensions to the speech disorders classification system (SDCS). *Clinical Linguistics & Phonetics*, *24*(10), 795–824. https://doi.org/10.3109/02699206.2010.503006

Smith, N. (2010). *Acquiring phonology: A cross-generational case-study (Cambridge Studies in Linguistics)*. Cambridge University Press. https://doi.org/10.1017/CBO9780511770692

So, L. K. H., & Dodd, B. (1994). Phonological disordered Cantonese-speaking children. *Clinical Linguistics and Phonetics*, *8*(3), 235–255. https://doi.org/10.3109/02699209408985309

Sosa, A. (2015). Intra-word variability in typical speech development. *American Journal of Speech-Language Pathology*, *24*(1), 24–35. https://doi.org/10.1044/2014_ajslp-13-0148

Sosa, A., & Stoel-Gammon, C. (2012). Lexical and phonological effects in early word production. *Journal of Speech, Language, & Hearing Research*, *55*(2), 596–608. https://doi.org/10.1044/1092-43882011/10-0113

Stackhouse, J., & Wells, B. (1997). *Children's speech and literacy difficulties: A pyscholinguistic framework*. Whurr.

Ttofari Eecen, K., Eadie, P., Morgan, A., & Reilly, S. (2019). Validation of Dodd's model for differential diagnosis of speech sound disorders: A longitudinal community cohort study. *Developmental Medicine and Child Neurology*, *61*(6), 689–696. https://doi.org/10.1111/dmcn.13993

Waring, R. (2019). *An investigation of the cognitive-linguistic profile of children with phonological delay and phonological disorder* [Unpublished doctoral dissertation]. The University of Melbourne.

Waring, R., & Knight, R. (2013). How should children with speech sound disorders be classified? A review and critical evaluation of current classification systems. *International Journal of Language & Communication Disorders*, *48*(1), 25–40. https://doi.org/10.1111/j.1460-6984.2012.00195.x

Zarifian, T., Ahmadi, A., & Ebadi, A. (2020). Development and measurement of psychometric properties of the Persian test of speech consistency in children with typical development. *Applied Neuropsychology: Child*, *22*(11), 226–234. https://doi.org/10.1080/21622965.2020.1786831

Appendix 1. DEAP normative data* (Dodd et al., 2002): speech sounds articulated at least once, and phonological error patterns used in ≥ 5 different lexical items by ≥ 10% of children in each age group.

Age	All sounds articulated except	Acceptable error patterns	
3;0–3;5	/ʃ ʒ tʃ dʒ θ ð ɹ/	Gliding	Cluster reduction
		Deafffrication	Weak syllable deletion
		Fronting	Stopping
3;6–3;11	/ʃ ʒ dʒ θ ð ɹ/	Gliding	Cluster reduction
		Deafffrication Fronting	Weak syllable deletion
4;0–4;11	/ʃ θ ð ɹ/	Gliding	Deafffrication
		Reduction of three element clusters	
5;0–5;11	/θ ð ɹ/	Gliding	
6;0–6;11	/θ ð/	None	

*Based on 860 participants aged 2;0–6;11, stratified for gender, socio-economic status and 10 urban and rural geographical areas in UK and Australia.

Examples:

- Gliding: *rain* [weɪn]; *light* [jaɪt]; Deafffrication: watch [wɒʃ], [wɒᵗs]
- Fronting velars: *kangaroo* [tændʌɹu]; Fronting fricatives: *sheep* [sip], *three* [fɹi]
- Cluster reduction: *spider* [paɪdə], *train* [teɪn], *elephant* [ɛlɛfən], *umbrella [*ʌmbəɹɛlʌ], *splash* [pæʃ], *square* [kwɛə], *strawberries* [təbɛɹiz]
- Weak syllable deletion *elephant* [ɛfənt], *helicopter* [heɪkɒptə]; *umbrella* [bɹɛlʌ]
- Stopping: *gloves* [glʌbz], *teeth* [tit], *five* [paɪv], *zebra* [dɛbrʌ], *house* [haʊt].

Note: Atypical patterns, used by ≤10% of normative sample in any age group that were identified in the IPD data were as follows: syllable initial consonant deletion; affrication of fricatives and clusters, and backing.

Appendix 2. Default sound sequences from 18 children with IPD, number of target words affected and examples.

Default Sound Sequences	Frequency	Examples
[w] for WI fricatives	6	*fish* [wɪs[, *scissors* [wɪsəz], *zebra* [wɛbʌ], *sheep* [wip], *shark* [wat]
[d] marker for SI consonant	11	*shark* [da], *parrot* [pædi], *hoover* [dudə], *you* [du], *fish* [dɪ]
[stops] mark glides and WI fricatives	11	*scissors* [kɪdʌd], *helicopter* [hɛbikɒptə], *slide* [kaɪd], *shark* [gat] *you* [ku]
Words end with vowel cluster [ɪə]	11	*scissors* [kɪ:iə], *ladybird* [weɪ:ibiə], *witch* [wɪiə], *zebra* [fɛbiə] *cockatoo* [koʊtuə]
[j+vowel] marks last syllable	6	*parrot* [pæjə], *jump* [soʊjɜ], *hoover* [hujə], *umbrella* [jʌmbeɪjʌ], *helicopter* [hɛlikɔɪjə]
[h] SI substitute	23	*scissors* [hɪtɪ], *witch* [hɪt], *five* [haɪd], *tongue* [hʌŋ], *vacuum* [hætju],
[f, v] marks stops in clusters	7	*umbrella* [ʌnvəlɔ]; *zebra* [lɛvə]; *bridge* [vɪdz], slippery [slɪfi]
[h] clusters and fricatives	8	*shark* [hak], *slide* [haɪd], *five* [haɪv], *fish* [hɪʃ], *sheep* [hɪp], *spider* [haɪdə]
Syllable reduplication	5	*zebra* [bɛbə], *fish* [ʃɪʃi], *helicopter* [tɒtɒtə], *brella* [wɛwə], *elephant* [jɛjə]
[k/g] for WF cons	11	*boat* [boʊg], *jump* [dʌk], *bridge* [bɪk], *teeth* [tik], *chips* [tɪk]
Glides marked by [t]	5	*parrot* [pætə], *elephant* [ɛtəfən], *umbrella* [ʌmbɜtoʊ], *slide* [taɪ],*helicopter* [hɛtitɒptə],

(*Continued*)

(Continued).

Default Sound Sequences	Frequency	Examples
[d] to mark intervocalic consonants	6	*zebra* [zɛdʌ], *parrot* [pædət], *umbrella* [ʌbɛdʌ], *helicopter* [h0252dəkɒtə], *yellow* [lɛdoʊ]
[w] marks WI fricatives	9	*zebra* [wibə], *shark* [wa:ʔ], *slide* [weɪ], *scissors* [wɪ:ɪ], *chips* [wɪp],
[d] to mark WI SIWW consonants	10	*zebra* [dɛdwə], *elephant* [adɛnt], *helicopter* [dɛlidɒtə], *fish* [dɪ], *sheep* [di]
[d] to mark SIWW consonants	9	*zebra* [ɛdʌ], *parrot* [pædət], *kangaroo* [ædu], *elephant* [ɛdɪt], *umbrella* [ʌbʌdə]
[n] marks/l/	7	*lady* [neɪdi], *light* [naɪt] *helicopter* [hɛnədɒtə], *umbrella* [ʌbʌnʌ], *yellow* [ɛnoʊ]
[t/d] mark fricatives/clusters	6	*fishing* [dɪti], *elephant* [ɛlədə], *hoover* [hudə], *dinosaur* [daɪdidɔ] *jump* [wɒd]
Syllables deleted/marked by vowel	9	*thankyou* [æ:u], *helicopter* [ɛ:i:ɒ:ə], *elephant* [ɛ:ɛ:ɛ], *ladybird* [deɪbɜ], *umbrella* [ɹɛ]

Appendix 3. Typically developing children’s inconsistent errors (from Holm et al., 2022).

Summary of methodology

There were 96 participants aged 30–60 months, half female, who participated in a large normative study of speech development currently being conducted in Australia. They attended nine childcare centres or schools selected to provide a sample stratified for socio-economic status (SES) based on data from the Australian Bureau of Statistics. In one task, they named 15 pictures twice, in separate trials, to measure the consistency of word production. Words selected had been error prone in pilot trials. The mean number of words produced with different errors was 10% of 1440 words named twice. Of these 143 words, 56% were classified as being due to alternate developmental errors (see Appendix 1 for developmental error criteria) and 22% involved at least one atypical error (error patterns not apparent in 10% of normative data at any age: in this sample restricted to initial consonant deletion; backing; affrication and frication of other consonants/clusters; and, vowel errors). The remaining 31 errors (22%) were characterised by word structure sequencing errors. The mean point-to-point reliability was 95.05% (SD 3.7, confidence interval ±2.3%) for transcription reliability and error classification was checked and agreed by authors. All words produced with different errors are in the list below.

Data for typically developing children across four age groups (36–60 months): All occurrences of both words in error

36–42 months: 56 words with different error forms from *n* = 24 children		
Differences between word pairs due to developmental errors: 30/56 = 54%		
fwɔ fwɔg	bækjʉ:mki:nə bækjʉ:mkli:nə	*skɹʉ:dɑevə skʉ:dɹɑevə
ɹɔg fɹɔk	vækɹʉ:mkli:nə vægɹʉ:mkli:nə	skwʉ:dɹɑevə skʉ:dɹɑevə
bɔg fɔg	bækjʉ:kli:nə bækʉ:kli:nə	sɹʉ:dɹɑevə sɹʉ:ɹɑevə
flɔg fwɔg	lɐnbɔks lɐnbɔts	skwʉ:dwɑevə skwʉ:dɹɑevə
sɹo:beɹi:z sɹo:beɹi:	lɐmpɔks lɐmpɔk	fwɪŋkəl fwɪŋkəlz
sto:bewi:z do:bewi:z	lɐnbɔks lɐntbɔks	bɪkəlz bɪŋkəlz
sto:bi:z stɹo:bi:z	lɐnbɔks lɐbɔk	ɹɪŋkəl sɹɪŋkəl
so:bewi:z do:bewi:z	ʃi: tʃi:	kæɹʉ: kæwʉ:

(*Continued*)

(Continued).

tɹo:bɹi: do:bwi:z	efənt eləfən	slæʃ tlæʃ
sto:bewi:z stɹo:bewi:z	kwæɔd kwæɔ:	
Differences in word pairs involving an atypical error: 11/56 = 20%		
*stɹo:bwi:z ʃo:bɹi:z	tʃo:bɹi: sto:bewi:	flæʃ flæs
tʃo:bɹi: sto:bewi:	pɹɪŋkəlz fɹɪŋkəlz	kɹʉ:dɹɑevə kɹʉ:gɹɑevə
stɹo:bi:z gɹo:bi:z	fwɪŋkəlz kwɪŋkəlz	fɹʉ:dɹɑevə fɹʉ:dɹɑe:ə
tʃo:bɹi:z fɹo:bɹi:z		
Differences in word pairs due to syllable and word structure errors: 15/56 = 27%		
æpsəpʊs ɔptəpʊs	spɹɪŋkə:s spwɪŋkʊs	hɔtəkɔtə hɔli:kɔtə
ɔtəpʊspʊs ɔtəpʊs	spwɪŋkʊzə pwɪŋkəw	heli:kɔftə heli:kɔktə
ɔpəpʊs ɔptəpʊs	bæjʉ:ti:mə bækjʉ:mti:nə	ejɐtɔkwə ewi:tɔktə
kæŋgɹʉ: kænjʉ:	bɹækjʉ:ki:nə bækjʉ:mki:nə	hewəkɔtə hewəklɔtə
eflənt efənt	dʉ:dɹɑevə nʉ:dɹɑeʃə	hepətɔktə hɔkdətelə
43–48 months: 38 words with different error forms from *n* = 24 children		
Differences between word pairs due to developmental errors: 23/38 = 61%		
*fɔg fwɔg	skʉ:dɹɑevə ɹʉ:dɑevə	bɪŋkəlz pɪŋkəlz
*efənt ewəfənt	stʉ:dɹɑevə stɹʉ:dɹɑevə	pɹɪŋkəlz spɹɪŋgəlz
pæs plæs	stʉ:dɑevə dʉ:dɑevə	pɪŋkəlz pɹɪŋkəlz
bæs bæʃ	tɹɔbwi: tɹɔbɹi:z	fɔdi: fɹɔdi:
splæs spæs	stɹɔbewi:z stwɔbewi:z	klæɔs kæɔs
jɐntʃbɔks jɐntbɔks	wɔbewi:z stɔbewi:z	heli:tɔtə hedɔtə
lɐnsbɔks lɐbɔks	bækjʉ:mkwi:nə bækjʉ:mtwi:nə	heli:kɔktə heli:tɔktə
Differences in word pairs due to atypical errors: 8/38 = 21%		
sɔbi:z tʃɔbɹi:z	bægʉ:gi:nə vægjʉ:ngi:nə	li:p si:p
pjɔbɹi:z sjɔbɹi:z	gækjʉ:mki:nə bækjʉ:ki:nə	wɪts wɪθ
fʉ:fɑevə fʉ:dɑevə	spɹɪgəlz spɹɪnəlz	
Differences in word pairs due to syllable and word structure errors: 7/38 = 18%		
hewi:tɔktə hewi:tɔtə	ʃʉ:dɹɑevə dʒʉ:dʒɑevə	pwɪŋkəlz pətʃɪŋkəlz
hɔktətelə hetətɔktə	spwæs ɸpwæs	pɹɪŋkəlz ɸpwɪŋkəlz
æzəkɔptə hewəkɔptə		
49–54 months: 21 words with different error forms from *n* = 24 children		
Differences between word pairs due to developmental errors: 10/21 = 48%		
wɐntʃbɔk wɐntʃbɔks	tæŋgəwʉ: kæŋgəwʉ:	skʉ:dɹɑevə skʉ:bɹɑebə
spæʃ spwæʃ	pækwʉ:mti:nə fætwʉ:mtli:nə	stʉ:dɹɑevə skʉ:dɹɑevə
spwæʃ spwæs	wækjʉ:mkli:nə wækjʉ:mkwi:nə	pɹɪŋkəlz bwɪŋkəlz
stɹɔbewi:z stɔbewi:z		
Differences in word pairs due to atypical errors: 6/21 = 29%		
kwæɔs kwæɔdz	dækjʉ:mtli:nə lætjʉ:m tli:nə	kɹʉ:zdɹɑeə kɹʉ:zgɹɑezə
heji:tɔtə eji:dɔtə	sɪŋkəlz sɪ:əlz	sʉ:dɹɑevə sʉ:gɑevə
Differences in word pairs due to syllable and word structure errors: 5/21 = 24%		
ɔptəpʊs heli:pʊts	kwæpʉ:kwi:nə kwæŋkʉ:nkwi:mə	æɔnsənt æɔsənt
kɔjəkɔwə kɔkə	tɹɔbi:bewi:z bwɔwi:z	
55–60 months: 28 words with different error forms from *n* = 24 children		
Differences between word pairs due to developmental errors: 17/28 = 61%		
*fɔg fwɔg	skʉ:tɑeə skɹʉ:tɑeə	skʉ:dɹɑevə stʉ:dɑevə
spwɪŋkəl spɹɪŋkəl	wɪt wɪts	helkɔtə heli:kɔtə
*spɪŋkəlz spwɪŋkəlz	splæs plæʃ	tæŋgəwʉ: kæŋgəjʉ:

(*Continued*)

(Continued).

stɹɔbewi:z sɔbebi:z	klæɔ kwæɔ	bækjʉ:kli:nə bækjʉ:ki:nə
ʃɹɔbewi:z ʃɔbewi:z	ewəbən ewəpən	heləkɔpə heləkɔ:ə
Differences between word pairs due to atypical errors: 7/28 = 25%		
ʃɔbewi:z stɔbewi:z	skʉ:sɑevə skʉ:zɑevə	fɪŋkəlz swɪŋkəlz
stabeɹi: stɔbeɹi:	skʉ:dɹɑevə ʃʉ:dɹɑevə	fɐg fɔg
ɔwi:kɔtə hewəkɔtə		
Differences in word pairs due to word and syllable structure errors: 4/28 = 14%		
ɔptəkʊpʊs ɔptəkʊs	skɹɪŋgəl skɹɪskɪəl	bækjʉ:piə **v**ækjʉ:vi:
ɔpʊ: ɔpəpʊt		

*2 examples.