Warlpiri IDS: Expanding the path to communicative success

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Abstract

The present study examines the spectral and temporal characteristics of Infant Directed Speech (IDS) vowels spoken to young children in the Indigenous Australian language Warlpiri. The results show that vowel hyperarticulation, temporal expansion and pitch raising are characteristics of Warlpiri IDS to children in the third year of life. The results also suggest that vowel space fronting may be a common strategy, and that vowel space and durational expansion may play a didactic role in IDS young children at an age characterised by rapid vocabulary expansion and increased multiword utterances
Index Terms: IDS, ADS, Warlpiri, Vowels, Nouns.

1. Special Speech Registers for Children

The use and characteristics of special Infant and Child Directed Speech registers (IDS; CDS; or in older literature Baby Talk; Motherese) has been argued to be a supportive strategy adopted by carers (mothers, fathers, other carers, and older children) with the aim to scaffold language acquisition. Questions of the universality of IDS have received significant attention in the literature, and cross-linguistic research has demonstrated differences across languages and cultures, and on changes in the characteristics of IDS across development. The present study examines the spectral and temporal characteristics of IDS vowels spoken to young children in the Indigenous Australian language Warlpiri. The results show that vowel hyperarticulation, temporal expansion and pitch raising are characteristics of Warlpiri IDS to children in the early multiword stage of language acquisition and beyond. The results also suggest that vowel space fronting may be a common strategy observed in Warlpiri IDS, and that vowel space and durational expansion may play a particular didactic role in the speech to young children who are at an age where rapid vocabulary expansion is typical, as nouns appear to be the locus of the greatest IDS modifications.

IDS is characterised by a slower speech rate, higher fundamental frequency, and greater pitch variations [1], longer pauses, often repetitive intonational structures [2], and shorter sentences with a more limited lexicon than Adult Directed Speech (ADS) [3]. IDS is also characterised by more hyperarticulation: vowels (and consonants) are often given articulatory/acoustically more extreme realisations, resulting in an expanded articulatory/acoustic vowel space, and increased acoustic/articulatory differentiation [4]. Such vowel hyperarticulation is also a feature of Foreigner Directed Speech (FDS: [5], but not Pet Directed Speech (PDS: [6] unless the pet is a parrot [7], suggesting that slow and clear speech is used as a didactic strategy in communication with individuals/entities who are perceived to be language learners (or at least capable of some language learning) but who are still learning.

IDS has been hypothesised to serve a number of different functions, most likely simultaneously and to varying degrees at different developmental stages, including **(1)** regulating infant attention [8], [9], [10]; **(2)** communicating affect and supporting social interaction [11], [12], [13], and; **(3)** supporting language acquisition [14], [15], [16], [17], the latter of which is the focus here. Vowel hyperarticulation in IDS has been particularly highlighted as potentially facilitating certain aspects of language acquisition: in particular, *segmental acquisition* (the learning of vowels and consonants), and in word-learning. In particular for the first year of life, vowel hyperarticulation has been argued to enhance *segmental learning*, as argued by [18] by providing infants with input containing high-quality and maximally differentiated vowel tokens that infants might attend to preferentially, perhaps due to its prosodic characteristics, as discussed above. Not all studies have shown that all vowels are uniformly *hyper*articulated: In at least one study [19], mothers were found to *hypo*articulate back vowels. This was interpreted to make the articulation more visibly accessible to infants than they are in ADS and thus rather than representing a goal of target undershoot, it indicated *enhancement* in the visual domain (as opposed to the acoustic).

In the second year of life, vowel hyperarticulation has been argued to be helpful in terms of *word-learning*, with research showing that the degree of vowel hyperarticulation in the maternal input at 18 months of age is correlated with the size of the receptive and productive language at 24 months of age [20]. This suggests that extra clarity in the phonemic specifications of words in IDS supports the acquisition of new vocabulary items. Other research has shown that IDS increases neural activity in 6- and 13-month-old infants compared to ADS, which again is argued to assist with the 'word spotting' of young word learners [21]. It is possible that increased neural activity also reflects recognition of being a potential addressee of IDS utterances [22], particularly in older infants and children. The findings in [20] are, however, also consistent with results showing that IDS vowel hyperarticulation (but not an enhanced pitch range) plays an important role in word recognition and word learning. And in one word recognition study, vowel hyperarticulation improved 19-month-olds' performance in word recognition tasks [23]. In another study, using a word learning paradigm, [24] showed that 21-month-olds learned new words only in IDS unless they already had large vocabularies, while 27-month-old toddlers learned new words in both ADS and IDS.

The acoustic characteristics of IDS, however, are not stable across early development [25], [26], [27]. This is generally taken to indicate that carers finetune their IDS to the

developmental stage of the child, including its linguistic development. In a cross-sectional design, [28] showed that the use of vowel space expansion and vowel target precision in IDS changes from infancy into toddlerhood, such that vowels are more hyperarticulated to early word-learners than prelingual infants, and young children who are combining words receive input with particularly hyperarticulated vowels—in both content words and function words. Longitudinal studies have also demonstrated that IDS segmental modifications (hyperarticulation and avoidance of segmental reduction patterns found in adult speech) changes over time. In another study, mothers were found to hyperarticulate vowels to pre-linguistic (<12 months of age) much more than to 5-year-old children and to adults [26], and [25] show that mothers' use of segmental deletion increases between 1;6 and 2;0 years of age only to decrease again between 2;0- 2;6 years of age, suggesting deliberate avoidance of deletion in speech to children during segmental acquisition and again in the early multiword stage of language acquisition. It is plausible that these changes in input characteristics reflect a 'first wave' of hyperarticulation to support vowel learning, and a 'second wave' to support rapid word-learning in the second year of life.

The research findings reported above, however, are predominantly based on studies undertaken in just a few of the worlds' languages [29], leaving large gaps in our knowledge of cross-linguistic IDS patterns. And while most studies indicate that carers do use special registers with children, not all studies have found that carers hyperarticulate vowels at all [30], [31]. Likewise, crosslinguistic comparisons have demonstrated differences in the implementation or degree of hyperarticulation and pitch raising across different languages, when hyperarticulation is present (e.g., [32]). The prosodic system of the target adult language has also been found to influence the particular prosodic modifications made in IDS ([33], as do sociolinguistic considerations ([34], [35]). Taken together, this suggests that the 'shape' of IDS in each language is subject to significant variability and reflects linguistic and sociolinguistic demands outside of the carer-child interaction and the developmental characteristics of the child.

Warlpiri is a Pama-Nyungan language spoken by approximately 2500-3000 people, mostly in the remote communities of Yuendumu, Lajamanu, Nyirrpi, and Willowra, in the Northern Territory (NT), and in regional towns and cities, including Alice Springs and Darwin, NT. Although endangered, Warlpiri continues to be learned by children as their primary language in three of the communities (Yuendumu, Nyirrpi, and Willowra), and as one of their first languages in Lajamanu. Families may travel between the regional towns and cities and remote communities and spend varying amounts of time in one location. The families in this study were recorded while in Alice Springs, where they were staying temporarily.
Phonologically, Warlpiri is characterized by a single series of stops /p t ʈ c k/ with five main places of articulation. This is repeated in the nasal series /m n ɳ ɲ ŋ /, and Warlpiri further has three laterals /l ɭ ʎ/, two approximants /w j/, and two or three rhotic phonemes; trill /r/ approximant /ɻ/, and a retroflex flap /ɽ/, though the phoneme status of the latter has been recently questioned [36]. In terms of vowels, Warlpiri sports only three: /i/, /a/, and /u/, with a phonemic length contrast. The Warlpiri formant space is compact, with a relatively compressed F1 range [37]; who reports the F1/F2 values of a single female Warlpiri speaker, indicating an F1 range of appx. 470-600 Hz (/i/ and /u/ vs /a/, and an F2 range of 1200-2400 Hz (/u/ vs /i/). The three Warlpiri vowels are distributed unevenly in the lexicon according to a vowel count of all entries in PanLex (https://vocab.panlex.org/wbp-000?page=0), with /a/ contributing 45% of vowels, /i/ vowels contributing 33%, and /u/ only 22%, making /u/ only half as frequent as /a/. This is typical for many Australian Indigenous languages. The existing literature on the characteristics of 'Baby Talk' in Warlpiri (and the limited literature on IDS in other Australian languages) has attended particularly to the consonants and to changes to adult wordforms. [38] identifies patterns of substitution of coronal consonants (stops /t ʈ/, nasals /n ɳ/, and laminals /l ɭ/) with the corresponding lamino-palatal consonants /c ɲ ʎ), and the use of special IDS wordforms, for instance, 'apa' for 'ngapa' (water). [39] report similar segmental changes in IDS in the neighbouring language Gurindji Kriol. In addition to coronal place neutralisation through palatalisation, like in Warlpiri, [39] list patterns of rhotic replacement, cluster simplification, deletion, consonant harmony, and replacement of apical postalveolars with apical alveolars as characteristic of Gurindji Kriol IDS. The authors further highlight that these segmental modifications are very common cross-linguistically in IDS and in children's speech development. The present study does not examine consonant modification. Consonant substitution and cluster simplification in Warlpiri and Gurindji Kriol IDS potentially arise from a desire to create wordforms that children can more easily copy in their own production, or that reflect typical child-language forms ⌈38], ⌈39]. IDS phoneme substitution and coronal neutralisation through palatalisation may also be intended to aid speech perception and word recognition, though this of course may in some sense be a double-edged sword. The observed pattern of coronal neutralisation, for instance, effectively eliminates a series of consonant contrasts that can be difficult to discriminate even for adult speakers [40]. Substitutions may also increase the risk of phonological overlap in lexical items used by children. Unfortunately, there is currently no systematic information about the acquisition ages—in terms of speech production as well as speech perception—of the typologically unusual inventories of many Indigenous Australian languages, though cross-linguistic comparisons [41] and informal observations [38], [39] may give some indication of what we might expect for both production and perception. The existing literature on IDS in Warlpiri and other Australian languages also does not offer information about the potential systematic modification of IDS in terms of prosody, vowel quality and vowel quantity, the foci of the present study.

In the following, we report on the acoustic characteristics of vowels in IDS to young Warlpiri-acquiring children by comparing ADS and IDS vowel quality, quantity, and pitch within a group of three adult speakers. The study provides a first examination of IDS vowels in a three-vowel system, where pressures for contrast enhancement might differ from those in languages with more crowded vowel inventories, such as English; or vowel systems (such as Japanese) where vowel duration is phonemic (vowel length is contrastive in only in a very restricted set of words in Warlpiri: [42]). We also examine the characteristics of vowels in IDS nouns relative to 'general' IDS, testing the possibility that IDS at that stage is (at least in part) a didactic strategy for scaffolding vocabulary development in young word-learners.

2. Method

2.1. Participants

We report on data from two Warlpiri-speaking women (A and M) and one Warlpiri-speaking man (G), who were recorded

(video, audio) at their homes in Alice Springs, NT. The women were recorded interacting with each other, a third woman, and three young children, while taking part in play, storytelling and discussion activities, centered on the day-to-day child-rearing activities and interactions with the children. At the time of the recordings, A was in her 50s, and M was appx. 30 y.o. Two of the three children were 28 and 30 months at the time of the recording; the date of birth of the third is not known, but the child was approximately 24 months. The women and children are all close family. The male participant (G; 50+ y.o.) was recorded while taking part in a play and conversation activity with a young child (40 months) and the child's mother, all related.

2.2. Materials

The video/audio recordings of the three adult participants (A, M, G) were transcribed, glossed, and translated into English, and coded for the intended addressee (IDS or ADS on the basis of close viewing of the video recordings) in *ELAN 6.3*. Target vowels were then hand-segmented and labelled in *Praat 6.2.12*., and vowel duration, F0, F1, and F2 extracted using an automatic script. We extracted target measurements from as many IDS vowels as possible from each of the female participants, as well as a roughly matching number of ADS vowels. The male participant provided ~240 IDS vowels but had only one brief ADS interaction during the recording session, providing just nine /i/, /a/, and /u/ tokens. We further coded all IDS vowels from concrete nouns in the IDS of the three speakers, creating two subsets of IDS vowel data: Vowels from (concrete) nouns (IDS Nouns) and vowels from everywhere else (IDS Non-Nouns). Vowels degraded by environmental noise, overlapping talkers, etc., were excluded from the dataset. In all individual datasets, /a/ was vastly overrepresented relative to /i/ and /u/, consistent with the general distribution in Warlpiri. The distribution of vowels by speaker and vowel quality is presented in *Table 1*.

Table 1. *Summary of the number of vowels extracted by speaker (A, M, G) and condition (ADS, IDS; IDS Nouns, and IDS Non-Nouns).*

ID	Style	Total	/a/	/i/	/u/
A	ADS	320	196	71	53
	IDS	382	206	61	109
	IDS Nouns	120	45	30	45
	IDS Non-Nouns	262	164	34	64
M	ADS	189	115	50	24
	IDS	149	93	31	25
	IDS Nouns	57	31	14	12
	IDS Non-Nouns	92	62	17	13
G	ADS	9	5	2	2
	IDS	242	144	30	68
	IDS Nouns	84	45	13	26
	IDS Non-Nouns	158	99	17	42

Data extracted in a naturalistic setting, such as the data reported on here, is often less controlled than data collected under laboratory conditions, especially in terms of the vocabulary used, and the number of instances of the target vowels that can be extracted. This is unfortunate, but it is likely that such datasets have other advantages in terms of ecological validity. We also wish to highlight another difference between lab-based and 'naturalistic' data collection such as this. In many studies of vowel hyperarticulation in IDS, parents/caregivers are provided with special toys to induce the use of corner vowels /i/, /a/, and /u/ in the play interactions with the children. Parents are often also asked to discuss these objects with researchers in a separate (consecutive) session, to match the IDS dataset. In languages with large vowel systems such as English and Danish, it may make good practical sense to ensure sufficient target vowels are produced in each data collection session through this type of experimental manipulation, but the data collected in such a context may consequently reflect additional linguistic phenomena to those intended. Task-induced use of contrastive, focus and question intonation, for instance, may induce changes in pitch, vowel quantity, and vowel quality, without these phenomena reflecting aspects particular to IDS (or which may be overrepresented in the data).

3. Results

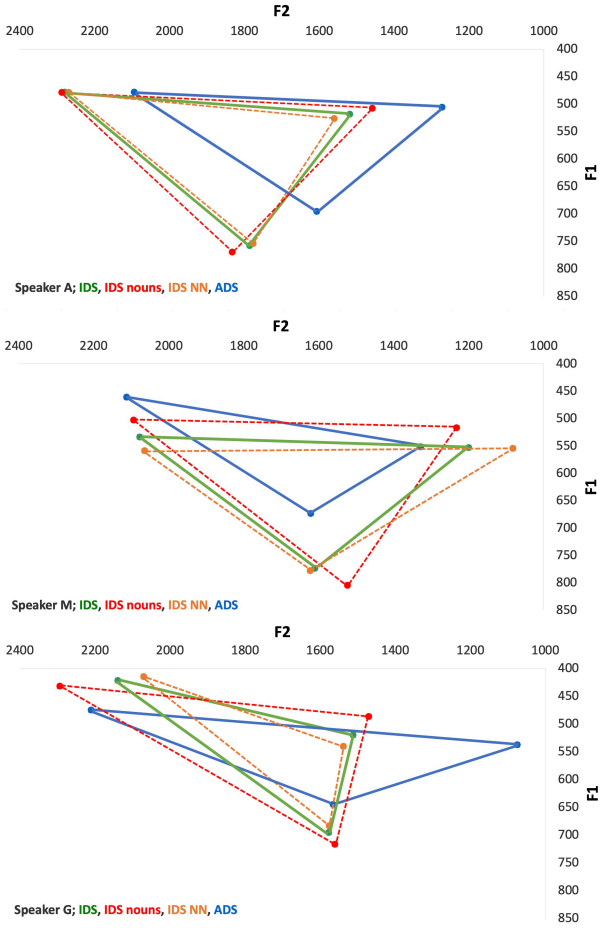
To assess whether vowel hyperarticulation, vowel expansion and pitch raising are characteristic of Warlpiri IDS, we compared vowel quality (F1, F2), vowel duration, and F0, in IDS and ADS for each of the three speakers separately. We present vowel duration and F0 in *Table 2* and F1/F2 plots for each speaker separately in *Figures 1-3*. Multivariate ANOVAs applied to *Speaker A* and *M's* vowel data revealed significant differences between their IDS and their ADS. *Speaker A's* IDS vowels were all longer and had a higher F2 than her ADS vowels (fronting), and in the case of /a/, also a higher F1 (lowering). *Speaker A*'s IDS /a/ also had a higher F0 than the ADS counterparts. *Speaker M*'s IDS /i/ and /a/ vowels were produced with a higher F1 (fronting) and a higher F0 than their ADS counterparts; but there were no significant differences in /u/, and no durational differences for any vowel. We did not conduct a statistical analysis of *Speaker G*'s data due to the low number of ADS observations, but we note a pattern of F2 and F1 raising (vowel fronting and lowering, in particular of /a/) in his dataset largely consistent with the two female speakers, and *Speaker A* especially. We also observe IDS vowel durations of almost double those in ADS, and likewise higher F0 (/a/, /u/).

Table 2. *Vowel duration for /a/, /i/, and /u/ (ms) and F0 (Hz) in ADS and IDS across speakers (A, M G).*

ID	Style	/a/ ADS/IDS	/i/ ADS/IDS	/u/ ADS/IDS
A	Dur.	72/94 ms	77/147 ms	60/100ms
	F0	203/214 Hz	206/218 Hz	207/206 Hz
M	Dur.	85/91 ms	89/105 ms	75/95 ms
	F0	197/230 Hz	200/220 Hz	203/226 Hz
G	Dur.	53/87 ms	51/84 ms	50/91 ms
	F0	195/216 Hz	218/209 Hz	157/216 Hz

We conducted a further analysis to investigate the hypothesis that IDS is a dynamic didactic modification, suited to the developmental needs of an infant/child. In the present study, the children were all in the early multiword stage of language acquisition, and we hypothesise that carer modifications may (among other things) be particularly targeted to word learning, and perhaps in particular to the teaching of 'names for things', consistent with the results of [20]-[24]. If that is the case, we would expect vowel hyperarticulation and temporal expansion to be driven by the characteristics of nouns rather than reflect IDS in general. We test this hypothesis by comparing vowel quality, duration and pitch in vowels extracted from IDS (concrete) nouns and vowels extracted from all other IDS words for each of the three speakers, again using

a series of Multivariate ANOVAs (See *Figure 1-3* for F1/F2 values, and *Table 3* for Duration and F0 values). In this analysis, we include Speaker G. The results indicate that /a/ and /i/ are longer in IDS nouns than in general IDS for *Speaker A*; /a/ is produced with a higher F2 and longer duration in IDS nouns produced by *Speaker M*, whose IDS Noun /u/s are also longer. *Speaker G* produces longer IDS Noun /a/s than in general IDS, and /i/s in Nouns that have a higher F1 than in IDS in general.



Figures 1-3: *F1-F2 vowel plots for Speakers A, M, G; IDS in green; ADS in blue lines. IDS Nouns and Non-Nouns (NN) in red and orange dotted lines.*

Finally, we assessed the degree of vowel space expansion in IDS versus ADS, and in IDS Nouns and IDS Non-Noun materials by calculating the Euclidian space enclosed by the F1/F2 values of each of the three vowels /i/, /a/, and u/. The ranking in terms of the vowel triangle of each vowel dataset is presented in *Table 4*. Minor idiosyncrasies aside, the data from the three speakers shows that IDS nouns are characterized by a much larger vowel space than IDS in general and IDS non-noun material, and that ADS tends to be characterized by the smallest vowel space of the four datasets. The exception—the relatively large vowel space characterising the ADS of *Speaker G*—must be taken with caution due to a very small dataset (See *Table 1*). The question of vowel space expansion is particularly interesting in the present dataset where two of the three speakers demonstrate substantial vowel space fronting, perhaps as argued by [19] to enhance the visual speech information, but this fronting does not result in vowel space reduction. It is also possible that the modifications observed bring the adult F1/F2 values closer to those observed in child speech and which children may prefer [43].

Table 3. *Vowel duration (ms) and F0 (Hz) for /a/, /i/, and /u/ in IDS Nouns (Ns) and IDS Non-Nouns (NNs) across speakers (A, M, G).*

ID	Style	/a/ Ns/NNs	/i/ Ns/NNs	/u/ Ns/NNs
A	Dur.	137/82 ms	117/172 ms	130/79 ms
	F0	221/212 Hz	215/221 Hz	206/206 Hz
M	Dur.	109/81ms	132/84 ms	135/59 ms
	F0	236/232 Hz	206/232 Hz	240/211 Hz
G	Dur.	106/79 ms	100/74 ms	109/79 ms
	F0	216/220 Hz	209/201 Hz	216/215 Hz

Table 4. *IDS, IDS Nouns (Ns), IDS Non-Nouns (NNs) and ADS ranked in terms of the Euclidian Space denoted by the F1/F2 values of vowels /i/, /a/ and /u/.*

ID	1st	2nd	3rd	4th
A	IDS Ns	IDS	IDS NNs	ADS
	△114022	△96300	△85788	△82599
M	IDS NNs	IDS Ns	IDS	ADS
	△108411	△101550	△100804	△79532
G	IDS Ns	ADS	IDS	IDS NNs
	△96851	△76211	△58361	△40413

4. Discussion

The study reported here is the first investigation of the acoustic characteristics of vowels in IDS in an Australian Indigenous language. The results show that adult speakers of Warlpiri raise the pitch, increase vowel duration, and produce more extreme F1/F2 values in their speech to young children compared to speech to (well-known) adults. This is largely consistent with what has been reported for IDS in languages from other parts of the world, though the strong indication of vowel space fronting in the data of two of the three speakers in the present study is not broadly attested, if arguably helpful in terms of improving visual speech information [19] or attracting the attention of children [43]. The study also indicates that hyperarticulation in Warlpiri IDS may serve a didactic purpose: The IDS analysed here was directed to young children who were rapidly acquiring new vocabulary and beginning to use multiword phrases, and the results from the present study clearly show that IDS Nouns stand out in terms of their acoustic characteristics: they have longer and more extreme vowels than other words in IDS. We suggest that this is consistent with patterns of avoidance of lenition processes [25] in speech to children of a similar age: reducing speech clarity is simply not helpful at an age where clarity of speech may assist a child to correctly learn and recognise new words. Interestingly, vowels from IDS nouns are not characterised by a higher F0 than Non-Noun IDS vowels, suggesting that F0 is not used for the same didactic purposes as vowel hyperarticulation and expansion. This appears consistent with reports that IDS pitch modulations are used to convey affect to young infants, and perhaps convey a range of emotions, or what we might call 'caregiver stance', to slightly older children, including indications of what behaviours are desirable and which are not, rather than assisting with word-learning. Finally, the results reported here suggest that studies of the acoustic characteristics that focus on target vowels from a subset of data (nouns referring to special toys used in the lab to elicit corner vowels) may not tell the whole story about the purposes of IDS.

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6. References

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