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Articles

Infant-directed speech in Brazilian Portuguese: The prosody of questions

Fala dirigida à criança em português brasileiro: A prosódia de perguntas

Cristina Name[1,2]
Juan Manuel Sosa[3,4]

ABSTRACT

Infant-directed speech (IDS) is the register commonly used in infant-adult interactions in many linguistic communities, and presents a number of special lexical, syntactic and prosodic particularities when compared to adult speech, such as words with syllable reduplication, high question rate and exaggerated prosody. In this study, we focus on interrogatives and their prosodic properties as the object of investigation. Data analysis of interactions of ten Brazilian Portuguese-acquiring infants aged 4 to 12 months and their caregivers, revealed that questions corresponded to 33% of the total utterances produced and are emphasized mainly by marked pitch (raised pitch range and expanded pitch span), as well as increased duration. Moreover, the pitch contours of Wh and Yes/No questions

1. Federal University of Juiz de Fora – UFJF. Juiz de Fora – Brasil. https://orcid.org/0000-0001-5625-9503. E-mail: cristina.name@ufjf.br.
2. National Council for Scientific and Technological Development – CNPq.
3. Federal University of Juiz de Fora – UFJF. Juiz de Fora – Brasil. https://orcid.org/0000-0002-4781-6336. E-mail: juan_sosa@sfu.ca.
4. Simon Fraser University. Vancouver – Canada.

followed their respective patterns observed in adult speech. These results are compatible with those found in the literature and indicate that, in general, the IDS used in Brazilian Portuguese has similar characteristics to this register in other languages.

Keywords: *infant-directed speech; prosody of questions; intonation; Brazilian Portuguese.*

RESUMO

A fala dirigida à criança (FDC) é o registro comumente usado nas interações bebê-adulto em muitas comunidades linguísticas, e apresenta uma série de particularidades lexicais, sintáticas e prosódicas quando comparada à fala entre adultos, tais como palavras com reduplicação de sílabas, alta taxa de perguntas e prosódia exagerada. Neste estudo, elegemos como objeto de investigação as interrogativas e suas propriedades prosódicas. A análise de dados de interações de dez bebês de 4 a 12 meses adquirindo o português brasileiro e seus cuidadores revelou que as perguntas corresponderam a 33% do total de enunciados produzidos e são realçadas principalmente pelo pitch *marcado (maior* pitch range *e* pitch span*), e maior duração. Ainda, os contornos de* pitch *das perguntas Qu e Sim/Não (perguntas totais) seguem seus respectivos padrões observados na fala adulta. Esses resultados são compatíveis com os encontrados na literatura e apontam que, de modo geral, A FDC usada no português brasileiro apresenta características semelhantes a esse registro em outras línguas.*

Palavras-chave: *fala dirigida à criança; prosódia de perguntas; entoação; português brasileiro.*

1. Introduction

It's practically impossible to talk to a baby without using a high-pitched sing-songy voice. (...) Not only do babies prefer listening to IDS but it also helps support little ones' comprehension. Plus, babytalk often uses exaggerated prosody. (…) Infant-directed speech is exaggerated and filled with different rhythms and melodies because this is what infants comprehend. Research shows that infants are much more likely to associate meanings of words when the adult is utilizing IDS versus adult-directed speech (ADS). (Stangl, as cited in Cinelli, 2021)

Infant-directed speech (IDS) is the register used by adults when interacting with infants and young children in many and diverse cultures (Fernald, 1992; Saint-Georges et al., 2013). Compared to adult-directed speech (ADS), this register is distinguished by presenting shorter and structurally simpler sentences, high number of questions, repeated and modified words by reduplication, hyperarticulation, long pauses between utterances, slower tempo, higher pitch and greater pitch variations (Fernald, 1992; Garnica, 1977; Snow, 1977; 1995, among others).

Although still a controversial issue, the idea that IDS may facilitate the language acquisition process is advocated by many authors. Syntactically simple sentences, repetitions and hyperarticulation would facilitate the identification of the syntax and lexicon of the language, but above all exaggerated prosody is said to play an important role not only in language development, conveying affect, attracting attention and engaging the infant in social interactions, but also in highlighting words, and boundaries between constituents and different structures (declarative and interrogative) (Adriaans & Swingley, 2017; Fernald, 1992; Snow, 1977; Thiessen et al., 2005).

In fact, specific adaptations of prosodic features have been observed in the IDS of speakers of tonal and non-tonal languages (Kitamura et al., 2001), stress-timed, syllable-timed, and mora-timed languages (Fernald, 1992; Fernald et al., 1989; Saint-George et al., 2013; Wang et al., 2016). Women and men who use IDS when speaking to infants show similar acoustical features such as higher pitch and exaggerated pitch excursion (Fernald et al., 1989; Niwano & Sugai, 2003; Papousek et al., 1987; Soderstrom, 2007), but some studies have pointed out some differences. For instance, Benders et al. (2021) reported pitch differences between fathers and mothers using IDS when talking to their infants in Dutch.

As for Brazilian Portuguese (BP), there are few studies focusing on IDS, and particularly fewer on its prosodic features. Dadalto and Goldfeld (2006) observed high pitch and exaggerated intonation on language interactions between a mother and her 12-month-old son. Splendore et al. (2019) analysed the interaction between 10 mothers and their respective infants aged from 3 to 8 months. The authors found that 9 of 10 mothers used IDS, mostly characterized by reduced speech rate/slower rhythm and increased vocal range.

Focusing on questions, Name and Sosa (2020a, 2020b), analysed the IDS used by adults in interactions with four BP-acquiring infants between ages 4- and 12-months. As reported in the literature, adults ask many questions to infants, even though they do not expect an effective verbal or non-verbal response from them (Geffen & Mintz, 2017; Newport et al., 1977; Soderstrom et al., 2008; Thorson et al, 2014). According to Name and Sosa (2020b), questions accounted for 36.7% of the total utterances analysed, and more than 70% of them were marked by one or more prosodic features, with a prevalence of high register, pronounced differences between peaks and valleys and slow rhythm. The pitch contours of wh- and yes-no questions (also known as polar questions) followed the patterns found in the ADS – respectively, falling and rising-falling – but mostly marked by the wide pitch movement. As far as we know, there are no studies contrasting prosodic features of IDS of women and men in BP.

With the aim of contributing to the precise characterization of the prosodic properties of IDS in BP, this paper presents the results of our analysis of corpora of interactions between ten children and their families. We chose to analyse questions due to their communicative role in adult-infant interactions, and because of the fact that in Portuguese declarative and interrogative utterances are only distinguished by their respective intonational contours, which may be a cue to a preliminary identification of these syntactic structures by infants. We sought to find out (i) the rate of occurrences of interrogatives in relation to other utterances; (ii) the most common IDS prosodic features in interrogatives; (iii) the intonational pattern of wh- and yes-no questions, whether they were compatible or not with those found in BP ADS; and (iv) prosodic similarities and differences between women and men IDS. For this purpose, we expanded the corpora presented in Name and Sosa (2020a, 2020b), including adult-infant interactions with six more children (a total of 10 children).

2. Infant-Directed Speech - IDS

In many cultures adults and older children frequently use IDS when they talk to babies and younger children. Cross-linguistic similarities such as simpler syntactic structures, great number of questions, word

repetition, hyperarticulation and exaggerated intonation were observed when this register was compared to ADS (Fernald, 1992; Garnica, 1974; Snow, 1977, 1995). Although its use may not be universal (Cristia et al., 2019; Weber et al., 2017), IDS seems to have a positive impact on the emotional, cognitive, and linguistic development of the baby. IDS promotes greater babies' social engagement (Cavalcante & Barros, 2012; De Pablo et al., 2020; Fernald & Simon, 1984), facilitates word segmentation (Thiessen et al., 2005), word learning (Gout et al., 2004; Matsuoka & Name, 2011), and syntactic structure distinction (Chiang et al., 2018; Floccia et al., 2016; Frota et al., 2014; Graf Estes & Hurley, 2013; Splendore et al., 2019). Newborns and infants prefer this type of speech to ADS (Cooper & Aslin, 1990), and evidence from 9-month-old infants' brain responses suggests that IDS stimuli are easier to discriminate than ADS ones (Peter et al., 2016). Also, 12- to 15-month-old babies have expectations about the register adults would/should use according to their interlocutor, rejecting the use of ADS when addressed to children (Soley & Sebastian-Galles, 2020).

In particular, the prosodic properties of IDS, and especially its exaggerated pitch contours, seem to attract their attention (Fernald, 1992). Fernald and Kuhl (1987) manipulated IDS utterances by extracting and presenting separately F0, amplitude and duration to 4-month-old infants. The infants preferred the utterances that maintained the F0 compared to the other utterances. For Räsänen et al. (2018), the exaggerated pitch contour would make the utterances more stimulating, recruiting more of the infant's attentional resources.

IDS prosodic characteristics

In the first systematic analysis of IDS, Garnica (1974) compared utterances produced by adult speakers of American English in contexts of interaction with children between 1;10 and 2;6 years (mean age: 2;3 years), with children between 5;1 and 5;7 years (mean age: 5;4 years), and among adults. The author observed in the speech directed at 2-year-old children "higher mean F0, a greatly expanded frequency range, numerous instances of rising sentence pitch terminals in declarative and imperative sentences, a high incidence of whispering, increased durations of certain key content words in sentences, and the multiple

assignment of primary stress within a sentence unit" (Garnica, 1974, p. 56). Such features did not occur significantly in interactions with 5-year-old children or among adults.

Higher pitch, expanded pitch range and slower tempo have also been documented in IDS in different languages, such as British English, German, French, Italian, Japanese (Fernald et al., 1989), Latvian, Comanche, Sinhala (Fernald, 1992), Xhosa (Fernald & O'Neill, 1993), and Mandarin Chinese (Grieser & Kuhl, 1988) (see Cristia, 2013; Saint-George et al., 2013 and Wang et al., 2016 for systematic reviews of IDS literature). In a cross-linguistic study with Lankan Tamil, Tagalog and Korean speaking mothers, Narayan and McDermott (2016) verified slower speech rate, raised pitch and wide pitch excursions when they interacted with their 4- to 16-month-old children, than in their adult interactions. Interestingly, speech rate changed and became faster as the babies grew up, but pitch characteristics remained constant over the infants' development.

In a systematic review of the literature, Saint-Georges et al. (2013) report that

> longer pauses, a slower tempo, more prosodic repetitions, and a higher mean F0 and wider F0-range were observed for fathers and mothers across various languages (Fernald et al. 1989; Niwano & Sugai, 2003; Shute & Wheldall, 1999), except regarding to the wider F0-range (…) and also for grandmothers interacting with their grandchildren (Shute & Wheldall (2001). (Saint-Georges et al., 2013, p. 3)

Papousek et al. (1987) compared syntactic, lexical and "temporal-melodic" features of German mothers' and fathers' IDS produced during interactions with three-month-old infants. According to the authors, both parents adjusted their talks in similar ways in all linguistic levels. Fernald et al. (1989) analysed prosodic features of mothers' and fathers' IDS register in American and British English, French, Italian, German and Japanese (mean F0, minimum- and maximum-F0, F0 range and variability, utterance and pause durations). They found that across languages, both mothers and fathers produced higher mean, minimum and maximum of F0, greater F0 variability, shorter utterances and longer pauses in IDS compared to ADS. Only mothers produced a wider

F0 range and American English parents exhibited more exaggerated prosodic modifications than the other parents. According to the authors, these results suggest universal prosodic characteristics of IDS, but also possible cultural and gender speaker variations in the use of this register. Regarding more recent studies, the picture is less clear. On the one hand no effect of gender was found in IDS prosodic properties produced by German (Weirich & Simpson, 2019) nor Japanese parents (Niwano & Sugai, 2003). On the other hand, Benders et al. (2021) observed that Dutch-speaking fathers increased their pitch variability within and across utterances more than mothers did. Kitamura et al. (2001) found that pitch range addressing girls is consistently higher than addressing boys in Thai and Australian English IDS.

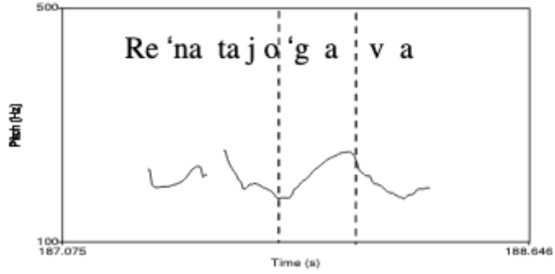
Regarding interrogatives, Geffen and Mintz (2017) compared declaratives, wh- questions and yes-no questions produced by three native American English mothers in interactions with their infants. Overall, the pitch contours of the three types of structures were similar to those found in ADS, but more exaggerated. In the comparison between structures, declaratives and yes-no questions differed significantly in pitch excursion, mean F0, Max F0 and duration, which did not occur with wh- questions. Soderstrom et al. (2008) also examined the prosody (among other characteristics) of questions in American English IDS in the data of two mothers talking to their babies. They found between 25% and 49% of interrogatives, depending on the baby and the baby's age (6- to 12-month-olds). Yes-no questions were mostly produced with the ADS rising contour (76%), while only 29% of wh- questions showed a falling or sinusoidal contour.

In BP, Name and Sosa (2020a, 2020b) analysed interrogatives produced in interactions of adults (parents and relatives) and four infants aged 4 to 12 months. They found over 70% of interrogatives marked by one or more prosodic features, with high register, pronounced differences between peaks and valleys and slow speech rate being the most commonly observed features. They conclude that the pitch contours of yes-no and wh- questions maintained the patterns of ADS, however more characterized by wide pitch movement.

Intonation of Questions in Brazilian Portuguese

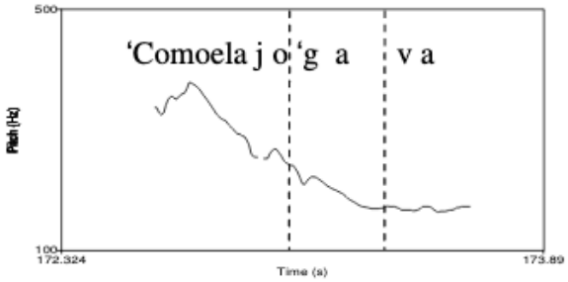
Interrogative intonation in BP has configurations and uses that differ from other languages, i.e., yes/no questions tend to be rising/falling with the peak on the final stressed syllable ('circumflex' contour). The shape of the terminal contour or nuclear accent is the feature that distinguishes statements from yes/no questions, which rises through the final stressed syllable with a late alignment of the F0 peak before the final fall, as seen in Figure 1 (taken from Moraes, 2008). The nucleus of yes/no questions has an accentual rise on the last stressed syllable followed by a L% boundary; this accentual rise has been characterized as a L+H* pitch accent. For an overview on the intonation of yes-no questions in Brazilian Portuguese dialects and in other Portuguese varieties, see Braga et al. (this volume).

Figure 1 – Contour of neutral yes/no question "Renata jogava?" (Moraes, 2008, p. 393)



Wh- questions in BP tend to be, as reported for several languages (Hedberg et al., 2010; Sosa, 2003), falling throughout the utterance; high pitch on the initial wh-word with gradual fall over the following syllables, until the last stressed syllable is reached with a H+L*L% nuclear contour, as seen in Figure 2 (also from Moraes, 2008). Rising wh- questions were also found, as well as rising-falling, which are used for specific contexts such as rising for echo-questions, or rising-falling for emphasis, focus or exclamation. For a comparison of acoustical properties between wh-questions and wh-exclamations from a perceptive perspective, see Miranda et al. (this volume).

Figure 2 – Contour of canonical wh- question "Como ela jogava?" (Moraes, 2008, p. 392)



In our data these two canonical contours were predominant, although we also encountered other kinds of contour shapes: i) Falling; ii) Rising; iii) Falling-Rising; or iv) Plateau (flat). All these nuclear contours occurred for both yes-no and wh- questions and have different interpretations according to pragmatic considerations. We found though that the design of the question types, whether displaying the canonical pitch trajectory or not, as well as the relative frequency of each one, were in agreement with what is found in adult speech: we thus conclude that contour shape of questions is not a feature in which IDS would differ from ADS.

3. Our study

Participants and Data Collection

Ten babies, 5 girls and 5 boys and their families participated in the research. The data we gathered were mostly produced by the babies' mothers, but fathers and other family members also participated in the interactions. Recordings took place in Juiz de Fora, Minas Gerais, and Florianópolis, Santa Catarina. The collection was carried out by the babies' caregivers themselves, who were instructed to make recordings of everyday situations of adult-baby interaction. In order to minimize possible disturbances in the routine of the baby and the family caused by the collection, the type (audio or video) and the amount of the recordings were at the discretion of those in charge. The researchers did not participate directly in data collection. This research

was approved by the Ethics Committee on Human Research (CAAE: 28142820.5.0000.5147) and those responsible for the children as well as the adults involved signed an Informed Consent Form. The names of the babies were changed for privacy concerns. Below we present the details of the data, by baby. In Table 1 we show a summary of the data.

– Interactions between Bibo, a 4-month-old male infant and his mother and/or father. The video recordings took place in spontaneous conversation and/or play situations at home, in which one or two adults and the infant participated, totaling 30 minutes and 57 seconds.

– Interactions between Guto, male infant and his mother or grandmother. The video recordings took place at 4 months and 10 months of age, in spontaneous play situations at home, involving one adult and the baby. The recordings lasted 2 minutes and 41 seconds at 4 months and 5 minutes and 10 seconds at 10 months, for a total of 8 minutes and 51 seconds. Given the interval of 6 months between the two collections, the data were analysed separately.

– Interactions between Gigi, a 4- to 5-month-old female infant and her mother, father, grandmother and uncle. The audio recordings took place in spontaneous play situations at home, in which at least two adults participated, and totalled 28 minutes and 6 seconds.

– Interactions between Don, a 6.5-month-old male infant and his mother, his great-grandmother, his uncle, and his aunt. The audio recordings took place during spontaneous play situations at home, in which at least two adults participated, and totalled 9 minutes and 21 seconds.

– Interactions between Bel, a 6- to 10-month-old female infant and her mother. The video recordings occurred during spontaneous situations of conversation and/or play at home, on three occasions - at 6, 8 and 10 months - totalling 4 minutes and 45 seconds.

– Interactions between Lala, female infant between 6.5 and 8.5 months and her mother, father, and brother. The video recordings occurred in spontaneous play situations at home and totalled 3 minutes and 10 seconds.

– Interactions between Cadu, a 7- to 8-month-old male infant, his mother and/or father. The video recordings occurred in spontaneous situations of conversation and/or play, at home or in the family's car, totalling 6 minutes and 2 seconds.

– Interactions between Juju, a 9-month-old female infant, and her grandmother, grandfather, and uncle. The video recordings occurred during spontaneous situations of conversation and/or play at home and totalled 5 minutes and 4 seconds.

– Interactions between Nino, a 9.5-month-old male infant and his mother. The audio recordings occurred during spontaneous play situations or during meals at home, totalling 8 minutes and 6 seconds.

– Interactions between Tata, female infant between 11 and 12 months and her godmother. The audio recordings occurred during conversation situations, games and/or during meals at home, and totalled 12 minutes.

Table 1 – Summary of the data by baby

Child's name	Sex	Age range of recordings	Caregivers	Total duration of recordings
Bibo	Male	4 months	Mother and father	29m57s
Guto	Male	4 months 10 months	Mother and grandmother	2m41s 5m10s
Gigi	Female	4 to 5 months	Mother, father, grandmother and uncle	28m06s
Don	Male	6.5 months	Mother, great-grandmother, uncle and aunt	9m21s
Bel	Female	6 to 10 months	Mother	4m45s
Lala	Female	6.5 to 8.5 months	Mother, father and brother	3m10s
Cadu	Male	7 to 8 months	Mother and father	6m02s
Juju	Female	9 months	Grandmother, grandfather and uncle	5m04s
Nino	Male	9.5 months	Mother	8m06s
Tata	Female	11 to 12 months	Godmother	12m

The Prosodic Variables

For this research we studied the prosodic variables that were the most salient, which were the ones that stood out the most in our IDS data and are repeatedly mentioned in the literature. They were *pitch register* and *pitch span*, *speech rate* and *final syllable duration*, and *quality of voice*.[5] These prosodic features used in classifying the questions follow:

Extent of pitch movement or pitch range

Also called 'pitch span' (Gussenhoven, 2004; Ladd, 2008) or 'excursion size' (Hart et al., 1990), defined as the difference between high and low targets in the speaker's range. Questions were classified as either *normal range* or *wide pitch span*. For this, the quantitative distance between valleys and peaks was measured in semitones and octaves comparing the minimum and the maximum value. Differences of an octave or more, either up or down, were considered as belonging to the *wide pitch span* category for this feature. We chose the octave as the threshold to distinguish between *normal range* or *wide pitch span* as it is double the reported range of human voices, which normally spans between half an octave below the median of the speakers' fundamental frequency and half an octave above (De Looze & Hirst, 2014). As these authors assert, intervals of octaves and half-octaves play crucial roles in speech production as well as perception. Increased pitch movement, particularly in the upper part of the speaker's register, is a common feature of expressive speech.

Pitch register

We divided the questions into two groups, depending on whether the average pitch of the whole utterance was produced in a *normal* or a *high* pitch range, i.e., whether the lower and upper limits of pitch movement (in Hz) were within the expected range for adults, or if on

5. The prosodic feature perceived loudness, sometimes used as synonymous to intensity, did not appear to be a distinguishing factor in IDS, given the kinds of interaction between the caregivers and the babies, usually at very close proximity; the voices were usually softer, quieter, giving an endearing, relaxed feel to the interaction. A low loudness level of modal voice shifts the affective ratings toward the low activation, intimate end (Grichkovtsova et al., 2012), but loudness contributes relatively little to the perceived affective colouring of specific voice qualities in our IDS data.

the other hand the whole utterance was produced in a raised fashion. Although rare, the raised mean pitch of the utterance sometimes was coupled with a raised tonal baseline (Rietveld & Vermillion, 2003), but by and large a *high* pitch range was the effect of the expanded upper limits and in some cases very high local accentual peaks. The majority of those peaks occurred at the beginning of wh- questions, mostly on the wh- word, and on the final syllables on yes-no questions.

Previous research (Faria et al., 2012) found that mean value for normal adult male voices in BP was a F0 of 127.77 Hz; and the value for adult female voices was a F0 of 204.87 Hz. Other studies that analysed European Portuguese and Brazilian Portuguese (Guimarães & Abberton, 2005; Silva, 1999) reported practically identical values in mean F0 and standard deviation values.

Based on these studies, we considered a question to be *high* according to the following criteria: i) the mean pitch is above 300 Hz for women and 180 Hz for men; ii) the top pitch reaches extremely high values, and/or the bottom is raised. The items that fit those criteria were classified as *high* in our analysis. During the data analysis stage, the utterances were first identified auditorily as *high* and then checked for confirmation in their quantitative values in Hertz for their mean and top frequencies and in semitones for their tonal span. We used Praat (Boersma & Weenink, 2019) for these analyses, adapting the pitch settings to the actual pitch range of the speaker. Following Liberman (2018), we estimated each speaker's range as running from their modal F0 value minus seven semitones to their modal voice value plus ten semitones, although for some speakers with extremely high-pitched voices we manually adjusted the settings.

Speech rate and increased final vowel duration

We measured whether the questions were produced with a slower speech rate as opposed to what is considered normal speed in BP. This was done manually by dividing the number of syllables in the utterance with its duration to get the syllable rate in syllables/second and comparing that with what was considered to be the standard BP adult speech rate, established by Castro et al. (2014) to be a median of 214.3 syllables/minute, and by Martins and Andrade (2008) to be a mean of 210.7 syllables/minute.

We observed that most of the questions that were initially auditorily labelled as *long* were made distinctive by a substantial increase in the duration of vowels, in particular the final stressed ones, some sort of final lengthening. When these vowels were more than three times longer than in non-phrase-final syllables, the question was counted as *long*, and many were even longer than that. Questions with such increased durations, either of the whole utterance or more commonly of the final stressed syllable, or both, give the impression of deliberate delivery, careful enunciation, compatible with the often-mentioned exaggerated articulation feature of IDS. This extra final lengthening was more evident in IDS yes-no questions than in wh- questions (Geffen & Mintz, 2017).

Both duration of utterance and longer final stressed syllable were previously observed in BP IDS. Splendore et al. (2019) analysed ten mother-baby dyads between 3 and 8 months. Nine of the ten mothers made use of IDS; wide pitch variation, high-pitched voice, and slow speech rate were the most observed acoustic characteristics. Silva and Name (2014) found, in the interactions of a mother with her 11- to 13-month-old baby, high register, slow rhythm with many elongations of stressed syllables, and recurrent and prolonged pauses.

Voice quality

We distinguished whether a question or part of a question was perceptually *breathy* or not. Breathy voice has been associated with intimacy and affection (Laver, 1980), involving minimal laryngeal tension resulting in audible frication noise. Breathiness is related to perceptions of emotional states such as tenderness as well as attractiveness (Campbell & Mokhtari, 2003; Grichkovtsova et al. 2012).[6]

4. Results and Discussion

Excluding chants, non-verbal vocalizations, and conversations between adults, 1672 utterances were counted. Tag questions were

6. Utterances totally or partially uttered with breathiness, as perceived by the coders, qualified as *breathy* in our analysis. We did not deem it necessary to acoustically quantify which percentage of laryngeal frication was present in the questions with this feature.

also excluded, due to the very low number of occurrences (less than 0.5% of the total number of questions). We found 554 interrogatives (33.13% of the total), thus distributed among the corpora in Table 2. As we pointed out, Guto's data were collected in two distinct periods with an interval of 6 months between them, at 4 and 10 months of age, and therefore they are displayed separately.

Table 2 – Total and percentage of questions and utterances

Infants	Bibo	Guto	Gigi	Don	Bel	Lala	Cadu	Juju	Nino	Guto	Tata	Total
Age (months)	4	4	4-5	6.5	6-10	6.5-8.5	7-8	9	9.5	10	11-12	
# Questions	137	16	150	53	23	17	26	4	31	34	63	554
# Other Utterances*	289	6	184	103	47	44	51	58	137	35	164	1118
Total Utterances	426	22	334	156	70	61	77	62	168	69	227	1672
% Questions/ Utterances	32.2	72.7	45	34	32.9	27.9	33.8	6.4	18.4	49.3	27.7	33.13

* Among the other utterances, exclamatives, declaratives and orders were the most frequent and had very close occurrence rates: respectively, 19%, 18.6% and 18.5%. Considering the total number of utterances (questions + others), we have: 12.7% of exclamatives, and 12.4% of declaratives as well as orders. Fragments of utterances were not considered.

These results are consistent with the findings of Soderstrom et al. (2008) and Name and Sosa (2020b). The mean rate of interrogatives (33.13%) is in line with that reported in the literature, which is around 30% (Snow, 1977). We observed wide variation in the percentage of questions addressed to the different infants, but only two had a rate far below 30%: Juju (9 months), who had a very small number of questions (4 out of 62 utterances, 6.4%), and Nino (9.5 months, 18.4%). On the other hand, interrogatives corresponded to 72.7% of all utterances addressed to Guto at 4 months, a rate well above the average. Excluding these three outliers, the mean rate of interrogatives in the corpora is 35.4%.

Increased pitch distribution

Regarding the pitch variables, we had analysed separately the variables *extent of pitch excursion* and *pitch register* (see section 3). However, for the tabulation of the results we ultimately binned these

two variables into one category since they tended to be concomitant to a high degree. In most cases pitch movements spanning an octave or more implied high peaks therefore higher average pitches of utterances. They were thus classified as marked for *increased pitch* in our nomenclature.

The discourse of adult males to infant males did not have much increased pitch height and/or width (*high* and *wide*). In contrast, adult males to infant females had much more pitch variation, both in mean height of questions and in pitch span, in some cases reaching up to two octaves. Adult females addressing infant males showed even more pitch variation and height. However, adult females addressing infant females showed less pitch variation and span. We checked whether adult females addressing infant females would have more variation and even higher proportion of *high* and *wide* pitches but found this wasn't the case. Why did this not happen? We think it was mainly because Gigi's mother and father – that had the greatest number of questions in our data - used more other IDS strategies: both employed breathy voice abundantly, indeed they were virtually the only caregivers that had this feature, and almost all their questions were of increased duration. However, their use of increased pitch was not. It has been proposed in the literature that increased flow and breathiness lead to lower F0 as pitch parameters interact with voice quality. For example, wider pitch excursions are associated with more tenseness and vowel prolongation (Grichkovtsova et al., 2012). Klatt and Klatt (1990) found that fundamental frequency tends to be lower in breathy voice and argued that breathy voice can result in lowered F0 as low F0 coincides with breathiness.

In Tata's case, less use of increased pitch features could be because the girl is older, as it was noted. We think for these reasons increased pitch was less used, probably affecting the proportion of use of this variable in the speech of women to female infants.

Of the total 554 questions, 318 were marked for increased pitch (57.4%). Adult males produced 100 questions in total, of which 32 were in interactions with baby girls. Of these, 53.1% (17) were marked for increased pitch. Differently, of the 68 questions addressed to baby boys, only 19.1% (13) were marked for pitch increase. As for the questions produced by women, the picture is more balanced: there

were 224 questions addressed to baby girls, 55.4% (124) pitch marked, and 230 to baby boys, 67.8% (156) pitch marked. The general picture of male and female adult production addressed to baby boys and girls is shown in Figures 3 (total values) and 4 (percent values). Figures 5 to 8 illustrate the intonation of questions marked for increased pitch produced by mothers and fathers to their baby boy or girl.

Figure 3 – Number of questions by gender/sex of adult and infant, marked/not marked by pitch - Total values

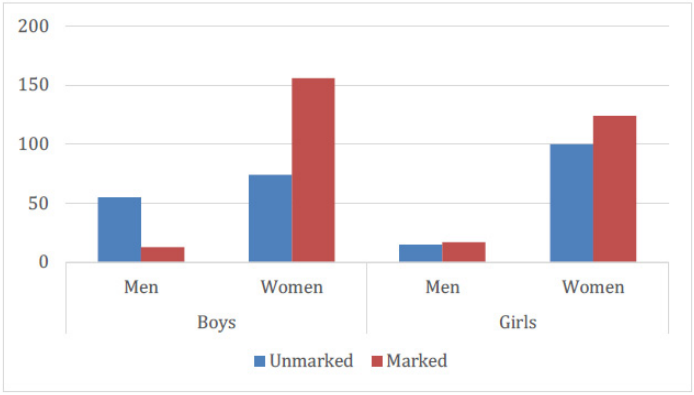


Figure 4 – Number of questions by gender/sex of adult and infant, marked/not marked by pitch - Percent values

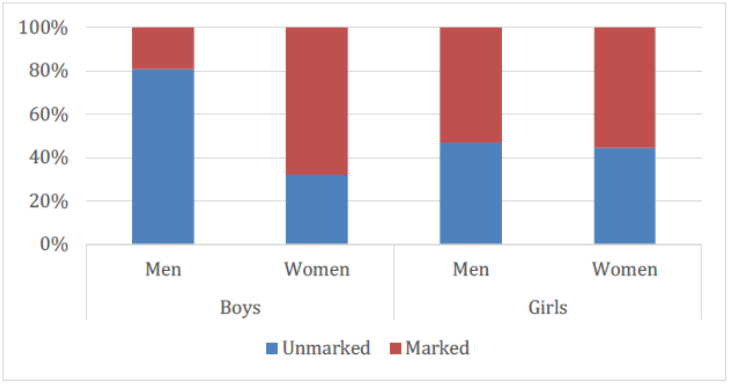


Figure 5 – An extra-high rising yes/no question by Lala's mother, *"Não filha, você não é não?"* (No daughter, you are not?). The final rise goes up to 880 Hz an upward movement of 22 semitones (st), close to two octaves

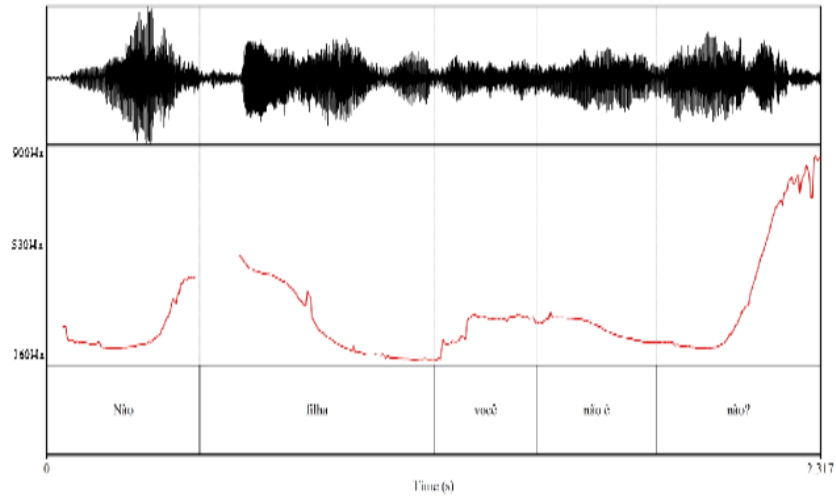


Figure 6 – A yes/no question by Cadu's father, *"Cê quer fazer bagunça?"* (You wanna make a mess?) in a low register. The movement of the interrogative rise/fall goes up only 3.5 st, then down 5 st

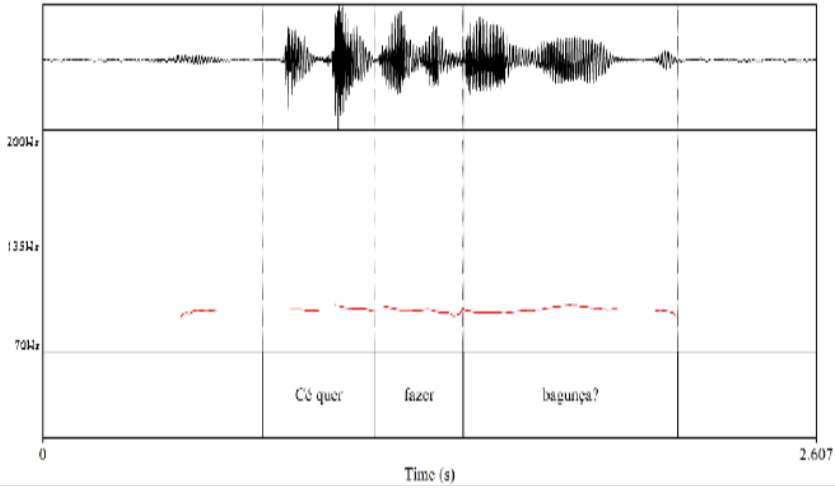


Figure 7 – High wh- question by Gigi's father, *"Que confusão que é essa?"* (What is this confusion?) with a wide movement of 14 st. In this case the high initial pitch is on the first syllable of the focused word *confusão*

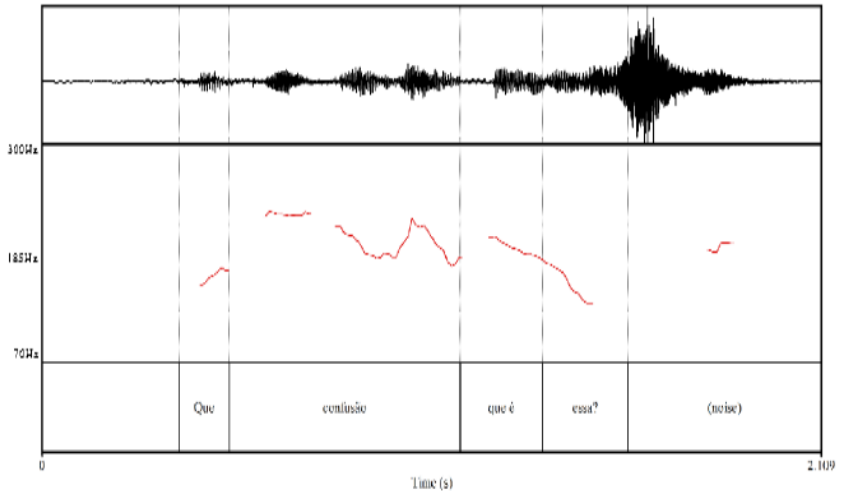
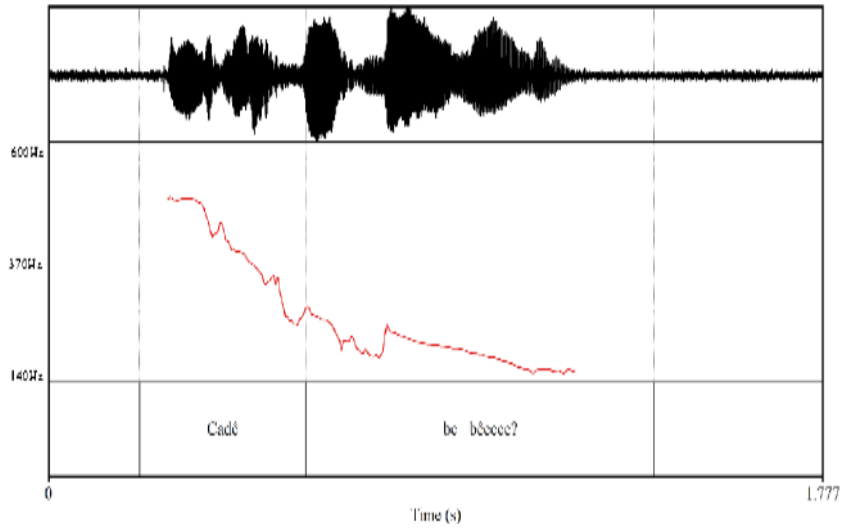


Figure 8 – Extra-high wh-question by Guto's mother, *"Cadê bebêeee?"* (Where's baby?) with a very long final vowel, the question is 1.1 sec and the last vowel is 0.51 sec, more than half the duration of the whole utterance. The pitch is very high, beginning at 550 Hz and falling to 215 Hz, a pitch movement of 16 st



The pitch differences observed between men and women, between girl and boy babies and in an older baby may be related to family characteristics (Gigi's case), baby's age (Tata's case) and/or cultural issues. As seen, prosodic similarities between maternal and paternal speech were reported (Fernald et al., 1989; Niwano & Sugai, 2003; Weirich & Simpson, 2019), but so were differences, as observed in the speech directed at baby boys or girls (Benders et al., 2021, Kitamura et al., 2001). Further studies specifically focusing on parental IDS and/or infant sex are needed to understand to what extent these variables may impact IDS prosody.

Increased duration

Slower speech rate and longer duration of accented final vowels, which we also conflated into one analytical category, *increased duration* (*long*), was used systematically by some adults, but not by all of them; for instance, Don's uncle did not have any *long* question. It is noteworthy that in Guto's case, when he was younger at 4 months, 14 out of 16 questions were *long*, but at 10 months only 2 out of 34. In terms of speech rhythm, we found that questions with increased duration of vowels as those we encountered in BP IDS give an overall auditory impression of syllable-timed rhythm. Syllables in IDS tend to sound distinctively pronounced giving an impression of syllabic isochrony; it is known that syllabic timing and durations tend to vary at distinct speech rate (Barbosa, 2000). As Meireles et al. (2010) have noted, a slower tempo may be associated with syllable-timing, as speech rate influences tendencies to syllabic or to stress-timed rhythm (Meireles & Barbosa, 2008).

Breathy Voice

Given the importance attributed to this feature in the literature describing the so-called affective speech, associating it with intimacy (Gobl & Ni Chasaide, 2003) and tenderness (Guzman et al., 2013), we were expecting the variable *breathy* to be more of a ubiquitous feature in BP IDS than what it actually turned out to be in our data. Altogether

only 11.4% of all questions were *breathy* (63 of 554). Of these 63 items, 40 were uttered by the parents of a single baby, Gigi; another 13 were produced by another caregiver, Bibo's; Tatá's had seven, Cadu's two, Nino's one. The rest of the caregivers did not employ it at all. We interpreted this breathiness as being an idiosyncratic feature of these parents, therefore concluding that it does not qualify as a general feature of BP IDS.

5. Conclusion

In this paper we present the results of our corpora analysis of interactions between ten infants and their families, in the IDS register. We endeavored to verify the rate of occurrence of questions, their main features and if the intonational patterns of wh- and yes/no questions are similar to their respective patterns in ADS. We also aimed at verifying if there were major prosodic differences between women and men's use of IDS in our data. We observed that the rate of occurrence of questions is in line with what is reported in the literature, around 30%. Also, the intonational pattern of wh- and yes/no questions agreed with what is found in ADS, respectively, falling and rising-falling.

Our main result was that the most instrumental features in characterizing BP IDS are related to pitch range and pitch span, and to a lesser degree to tempo and duration. We conclude that although these prosodic features are prevalent, there are no homogeneous or uniform patterns of IDS usage for all speakers. When present, IDS is manifested differently for different subjects, idiosyncratically. We noticed some differences related to gender/sex of the adults and the infants. Some caregivers, especially male, did not use the feature *long* at all, while others did not substantially raise their pitch range, and breathy voice was only used by some parents. This also depends on the age of the baby: as he/she grows, there seems to be a shift in the use of some variables. However, regardless of which distinct combinations of prosodic patterns were used in BP IDS, the great majority of questions were characterized by one or more of the features we have described.

As far as we know, this is the largest IDS study in Brazilian Portuguese. This register seems to play an important role in the infant's

affective, social, and linguistic development, and prosodically enhanced questions can promote communicative skills and be used as a cue for syntax acquisition.

The contribution of each family to the total data is quite varied. For example, the questions addressed to Gigi correspond to 27% of the corpora, whereas in Lala's case they were only 3%. We are thus aware of the limitations that the results of our analysis present for possible generalizations. Our main goal was to describe and characterize the prosodic properties more frequent in questions in BP IDS from a large volume of data, since the few published works present little data from a reduced number of infants. Therefore, we expected diversity. Our corpora were composed of naturalistic data from 10 infants aged 4 to 12 months interacting with various caregivers. More than 500 questions were produced by mothers, fathers, grandparents and relatives in various everyday situations. More research is currently underway in order to further contribute to a more precise characterization of IDS and particularly of interrogatives.

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Conflict of interests

The authors declare they have no conflict of interest.

Credit Author Statement

We, Cristina Name and Juan Manuel Sosa, hereby declare that we do not have any potential conflict of interest in this study. We have all participated in study conceptualization, methodology, study design, data analysis, data collection supervision and editing.

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