Infant-Directed Speech of Australian English mothers and fathers: A high and variable pitch with a more breathy and less creaky voice quality

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Abstract

Adults spontaneously speak differently to infants, in Infant-Directed Speech (IDS), compared to Adult Directed Speech (ADS). Key acoustic characteristics of IDS are the increased utterance-level pitch measures, specifically an increased mean or median, minimum, maximum and range. Lesser-studied characteristics of IDS include increased variability in utterance-level F0 across an interaction and a breathier voice quality. Moreover, while there is an abundance of literature on mothers' IDS, there is still limited understanding of fathers' IDS. To address these gaps in the literature, this study compared utterance-level pitch properties, across-conversation pitch variability and voice quality of Australian English mothers' and fathers' IDS, compared to ADS.

The final study sample consisted of eight Australian English mother-father dyads and their infant (6-12 months). IDS was elicited from parent-infant dyads during play with toys, and ADS was elicited from mother-father dyads during a play task. The IDS and ADS elicitation tasks were closely matched, maintaining consistency in interlocutor familiarity and the type of activity engaged in by dyads, thus isolating the effect of the infants' presence on both mothers' and fathers' speech. Audio recordings were segmented into utterances and perceptually coded for the presence of whispered speech, and breathy and creaky voice. Utterance-level pitch measures, the standard deviation of utterance-level F0, and the prevalence of voice quality types, were compared across parent genders and registers.

Both mothers and fathers increased all utterance-level pitch measures as well as across-conversation pitch variability in IDS, compared to ADS. Both parent genders, and especially mothers, decreased their creakiness and increased their breathiness in IDS, compared to ADS. These results are discussed in relation to methodological choices, including measures of pitch and voice quality, automated coding in acoustic analyses and task-design considerations.

Declaration

This thesis has not been submitted for a higher degree to any other university or institution. To the best of my knowledge, all sources of information and knowledge cited within this thesis have been given due reference. The research presented in this thesis has been approved by the Macquarie University Faculty of Human Sciences Research Ethics Sub-Committee (Ref: 5201833405057).

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1. Literature Review

1.1 General Introduction

Adults alter many characteristics of their speech and language during interactions with infants, which renders these interactions markedly different from those with other adults (Ferguson, 1964; Rondal, 1980). The speech styles used in these interactions are referred to as, respectively, Infant Directed Speech (IDS) and Adult Directed Speech (ADS). The IDS literature encompasses a broad range of research across linguistic sub-disciplines, including syntax, morphology, phonology (for an overview, see Soderstrom, 2007) and acoustics (for a review, see Cristia, 2013).

Previous research on the acoustic profile of IDS has predominantly focussed on mothers' speech and interactions with infants, motivated by the perception of mothers as the primary caregiver (Abkarian, Dworkin, & Abkarian, 2003; Lamb, 1975; Leaper, Anderson, & Sanders, 1998; Rondal, 1980). This research bias towards mothers' speech is also revealed through gendered terminology, such as 'motherese' for IDS. 'Motherese' is still in use as revealed, for instance, by the recent publication entitled "Fathers' Use of Fundamental Frequency in Motherese" (VanDam, De Palma, & Strong, 2015; see also: Falk, 2004; Haggan, 2002; Saint-Georges et al., 2013; Zellou & Scarborough, 2015).

Comparatively few studies have investigated the acoustic profile of fathers' IDS (see Subsection 1.4.2 for a detailed overview of these studies). A significant proportion of these studies were conducted at a time when society held the perspective that fathering was equated with breadwinning; this research may no longer reflect the IDS acoustic profile of modern-day fathers, who are now considered to be caretakers (Brady, Stevens, Coles, Zadoroznji, & Martin, 2017; Broesch & Bryant, 2017; Cerezo, Sierra-Garcia, Pons-Salvador, & Trenado, 2017; Tamis-

LeMonda, Shannon, Cabrera, & Lamb, 2004). In addition, studies on fathers' IDS have produced inconsistent results regarding the acoustic profile of paternal IDS; for example, with respect to the amount of acoustic variability in fathers' IDS (Benders, Fletcher, & StGeorge, under revision), the differences between rural and urban fathers' IDS (Broesch & Bryant, 2017), and the effect of speech task on fathers' IDS (Shute & Wheldall, 1999). While there is a large amount of data on maternal IDS in different languages and English varieties, there is a notable lack of research concerning paternal IDS cross-linguistically. Australian English is one such language, with data available for Australian-English mothers' IDS, but no comparable data for Australian-English fathers' IDS. The overarching aim of this study is to describe and compare the acoustic characteristics of Australian English parents' IDS and in particular, provide more insight regarding present-day fathers' speech to infants.

Addressing these gaps in the literature will provide more knowledge of fathers' IDS, which may have implications for our understanding of the role of fathers in infants' overall social and language development. Further research on fathers' IDS is warranted, particularly since paternal involvement and father-infant interactions have been linked to improved child outcomes (Barker, Iles, & Ramchandani, 2017; Cerezo et al., 2017; Lamb, 2010; StGeorge et al., 2018; Shorey, Hong-Gu, & Morelius, 2016; Southwood, 2010; Tamis-LeMonda et al., 2004; Yago et al., 2014).

This literature review will first present a summary of the key acoustic characteristics of IDS and influential factors on these acoustic properties, based on the research conducted with mothers. This will lead into an overview of studies and findings on fathers' IDS, followed by a comparison of mothers' and fathers' IDS, and a discussion of factors that have been found to influence fathers' IDS. The research questions and hypotheses for this study will then be presented, followed by a brief section on the considerations that have impacted the design of the present study.

1.2 Characterising and understanding IDS

When adults talk to infants (IDS), they use a different speaking style to that used during conversation with other adults (ADS). IDS differs from ADS in various linguistic aspects, including its acoustic profile. In order to describe the acoustic profile of these two speech styles, authors have examined pitch properties and voice quality, which will be discussed here in turn.

1.2.1 Defining Pitch

Pitch properties are acoustically analysed using the Fundamental Frequency (F0) of individual utterances or specific target words within an utterance (Fernald et al., 1989; Benders, 2013; Gergely et al., 2017). F0 is the lowest frequency in a periodic waveform and associated with the percept of pitch (Bachorowski, 1999). Male speakers typically have a lower average F0 than female speakers (Hollien, 1960; Peterson & Barney, 1952) and comparisons between mothers' and fathers' IDS must take these expected gender differences into consideration. It is particularly important to note that the scale used to measure F0 can impact the interpretation of differences between genders. As perception of pitch is non-linear, it has been argued that it is preferable to use the logarithmic Semitone (ST) scale, as opposed to the linear Hertz (Hz) scale (Benders et al., under revision).

1.2.2 Defining Voice Quality

Although yet to receive much attention within IDS research, voice quality has been investigated in some studies of mothers' IDS. Types of voice quality, or phonation, are perceptually distinct and characterised by the amount of tension and vibration of the vocal folds during speech production (Gobl & Ní Chasaide, 2003; Keating & Esposito, 2007; Szakay, 2012). Three categories of phonation have been identified cross-linguistically; modal, breathy and

creaky voice quality (Gobl & Ní Chasaide, 2003; Keating, Garellek, & Kreiman, 2015; Szakay, 2012). Modal voice is characterised by regular vocal fold vibration, breathy voice is characterised by lax vocal fold tension and creaky voice is characterised by high vocal fold tension and low levels of vibration (Gobl & Ní Chasaide, 2003; Szakay, 2012). The relative lack of research on voice quality in IDS may be due to the comparative difficulty of accurately measuring voice quality types, as opposed to the relative ease of extracting F0 measures from a signal (Gobl & Ní Chasaide, 2003). An overview of voice quality measures is provided in Subsection 1.2.4, and these measures will be discussed in more detail with regards to the results of this study (see Subsection 4.4).

1.2.3 Pitch Characteristics of IDS

1.2.3.1 Utterance-level Pitch Properties

Key F0 characteristics of IDS, as compared to ADS, are an increased mean or median, minimum, maximum, and range (Amano, Nakatani & Kondo, 2006; Benders, 2013; Broesch & Bryant, 2017; Bryant & Barrett, 2007; Fernald et al., 1989; Gergely et al., 2017). Increased F0 measures have been demonstrated in mothers' IDS, compared to ADS, across a variety of languages, including English varieties (British English, American English and Australian English), other European languages (French, German, Italian and Dutch) as well as in non-European languages (Japanese, Thai and Mandarin; Amano et al., 2006; Benders, 2013; Fernald et al., 1989; Gergely et al., 2017; Kitamura, Thanavishuth, Burnham, & Luksaneeyanawin, 2002; Lee, Kitamura, Burnham McAngus Todd, 2014; Narayan & McDermott, 2016; Niwano & Sugai, 2003; Papousek, Bornstein, Symmes, Nuzzo, & Papousek, 1990; Papousek, Papousek & Haekel, 1987; Shute & Wheldall, 1989). Note that although we have provided a table detailing fathers' IDS studies (see Subsection 1.3.2), it is impractical to provide an overview of mothers' IDS in table format, due to the immense quantity of literature on mothers IDS (see Cristia, 2013 for a review of the IDS acoustic literature).

1.2.3.2 Pitch Variability within and beyond individual utterances

The typical measures for describing the increased pitch fluctuations within utterances in IDS are the standard deviation and range of F0 (Amano et al., 2006; Broesch & Bryant, 2017; Cristia, 2013; Fernald et al., 1989; Rasanen, Kakouros, & Soderstrom, 2018). Although these utterance-level pitch properties have been well documented in the literature, less is known about how F0 changes across the entire conversation, henceforth referred to as across-conversation pitch variability. Across-conversation pitch variability can be quantified as the standard deviation (SD) of speakers' by-utterance average F0 values, possibly divided by the mean to obtain the Coefficient of Variation (CV). Increased across-conversation pitch variability in IDS, compared to ADS, has been found for Dutch and Australian English mothers (Benders et al., under revision; Lee et al., 2014).

1.2.3.3 Cross-linguistic Pitch Differences

Studies of different languages have reported differing acoustic measures of mothers' IDS, which suggests that IDS is present in most cultures but perhaps with somewhat different implementations (Farran, Lee, Yoo & Oller, 2016; Fernald et al., 1989; Kitamura et al., 2002; Ratner & Pye, 1984). For example, American English mothers have been reported to use a more exaggerated F0 in IDS, compared to mothers who speak languages other than English and mothers who speak British-English (Fernald et al., 1989; Shute & Wheldall, 1989).

Some studies have not found the typical increase of F0 measures in IDS, compared to ADS. Quiche Mayan-speaking mothers were reported to either have no increase in mean F0 or decrease their mean F0 in IDS (Ratner & Pye, 1984). However, these differences between study findings may be reflective of infant-age effects, rather than cross-linguistic differences, as there were three infant participants, aged 1;10, 2;0 and 2;9 (Ratner & Pye, 1984). As will be further discussed in Subsection 1.2.6, on infant age effects, mean F0 in IDS is modulated by infant age.

As another example of cross-linguistic differences, Kitamura et al., (2002) found that Australian English and Thai mothers increased the mean F0, but did not increase the F0 range in IDS, compared to ADS. The lack of range expansion in Australian English mothers' IDS has been reported in other studies of Australian English IDS as well (Burnham et al., 1998; Kitamura & Burnham, 2003), suggesting that this is a robust finding. This surprising deviation from the literature, which has frequently characterised IDS with a larger pitch range in other English varieties and other languages (Cristia, 2013; Fernald & Simon, 1984; Fernald et al., 1989; Gergely et al., 2017), implies that Thai and, possibly more striking, Australian English mothers' IDS is notably different to American English mothers' and British English mothers' IDS.

1.2.4 Voice Quality of IDS

1.2.4.1 Assessing Voice Quality with Acoustic Measures

Studies of voice quality in IDS have utilised acoustic measures to assess voice quality (Benders, Tobin, & Szakay, 2018; Malloch, Sharp, Murray Campbell, Murray Campbell, & Trevarthen, 1997; Miyazawa, Shinya, Martin, Kikuchi & Mazuka, 2017; Piazza, Iordan, & Lew-Williams, 2017; Shinya et al., 2009). Three of the aforementioned studies have used the H1-H2 measure, or the corrected H1-H2 measure, to assess voice quality in IDS, compared to ADS (Benders et al., 2018; Miyazawa et al., 2017; Shinya et al., 2009). The H1-H2 measure refers to the difference in amplitudes between the first harmonic (H1) and the second harmonic (H2); low H1-H2 values are associated with creaky voice, H1-H2 values close to 0 are associated with modal voice, and higher H1-H2 values are associated with breathy voice (Keating et al., 2015; Miyazawa et al., 2017).

1.2.4.2 Voice Quality & H1-H2

Two studies of Japanese speaking mothers' IDS have suggested that IDS, compared to ADS, is characterised by increased breathiness (Miyazawa et al., 2017; Shinya et al., 2009). Miyazawa et al. (2017) used the standard H1-H2 measure, which is positively correlated with

breathiness, in addition to the Cepstrum Peak Prominence (CPP) measure, (for details on this measure, see Miyazawa et al., 2017; Hillenbrand, Cleveland, & Erickson, 1994). Shinya et al. (2009) used the corrected H1-H2 measure, which takes into account the influence of F1 on H1-H2. Both studies found increased H1-H2 measures in IDS compared to ADS, which was interpreted as evidence for a breathier voice quality in IDS (Miyazawa et al., 2017; Shinya et al., 2009).

In contrast to the two previous studies with Japanese mothers, Dutch mothers do not appear to have increased breathiness in IDS, compared to ADS (Benders, et al., 2018). Benders et al. (2018) also utilised the corrected H1-H2 measure and did not find a significant difference between IDS and ADS. This is suggestive of cross-linguistic differences in voice quality use, as Japanese but not Dutch mothers have a breathy voice quality in IDS. Further research across a variety of languages is required to test this suggestion. This study will begin to address this gap by addressing voice quality in Australian English parents' IDS.

1.2.4.3 Other Acoustic Measures of Voice Quality

In addition to studies that have assessed voice quality with the H1-H2 measure, two other studies have investigated voice quality in IDS. Malloch et al. (1997) provided acoustic measures of roughness, sharpness and Tristimulus values for voice quality analyses of seven IDS utterances from one mother, directed towards her 4-week-old infant. These measures indicated that six of the seven analysed utterances were produced with lax vocal fold tension, suggesting a breathy voice quality (Malloch et al., 1997); however, it is difficult to extrapolate from these findings due to the lack of comparison with ADS. Piazza et al. (2017) found a significant difference in the voice quality of IDS, compared to ADS, based on the MFCC measures of spectral information obtained from a support-vector machine classifier; this was consistent for all languages included in the study (English, n=12; Spanish, n=1; Russian, n=1; Polish, n=1; German, n=2; Hungarian, n=1; French, n=1; Hebrew, n=2; Mandarin, n=2; Cantonese, n=1).

While this measure could only detect a difference in voice quality and not the voice quality type (Piazza et al., 2017), these findings are consistent with suggestions of voice quality differences between IDS and ADS, across a range of languages. The aforementioned studies have suggested that there are voice quality differences between IDS and ADS, but at present, the acoustic measures employed in these studies have not assessed perceptual judgements of voice quality (see Subsection 4.4 for an overview of acoustic measures versus perceptual judgements of voice quality). This study will begin to address this gap by analysing perceptual voice quality types in IDS, compared to ADS.

1.2.5 Whispered Speech in IDS

1.2.5.1 Observations of Whispered Speech

Another potential characteristic of IDS that is related to voice quality, is whispered speech, which refers to non-voiced sounds produced with minimal vocal cord vibration (Ito, Takeda, & Itakura, 2005; Zhang & Hansen, 2007). Only two studies have reported on the frequency of whispered speech in IDS, reporting that whispered speech accounted for 18% or 4.8% of mothers' IDS utterances in their corpus (respectively; Fernald & Simon, 1984; Papousek et al., 1987). These differences in the frequency of whispered speech in mothers' IDS across the two studies may reflect the age of the infants; suggesting that IDS directed to newborns (Fernald & Simon, 1984) contained more whispered utterances than IDS directed towards 3-month-old infants (Papousek et al., 1987).

1.2.5.2 Exclusion of Whispered Speech

Although few studies report on the prevalence of whispered speech in IDS, many studies will allude to the presence of whispered speech in their corpus of IDS. Authors often mention that tokens containing whispered speech were excluded from acoustic analyses, as it is not possible to extract F0 measures from the aperiodic signal of whispered speech. However, it is uncommon practice for authors to include a count of the number of excluded tokens that

contained whispered speech. Thus, despite frequent observations of whispered speech in IDS, there is limited data regarding the prevalence of whispered speech in IDS, compared to ADS. This implies that we have an incomplete picture of the speech input directed towards infants. This study will begin to address this gap in the literature, with analyses of the prevalence of whispered speech in mothers' and fathers' IDS, compared to ADS.

1.2.6 Moderating Effects on IDS

1.2.6.1 Infant Age Effects

Adults modify their IDS based on infants' developmental stage, thereby facilitating and supporting infants' early social interactions (Cristia, 2013; Englund & Behne, 2006; Gergely et al., 2017; Kalashnikova & Burnham, 2018; Kitamura et al., 2002; Kruper & Uzgiris, 1987; Leaper et al., 1998; Stern, Spieker, Barnett & MacKain, 1983). Infant age has particularly been associated with variation in F0 measures of mothers' IDS, with a typical increase in F0 from birth to 6 months (Kitamura et al., 2002; Kitamura & Burnham, 2003; Stern et al., 1983). However, the pattern of an increasing F0 is less consistent after 6 months; F0 may decrease at 9 months with another increase at 12 months, or vice versa (Kitamura et al., 2002), or it may decrease from 12 months onwards (Stern et al., 1983). Two studies have found that IDS directed towards infants aged 4-5 months has a higher mean F0, compared to infants aged 12 months or older (Gergely et al., 2017; Stern et al., 1983). British mothers' IDS directed towards 4-month-old infants, compared to newborns, 12-month-old infants and 24-month-old infants, has more exaggerated F0 measures (Stern et al., 1983). Hungarian mothers of younger infants (4.8 months) have a higher F0 mean and range in IDS, compared to Hungarian mothers of older infants (16.5 months) (Gergely et al., 2017).

Australian English mothers have different F0 measures in IDS, depending on the age of the infant. Australian English mothers increase the mean F0 in IDS, with the highest mean F0 values in IDS directed towards 6-month-old infants, followed by a small decrease in mean F0 in

IDS directed towards 9-month-old infants, and increases in mean F0 when infants are 12 months old (Kitamura et al., 2002; Kitamura & Burnham, 2003). In a separate study, Australian English mothers were found to increase F0 range in IDS with infant age (Kitamura & Burnham, 2003). Thai mothers' IDS appears to follow a similar pattern to Australian English mothers with increased mean F0, although Thai mothers increased the mean F0 when infants were 9-months-old and decreased the mean F0 when infants were 12-months-old (Kitamura et al., 2002).

1.2.6.2 Infant Gender Effects

Another infant characteristic that has an impact on modulations in mothers' IDS is infant gender. Australian English mothers of female infants, compared to mothers of male infants, use a higher overall mean F0 in IDS (Kitamura & Burnham, 2003). Australian English and Thai mothers of female infants, compared to mothers of male infants, also had an increased pitch range in IDS (Kitamura et al., 2002), with other work suggesting that the increased range to Australian English female infants may be specific to 9 and 12 months of age (Kitamura & Burnham, 2003).

1.3 Characterising Fathers' IDS

While previous research has identified acoustic characteristics that tend to describe mothers' IDS across cultures, less is currently known about fathers' IDS. This is due to the smaller number of studies with fathers as participants. A detailed overview of IDS studies that have included fathers as participants is provided in Table 1 (see Subsection 1.3.2).

1.3.1 Paternal IDS Literature

One critical characteristic of the paternal IDS literature is that more than half (n=8) of the studies on fathers' IDS were published between 1980 - 2000. Only two acoustic studies on paternal IDS were published in the past 10 years (Broesch et al., 2017; Gergely et al., 2017),

with a third currently under revision (Benders et al., under revision). While the age of a study is not sufficient to warrant critical interpretations of its results, current cultural attitudes and beliefs regarding the role of fathers in child-rearing have evolved from breadwinning to favour co-parenting; fathers spend more time with their children now, than in previous decades (Brady, Stevens, Coles, Zadoroznyi & Martin, 2017; Marshall, Davis, Hogg, Schneider & Peterson, 2014; Myers & Booth, 2002). Thus, observations of fathers' IDS in the 1980s may not be an accurate representation of the way modern-day fathers speak to their children, as suggested in more recent studies (Benders et al., under revision; Gergely et al., 2017). The present study aims to add further present-day data and contribute to the updated descriptions of the acoustics of fathers' IDS, compared to mothers' IDS.

1.3.2 Acoustics of Fathers' IDS

1.3.2.1 Utterance-level Pitch Properties

Similar to mothers, fathers' IDS has been characterised by a higher mean, minimum, and maximum F0, combined with increased F0 range, compared to ADS (Benders et al., under revision; Broesch & Bryant, 2017; Fernald et al., 1989; Gergely et al., 2017; Niwano & Sugai, 2003). Previous studies have consistently found that fathers' increase the mean F0 in IDS, compared to ADS (see Table 1), with few exceptions. Broesch & Bryant (2017) reported that while (rural) fathers living in Vanuatu increased the mean F0 in IDS, compared to ADS, but that (urban) fathers in North America did not. Shute & Wheldall (1999) found that British fathers only increased mean F0 during conversational interactions, and not during reading. Some studies have reported that fathers do not increase F0 range within utterances in IDS, compared to ADS (Amano et al., 2006; Broesch & Bryant, 2017; Fernald et al., 1989; Sheehan, 2008; Warren-Leubecker & Bohannon, 1984).

1.3.2.2 Across-conversation Pitch Variability in Fathers' IDS

A recent study found that fathers had increased F0 variability across utterances, to a greater extent than mothers (Benders et al., under revision). It was postulated that the larger increase in F0 variability in fathers' IDS, as compared to mothers, may be a reflection of the typically more exuberant and unpredictable paternal interaction style (Benders et al., under revision; StGeorge, Wroe & Cashin, 2018). While a few further studies have similarly reported increased F0 variability in parental IDS, comparing results across studies are currently complicated by inconsistent applications of measures of F0 (Broesch & Bryant, 2015; Warren-Leubecker & Bohannon, 1984). This study will assess the previously mentioned measures of across-conversation acoustic variability (see Subsection 1.2.3), to provide further insight regarding F0 variability in IDS, compared to ADS.

Table 1

Fathers Included as Participants in IDS Studies

Authors & Year	Language/s or Country	Infant Age	High M F0	High Min F0	High Max F0	Expanded F0 Range	High F0 SD
Amano, Nakatani & Kondo (2006)	Japanese	0 → 5; 0 (longitudinal)	✓ * Before infants produce 2-word utterances	N/R	N/R	✓ * Between utterances only, not within utterances	N/R
Benders et al. (under revision)	Dutch (Netherlands)	8 – 12 months & 15 months	✓	✓	✓	✓ * Within utterances & across conversation	✓ * Within utterances & across conversation
Broesch & Bryant (2017)	Vanuatu & North America (Languages not specified)	M = 7.8 months, SD = 4.3	✓ * Vanuatu fathers only	N/R	N/R	✓ * Across utterances	✓ * Small scale fathers only, not urban
Fernald et al., (1989)	French, Italian, German, Japanese, British-English & American-English	0; 10 – 1; 2	✓	✓	✓	✗	✓ * Differences in semitones between SD of means
Gergely et al. (2017)	Hungarian	4.8 months (± 7 weeks) – 25.5 months (± 14 weeks)	✓ * Qualified by task & child age	N/R	N/R	✓ * Largest during teaching, compared to storytelling task	N/R

Authors & Year	Language/s or Country	Infant Age	High M F0	High Min F0	High Max F0	Expanded F0 Range	High F0 SD
Jacobson, Boersma, Fields & Olson (1983)	American-English	0; 4 – 0; 8	✓	N/R	N/R	N/R	✓
Kaplan, Sliter & Burgess (2007)	U.S.	0; 5 – 1; 1	✓ * Non-significantly lower for depressed fathers	N/R	N/R	✓ * Non-significantly lower for depressed fathers	✓ * Marginally significantly lower for depressed fathers
McRoberts & Best (1997)	U.S.	0; 2 → 1; 6 (longitudinal)	✓ * F0 mean changed with child age	N/R	N/R	N/R	N/R
Niwano & Sugai (2003)	Japanese	3, 5 & 7 months	✓	✓	✓	✓	N/R
Papousek, Papousek & Haekel (1987)	German	3 months (M= 12.6 weeks)	✓	✗	✓	✓ * Within utterances	✓ * Speech frequency range over all productions
Reissland (1998)	American-English	0; 1 → 1; 4 (longitudinal)	✓ * Rhetorical questions had higher M F0 than real questions (child aged +15 months)	N/R	N/R	N/R	N/R

Authors & Year	Language/s or Country	Infant Age	High M F0	High Min F0	High Max F0	Expanded F0 Range	High F0 SD
Sheehan (2008)	American-English	M= 6.97 months	✓	N/R	N/R	✗ * ADS larger frequency range	✗ * No SD difference between IDS & ADS
Shute & Wheldall (1999)	British-English	1; 0 – 3; 0 (M= 24.4 months)	✓ * During conversation but not during reading * High modal F0 during conversation & reading aloud	N/R	N/R	N/R	✓ * Only 50% increased variability
Van de Weijer (1997)	Dutch (Netherlands)	0; 6 → 0; 9 (longitudinal)	✓	✓	✓	✓ * Within utterances	✓
Warren-Leubecker & Bohannon (1984)	American-English	2; 0 & 5; 0	✓ * High modal F0 when addressing 2 year olds	N/R	N/R	✓ * Across utterances when addressing 2 year olds	N/R

1.3.3 Mothers' vs Fathers' IDS

While mothers' and fathers' IDS acoustic profiles appear quite similar in terms of increased F0 measures, fathers are sometimes reported to exaggerate their IDS less than mothers. For instance, fathers do not always increase their mean F0 to the same extent as mothers, even once the expected differences in mean F0 and the perceptual implications are accounted for through the semitone scale (Fernald et al., 1989). However, the differences between mothers and fathers' IDS are inconsistent, suggesting that there may be more similarities than differences, between mothers and fathers' IDS.

Fathers' mean F0 has been reported to increase to a lesser extent than mothers (Amano et al., 2006; Fernald et al., 1989; Gergely et al., 2017) and to the same or greater extent than mothers (Benders et al., under revision; Sheehan, 2008; Warren-Leubecker & Bohannon, 1984). Fathers have been reported to increase F0 range to a lesser extent than mothers in IDS (Jacobson et al., 1983; Papousek et al., 1987; Fernald et al., 1989), to a similar extent to mothers (American & British fathers, Fernald et al., 1989; Gergely et al., 2017; van de Weijer, 1997), and to a greater extent than mothers (Benders et al., under revision; Niwano & Sugai, 2003; Warren-Leubecker & Bohannon, 1984). Although less frequent comparisons are made regarding minimum and maximum F0, these measures have been reported to increase to a lesser extent than mothers (maximum: Fernald et al., 1989), or to a similar extent to mothers (Papousek et al., 1987).

1.3.4 Voice Quality & Whispered Speech in Fathers' IDS

To the best of our knowledge, at present there is no published research regarding voice quality use in fathers' IDS. In addition, only one study has reported on the frequency of whispered speech in fathers' IDS, namely 14.6% of utterances in fathers' IDS, which was higher than that reported for mothers in the same study (4.8%) (Papousek et al., 1987).

1.3.5 Infant & Gender Effects on Fathers' IDS

Infant age effects on fathers' IDS has received little attention within the acoustic literature. Hungarian fathers of younger infants, compared to those with older infants, have an increased mean F0 and increased F0 range in IDS (Gergely et al., 2017). This study also suggested that fathers' IDS was more sensitive to infant age, than mothers' IDS (Gergely et al., 2017). McRoberts and Best (1997) reported that mean F0 in one British father's IDS was highest when the infant was 7-months-old, compared to when the infant was aged 3-,15- and 17 months; this is similar to the pitch peak at 6 months in mothers' IDS (Kitamura et al., 2002; Kitamura & Burnham, 2003; Stern et al., 1983). Infant gender effects on fathers' IDS have yet to be reported within the literature.

1.3.6 Cross-linguistic Differences in Fathers' IDS

As with mothers, cross-linguistic differences in fathers' IDS have been observed, as indicated by the diversity of findings presented in Table 1 (see Subsection 1.3.2). While the majority of studies have reported that fathers increase their mean F0 in IDS (including American English, British English, German, Italian, Dutch, French & Japanese, see Table 1), one study reported that this distinguishing feature was absent in North American fathers' IDS (Broesch & Bryant, 2017). This is a surprising finding, as American English fathers have been reported to increase mean F0 in IDS, compared to ADS, to a larger extent than German, Italian, French and British English fathers (Fernald et al., 1989). It has also been suggested that British fathers' IDS only had a high mean F0 during conversational tasks, but not during book reading (Shute & Wheldall, 1999). Moving to a different F0 characteristic, some studies indicate that fathers do not increase F0 variability at the utterance-level in IDS, compared to ADS (Japanese, Amano et al., 2006; American English, British English, German, Italian, Japanese, French, Fernald et al., 1989; American English, Sheehan, 2008), whereas other studies have reported this increase for fathers' IDS in Dutch (Benders et al., under revision; Van de Weijer, 1997), German (Papousek

et al., 1987), Japanese (Niwano & Sugai, 2003), American English (Kaplan et al., 2007) and Hungarian (Gergely et al., 2017). Finally, F0 variability across the interaction in IDS has only been investigated for Dutch fathers (Benders et al., under revision).

1.3.7 Interpreting Different Results on Fathers' IDS

However, with so few studies on fathers' IDS, it is unclear whether these inconsistencies across studies stem from cross-linguistic differences, or from other factors. For instance, methodological discrepancies across studies may account for some of the discrepancies across studies. Variables such as infant age (Gergely et al., 2017; Kitamura & Burnham, 2003; Kruper & Uzgiris, 1987; Stern, Spieker, Barnett & MacKain, 1983), elicitation task, such as reading or play tasks, (Gergely et al., 2017; Martin, Igarashi, Jincho & Mazuka, 2016; Shute & Wheldall, 1999), and differences between speech elicited in the home versus lab setting (Abkarian et al., 2003; Amano et al., 2006; Leaper, Anderson & Sanders, 1998) can have a significant impact on parents' speech to infants. Attributing these variables to each study that has reported discrepancies, is beyond the scope of this thesis. Within the context of the present study, we will account for the type of elicitation task (see Subsection 1.6 for overview of task effects).

1.4 The present study

1.4.1 Addressing Gaps in the Literature

In order to describe paternal IDS, it is essential to conduct language-specific research with fathers; it is not sufficient to rely on what we know about mothers' IDS in that particular language, or what is known about fathers' IDS in other languages. To begin to address this gap, the present study will provide a comprehensive description of the acoustic characteristics of Australian English mothers' and Australian English fathers' IDS. In addition, the present study aims to address the lack of perceptual voice quality analysis in the literature and provide data on

English speakers, by analysing perceptual judgements of voice quality types in Australian English parents' IDS, compared to ADS.

1.4.2. Study Aim

The general aim of this study is to characterize the acoustic profile of Australian English fathers' and mothers IDS, compared to ADS. This aim will be addressed with three core research questions.

1.4.3 Research Questions & Hypotheses

Research Question 1. How do Australian English mothers and fathers change their utterance-level pitch properties in IDS compared to ADS? The **dependent variables** for this research question will be the median F0, minimum F0 (25_{th} percentile), maximum F0 (75_{th} percentile) and F0 range of the individual utterances. It is hypothesized that mothers and fathers will have increased median, minimum and maximum F0 values in IDS, compared to ADS. It is hypothesised that mothers and fathers will not increase F0 range in IDS, compared to ADS, as per previous work on Australian English mothers' IDS.

Research Question 2. How do Australian English mothers and fathers change their across-conversation pitch variability in IDS compared to ADS? The **dependent variables** for this research question will be the F0 SD and F0 Coefficient of Variation (CV) of the speakers' median F0 of all individual utterances. It is hypothesized that mothers and fathers will increase across-conversation pitch variability in IDS, compared to ADS, with a larger increase for fathers.

Research Question 3. How do Australian English mothers and fathers change their voice quality in IDS compared to ADS? The **dependent variables** for this research question will be the presence of perceived breathy voice quality, creaky voice quality and whispered speech. It is

hypothesized that mothers and fathers will have an increased prevalence of breathy voice and whispered speech in IDS, compared to ADS.

1.5 Research Design Considerations: IDS & ADS Elicitation

The elicitation tasks in the present study were designed to be generalisable across context, while isolating the effect of register. Section 1.5.1 provides an overview of task effects that may have an impact on acoustic measures of pitch.

1.5.1 Speech Tasks

Free play tasks may be more representative of fathers' typical exuberant interactions with their children, as fathers are more likely to engage in active physical play, while mothers typically prefer ritualized play (Abkarian et al., 2003; StGeorge et al., 2018). Investigating fathers' IDS during active physical play may be more representative of a typical interaction between father-infant dyads. However, considering that fathers interact with their children in a variety of activities, it is important to assess their speech across different speech tasks.

1.5.1.1 Speech Task Effects on F0

Tasks that may require more attention-grabbing effort on the part of the parent may elicit more exaggerated IDS. Fathers' IDS has been found to have a higher mean F0 during free speech/free play, compared to reading aloud where they may not have a higher mean F0 (but may have a higher mode F0) (Sheehan, 2008; Shute & Wheldall, 1999). Gergely et al. (2017) investigated task effects on two F0 measures, specifically the F0 mean and F0 range, in Hungarian mothers' and fathers' IDS, compared to ADS. Speech task effects were reported to impact on the F0 mean and F0 range in IDS, compared to ADS (Gergely et al., 2017). Tasks that required problem solving, elicited higher mean F0 values in IDS, compared to storytelling tasks or teaching tasks (Gergely et al., 2017). The F0 range was increased during problem solving and

teaching tasks, as opposed to storytelling tasks (Gergely et al., 2017). An increased F0 range may indicate that parents were attempting to gain or maintain the infants' attention.

1.5.2 Design-matched Speech Tasks in the Current Study

1.5.2.1 Speech Task Type

In light of the differences in results across studies that elicit IDS with differing task types, overarching conclusions about parents' IDS are ideally based on observations within more than one interactive context. Therefore, the present study will characterise Australian parents' IDS and ADS in two speech tasks, namely, a play task, which is designed to elicit more active interactions, and a story task, which is designed to elicit calmer narrative-based speech. The play and story tasks were design-matched; the design of each task type for IDS elicitation was matched as closely as possible to the design of each respective task type for ADS elicitation, but with materials appropriate for the age of the interlocutor. For example, foam blocks were used for the IDS play task, which were matched with Lego pieces in the ADS play task (see Subsection 2.3).

1.5.2.2 Interlocutor Familiarity

In addition to the design-matched speech tasks for IDS and ADS, the level of interlocutor familiarity will also be matched for elicitation of both registers. Most studies elicit ADS during conversation with the adult experimenter (e.g., Benders, 2013; Fernald & Simon, 1984; Kalashnikova & Burnham, 2017). Comparability of IDS and ADS in IDS studies is hindered due to the level of intimacy between the parent-infant dyad, as compared to the degree of formality between the parent and experimenter. In the present study, ADS will thus be elicited from mother-father dyads with the experimenter absent. The level of familiarity and intimacy between mother-father dyads can be expected to be highly similar to that of parent-infant dyads, and thus provide further consistency across register elicitation.

2. Methodology

2.1 Overview

This study aimed to address three core research questions regarding the effects of gender on the 1) utterance-level pitch properties, 2) across-conversation pitch variability and 3) perceived voice quality in IDS and ADS, during play and story tasks.

The independent variables for all research questions were Register, contrasting parents' IDS and ADS; Parent Gender, comparing mothers and fathers; and Speech Task, comparing play and story. The dependent variables of interest for the first research question were the measures associated with the acoustic profile; specifically, median F0, minimum F0, maximum F0 and F0 range. The dependent variables of interest for the second research question were the F0 SD and F0 Coefficient of Variation (CV). The dependent variables of interest for the third research question were perceptual judgements of voice quality (VQ); specifically, Breathy VQ, Creaky VQ, and Whispered speech. Each parents' individual interaction with their infant (IDS interactions) and mother-father dyad interactions (ADS interactions) were audio and video recorded. Following initial informal inspection of the data, the acoustic recordings of IDS and ADS during the story task were excluded from analysis (see Subsection 2.5).

2.2 Participants

The final study sample consisted of eight participant families (mother, father and infant), henceforth referred to as dyads. A total of twelve dyads were recorded, of which four were excluded after data collection based on the exclusion criteria. Initial screening criteria for this study specified that both mother and father spoke English as a first language, with no history of speech/language delay or hearing impairment, and that the infant, aged between 6-12 months at time of testing, was developing typically as reported by the parents.

Following data collection, the requirement that parents spoke Australian English was added to the inclusion criteria, in order to remove the extraneous variable of English language variety from the study. During the session, participants completed questionnaires, including a language questionnaire (see Appendix A) and a sociodemographic questionnaire (see Appendix B). A total of four dyads were excluded from data analysis based on their self-reporting that either the mother or father were not born in Australia or did not speak Australian English as a first language.

2.2.1 Participant Characteristics

2.2.1.1 Demographics

Infants in this study were mostly female, with only one male infant ($_{m}$age = 9;7, *SD* = 2;15, see Table 3). Parents in this study had a mean age of 35 years, with participant ages ranging from 29 years to 41 years. It is not possible to provide a separate age range for the mothers and fathers included in this study; the structure of the sociodemographic questionnaire led to inconsistent responses regarding each participant's date of birth. Mothers and fathers were all self-reported to be middle-class with no self-reported history of mental health diagnoses, based on responses to the sociodemographic questionnaire. Most fathers in this study were engaged in full-time work at the time of recording, while only one mother was working full-time (see Table 3). Additional demographic information regarding the dyads who were included in this study is provided in Table 3.

2.2.1.2 Fathers' characteristics

Fathers completed an additional questionnaire regarding their overall mental and physical wellbeing; responses to this questionnaire suggest that all fathers in this study had no underlying mental or physical complaints (see Appendix C for PROMIS-29 Profile Questionnaire). The PROMIS-29 Profile is not a diagnostic tool and the results of this questionnaire did not have direct implications for the research questions. The validity of this profile has been demonstrated

with various populations in clinical and research settings, and it provides a reliable summary of mental health (Ader, 2007; Hays, Spritzer, Schalet & Cella, 2018; Katz, Pedro & Michaud, 2017). This questionnaire was administered as previous research has found that symptoms of depression may impact the acoustic properties of fathers' IDS (Kaplan et al., 2007).

The Paternal Index of Childcare Inventory (PICCI; Radin & Goldsmith, 1985; see Appendix D) has previously been used in studies on fathers' involvement with their children, with high scores associated with greater father involvement (Jacobs & Kelley, 2006; Nangle, Kelley, Fals-Stewart, & Levant, 2003). The Beliefs Concerning the Parental Role (BCPR; Bonney, Kelley, & Levant, 1999; see Appendix E) has previously been used in research on fathers and it has been reported to be a valid and reliable instrument for assessing fathers' beliefs regarding their role in child-rearing (Bonney, Kelley, & Levant, 1999; Jacobs & Kelley, 2006; Nangle et al., 2003). Fathers' scores for child-care activities versus parenting beliefs are provided in Table 2 (see Appendix F for Questionnaires Scoring Descriptions).

Table 2

Fathers' Scores for Child Care Activities versus Parenting Beliefs

Dyad Code	Paternal Index of Child Care Inventory (PICCI) Score	Beliefs Concerning the Parental Role (BCPR) Score
#1	105	124
#5	85	[a]
#14	98	120
#15	64	130
#21	110	118
#22	114	126
#36	111	119
#39	101	107

Notes. Higher scores on PICCI indicate fathers complete more child-care activities compared to lower scores, total possible score = 195. Scores ~ 117 on PICCI indicate equal division of child-care between mother and father. Higher scores on BCPR reflect more liberal beliefs regarding parenting and traditional gendered parenting roles, total possible score = 130. (See Appendix F for Questionnaires Scoring Description)

[a] Incomplete questionnaire- Score of 85, adjusted total = 95

Table 3

Participant Dyads Demographic Information

Dyad code	Mother		Father		Infant		
	Education Level	Work Status	Education Level	Work Status	Age (m;d)	Gender (M/F)	Siblings (n)
#1	Bachelor	Full Time	Diploma	Full Time	9;2	F	1
#5	Bachelor	Home Maker	Bachelor	Full Time	6;29	F	0
#14	Diploma [a]	Maternity Leave	Bachelor	Full Time	6;28	F	0
#15	Diploma	Home Maker	Masters	Full Time	11;12	F	2
#21	Bachelor	Maternity Leave	Masters	Full Time	10;26	F	0
#22	Masters	Part Time	High School Certificate	Full Time	12;23	F	0
#36	Bachelor	Maternity Leave	Bachelor	Seeking Employment	8;4	F	0
#39	Diploma	Casual	Bachelor	Full Time	12;30	M	1

Notes. Participants were randomly allocated a Dyad Code from 1- 40

[a] *In Australia, a Diploma is obtained through TAFE vocational courses*

2.2.2 Ethics and Recruitment

The Macquarie University Human Sciences Subcommittee provided ethical approval for the current study (Project 3340) to be conducted by Elise Tobin, under the supervision of Dr. Titia Benders. Participants were recruited through flyers displayed on community notice boards, shopping centres, childcare centres, notice boards at the Macquarie University North Ryde campus, and websites and social media. In addition to the recruitment flyer, a recruitment video was created to promote interest in the study, distributed through the Child Language Lab social media accounts. Both the recruitment flyer and video included a link to a Qualtrics survey to request further information or register interest in participating.

2.2.3 Participant Reimbursement

Participant dyads received monetary reimbursement for their participation in the study, regardless of whether all tasks were completed; mothers received $20 and fathers received $25. The higher rate of reimbursement for fathers was commensurate with more participation requirements, as they were asked to complete additional questionnaires (see Subsection 2.2.1). Both mothers and fathers provided written, informed consent for themselves and on behalf of their infant, prior to their participation in this study.

2.3 Materials

2.3.1 IDS Elicitation Materials

Separate materials were provided for the IDS play task and IDS story task; the same materials were used for both mothers' and fathers' IDS elicitation. During the IDS play task, parent-infant dyads were provided with a canvas bag containing 12 foam blocks to provide a prompt for a play interaction (see Figure A). The foam material of these blocks was suitable for infants under 12 months and produced very little noise during play activities. The prompt for the IDS story task was an abridged version of The Very Hungry Caterpillar by Eric Carle, advertised as 'A Snuggly Cloth Book for Babies' (see Figure B). The abridged book is 8 pages long,

inclusive of the front and back cover. The inside pages of the book have an average of 3.5 words per page, with a range of 2 – 6 words per page (see Figure C). The Very Hungry Caterpillar is a well-known story, and this abridged version was intended to prompt parents into telling this familiar story, or a variation, rather than reading to the infant. This book was also chosen as it was an age-appropriate text stimulus for parents interacting with infants aged 6-12 months.

Figure A- Foam blocks provided for IDS Play Task

Figure B- Soft Book provided for IDS Story Task (exterior)

Figure C - Soft book provided for IDS Story Task (interior example)

2.3.2 ADS Elicitation Materials

Separate materials were provided for the ADS play task and ADS story task. During the ADS play task, parent-dyads were provided with Lego pieces and the manufacturer-produced instructions for the construction of a Lego Koala (see Appendix F for manufacturer-produced instructions). Dyads were also provided with additional written instructions; these were a brief summary of the verbal instructions for the play task (see Appendix G for written instructions). To reduce noise in recordings and facilitate task completion, Lego pieces were sorted by colour and shape, and provided in two foam-lined containers with multiple compartments (see Figure D & Figure E). The manufacturer-produced instructions were enlarged and split over two A4 pages, with one page displaying the first half of the instructions (see Figure D) and the second page displaying the second half of the instructions (see Figure E; see Appendix F). During the ADS story task, each parent was provided with one A4 laminated page with six black-and-white, candid images obtained through Creative Commons (see Appendix H).

Figure D- Instructions and Lego provided for ADS Play Task (Speaker 1)

Figure E- Instructions and Lego provided for ADS Play Task (Speaker 2)

2.3.3 Questionnaires

Dyads were asked to complete a total of five questionnaires (see Appendices A - E). Two of the questionnaires, the Language Questionnaire and the Sociodemographic questionnaire, could be completed by either the mother or father separately or together. Three of the questionnaires could be completed only by the father, namely the PROMIS-29 Profile, the PICCI

and the BCPR (see Table 3 for fathers' scores for the PICCI and BCPR; see Appendix F for questionnaires scoring description). Parents were asked to complete the questionnaires in another room while their partner and child were occupied with the IDS elicitation tasks.

2.3.4 Equipment

Parents' speech was recorded with head-mounted condenser microphones (AKG-C520), connected to a solid-state recorder (Marantz PMD661MKII). During IDS elicitation, the recorder was placed in a small, over-the-shoulder bag, worn by the parent to allow freedom of movement. During ADS elicitation, the two microphones were connected to the same recorder and placed on the table, between the mother and father. Video recordings of IDS and ADS elicitation were made with two Go-Pro Hero3+ cameras, mounted on tripods and arranged in opposite corners of the room.

2.3.5 Recording Settings

Of the eight sessions, seven sessions were conducted in a small, sound-proofed, child-friendly lab at Macquarie University. The lab was set up with separate areas for IDS and ADS elicitation, henceforth referred to as the IDS area and the ADS area. The IDS area was furnished with a picnic-rug, two child-sized chairs and three soft toys. IDS interactions involved the mother and father interacting with their infant on the picnic-rug and they did not typically sit on the provided chairs. The soft toys were provided for the infant to familiarise themselves with the IDS area at the start of the session, while the researcher provided consent forms and instructions to both parents. The ADS area was arranged with a table, two child-sized chairs and task materials propped up on a small stand in the centre of the table (see Figure F). During ADS interactions, the mother and father were seated on opposite sides of the table.

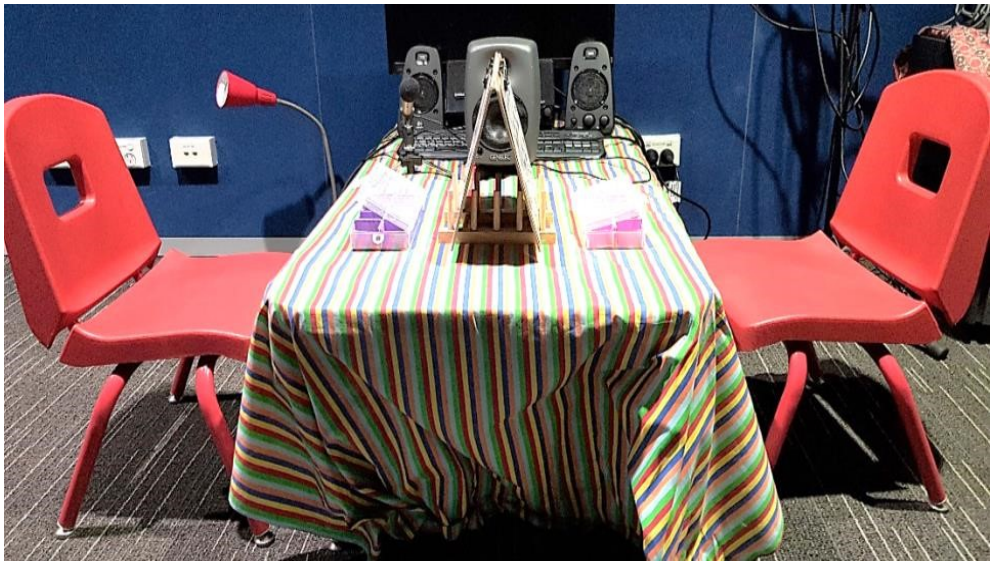

Figure F- ADS Area Set-up (Lab Setting)

Recruitment difficulties necessitated conducting sessions at locations outside of the Child Language Lab; one dyad was recorded in their home. The home setting was adjusted to recreate the IDS area and ADS in a quiet room. The quiet room was selected for the absence of audible external noise, such as traffic, in addition to the presence of sound-absorbing objects, such as couches and rugs. Following observation of the room's acoustic properties, extra blankets were placed on the floor to further reduce reverberation. To reduce background noise in audio recordings, participants were asked to keep pets outside and turn off noise-producing devices, such as air-conditioners. Potentially distracting objects, such as the infant's toys and books, were removed for the duration of the session.

2.4 Procedure

2.4.1 IDS Elicitation

IDS elicitation consisted of two speech tasks, a story task and a play task, with each task allocated seven minutes per dyad. For the story task, parent-infant dyads were given a soft book to elicit story speech (see Subsection 2.3.1) and parents were asked to interact and talk to their infant as they normally would when reading books with their infant. For the play task, parent-

infant dyads were given foam blocks to prompt a play interaction and parents were asked to play with the blocks with their infant and talk to their infant as they normally would during joint-play activities. IDS elicitation was recorded separately for mother-infant and father-infant dyads. The experimenter and the other parent were absent from the room for the duration of the IDS elicitations. Parents were informed that once seven minutes had elapsed for the first speech task, the experimenter would briefly return to the room to deposit the materials for the second speech task in the IDS area. Parents were informed that they did not need to acknowledge the experimenter, but to transition to the second task and orient their infant to the new materials. Parents were asked to focus infant attention on the designated task materials and keep their infant in the IDS area.

2.4.2 ADS Elicitation

Mother-father dyads were asked to complete two speech tasks together: a story task and a play task. Both tasks required a dialogue between mother and father; dyads were asked to avoid speaking simultaneously, within the natural constraints of conversation. These two tasks were designed to closely match the IDS tasks, but with adult-appropriate materials. Participants were given verbal instructions before each task, to reduce participants' cognitive load during each task. The experimenter and infant were absent from the room for the duration of each task.

2.4.2.1 ADS Story Task

During the story task, participants were asked to "dominate" the conversation for seven minutes each, using the pictures as prompts for the conversation topic or story. Participants were required to monitor the duration of the story-telling task, with the aid of the recording device which displayed the amount of time that had elapsed.

2.4.2.2 ADS Play Task

Before the play task commenced, participants were asked to not look at their partners' visual instructions, but they were permitted to show each other the Lego pieces. During the play task, participants were designated as either speaker 1 or speaker 2, as per the dyad's random allocation to a counterbalanced list (see Subsection 2.4.3). Speaker 1 gave their partner verbal instructions on how to construct the Lego koala, based on the provided visual instructions (see Appendix F for manufacturer-produced instructions). Once speaker 1 reached the end of their instructions, the half-finished koala was passed over, and speaker 2 gave their partner instructions on how to finish constructing the Lego koala. The play task ended when mother-father dyads reached the end of the visual instructions and completed the Lego construction; completion rates for this task ranged from 12-24 minutes.

2.4.3 Counterbalancing

The IDS procedure required one parent to complete the story and then the play task (or vice versa), before IDS was elicited from the second parent. The ADS procedure was slightly different, with both parents completing the story task and then both parents completing the play task (or vice versa). The order of register elicitation was counterbalanced across dyads; either IDS tasks were completed by both parents before completing ADS tasks, or vice versa. Task order was counterbalanced across dyads, and within dyads, the task order (story or play task first) was kept consistent across registers. The speaker order (father or mother first) was counterbalanced within dyads, and both speaker order and task sequence were counterbalanced across dyads. This resulted in 8 possible lists of task sequences. Dyads were randomly allocated to one of these lists.

The sequence of tasks in List 4 is provided as an example in Table 4 (see Appendix J for task sequences for all counterbalanced lists). As a result of excluding four dyads from data analyses, there was an uneven distribution of dyads across lists (List 1, n=1; List 2, n=2; List 3,

n=1; List 4, n=2, List 5, n=0, List 6, n=1; List 7, n=0; List 8, n=1). The dyad in List 6 did not complete the tasks according to the counterbalanced order, as a result of infant fussiness.

Table 4

Sequence of Tasks for List 4

List 4 Task Sequence

	Register	*Parent*	*Task Type*
1.	IDS	Father	Story
2.	IDS	Father	Play
3.	IDS	Mother	Story
4.	IDS	Mother	Play
5.	ADS	Mother	Story
6.	ADS	Father	Story
7.	ADS	Mother	Play
8.	ADS	Father	Play

2.5 Analysis

2.5.1 Data Selection

Audio recordings of IDS and ADS elicited during the IDS play task and ADS Lego task were included in the data analysis; audio recordings for the IDS and ADS story task were excluded from the data analysis. Despite piloting the tasks, participants did not interact as expected with the IDS book and ADS story materials and tended to quickly disengage with the provided materials. In the IDS story task, there was a tendency for parent-infant dyads to look through the book once, with minimal (if any) elaboration on the written text, before engaging in other play activities. A similar pattern was observed in the ADS story task, as mother-father dyads tended to only briefly mention the visual prompts and the majority of elicited speech was related to their daily lives or planned activities. The IDS story task thus elicited speech more typical of a play interaction, while conversational speech was elicited during the ADS story task. The audio recordings, therefore, were determined to be an invalid representation of story speech

and invalid basis for comparison between IDS and ADS. The small amount of story speech data that was collected (typically less than a minute duration per parent-infant dyad) was deemed insufficient for statistical analyses.

To ensure a consistent quantity of data was analysed for each dyad, annotation of audio files for each task and speaker was capped at seven minutes. A maximum of 28 minutes was annotated for each dyad. Some dyads provided less than 28 minutes of speech data, due to faster completion of the ADS play task.

2.5.2 Utterance Definition

Although the duration of a pause is frequently used in the IDS literature to define an utterance (e.g., see Kitamura & Burnham, 2003; Sheehan, 2008), it is important to note that in the present study, pause duration was not the most important characteristic for determining whether a section of speech consisted of one or more utterances. Instead of pause duration, an utterance was identified based on the intonation contour and whether the utterance conveyed meaning (Crookes, 1990; Henning, Striano, & Lieven, 2005). Thus, if the intonation contour was not interrupted, an utterance could consist of either an isolated word, a multi-word phrase, or multiple phrases. Pause duration was used to distinguish an utterance when the previously mentioned criteria were inadequate to separate sequences of speech.

2.5.3 Acoustic Annotations

Acoustic annotations of speech data were completed using Praat (Boersma & Weenink, 2018). The first step for acoustic annotations involved running an automated script using the Textgrid to Silences command in Praat, which provided an estimation of utterance boundaries for each speech file recording (Boersma & Weenink, 2018). The second step involved manually adjusting these utterance boundaries, as per the utterance definition. Spectrogram settings were kept consistent across all acoustic annotations as per Praat Standards and only minimally

adjusted if it was difficult to determine the onset and offset of an utterance; for example, increasing the set dynamic range (dB) from 70 to 75 for whispered tokens.

2.5.3.1 Utterance Coding

Simultaneously with manual adjustment of utterance intervals, it was annotated whether the automated utterance intervals boundaries contained verbal content, as opposed to utterances that did not contain any parent verbal content, such as isolated infant vocalisations. Utterances were coded to make note of additional parent input, such as whether the utterance contained laughter, breaths, exclamations and sound effects (see Table 5 for codes, definitions and examples). The third step of acoustic annotations involved perceptual judgements of each utterance for various features of interest, including voice quality type (breathy, creaky or whisper), sound effect type (animal or other), utterance type (question or statement), intention (directive, affirmation or none), and infant directed (infant name, infant action or none) (see Table 5).

2.5.3.2 Pitch Settings

Initial pitch floor and pitch ceiling settings, respectively, were set at 100-600Hz for mothers and 65-400Hz for fathers; the pitch ceiling for mothers was increased to 650Hz (see Subsection 2.5.4). This pitch ceiling was selected based on the average pitch ranges of Australian English male and female speakers (Yan, Vaseghi, Rentzos, Ho, & Turajlic, 2003). The standardised pitch settings were manually adjusted if needed, for example if there was evidence of pitch-doubling or pitch-halving. F0 measures were approximated in Hertz using the auto-correlation method, with a 0.01s time step, 0.03 silence threshold and 0.45 voicing threshold.

Table 5

Utterance Annotation Codes, Definitions and Examples

Utterance Codes	Definition	Examples
Whisper [a]	Utterance containing whisper	
Breathy [a]	Utterance containing additional air turbulence	
Creaky [a]	Utterance containing creaky/rough vocal quality	
Laughter	Parent laughter	
Speech-Laughter	Simultaneous speech and laughter	
Exclaim	Gasps & vocalisations without language content	oh | um | mmhm | woah | yay
Animal	Speaker imitating animal sound	meow | buzz
Other Sound Effect	Speaker producing non-animal sound effects	plane sounds | imitating infants
Inhale	Audible breath prior to/during an utterance	
Question	Speaker asking question	"Where are the blocks?"
Statement	Speaker making a statement	"Here are the blocks."
[Intention] Directive	Speaker giving instructions to listener	"Knock down the blocks."
[Intention] Affirmation	Speaker confirming accurate task completion or providing praise	"Good job, you did it."
[Intention] None	Neither Directive nor Affirmation	
[Infant Directed] [b] Infant Name	Infant addressed by name/nickname	
[Infant Directed] [b] Infant Action	Speaker commenting on infant's activity	"Where are you going?"
[Infant Directed] [b] None	Neither Infant Name nor Infant Action	"Let's stack the blocks up."
Attention [b]	Speaker attempt to gain/maintain infant attention	"Look at the blocks!"
Environment	Speech referring to something other than task materials	"That's a microphone."
Noise	Overlapping sound in recording	Infant vocalisations

[a] Voice quality types did not need to be present throughout the entire utterance

[b] Coded only in IDS

2.5.4 Data Analysis

Following the acoustic annotations, an automated pitch script was used to extract and calculate F0 measures for each utterance (mean, median, minimum 10%, maximum 90%, and SD) in both Hertz (Hz) and Semitones (ST) re 200 Hz. This automated pitch script utilised the manually adjusted pitch settings for all data analyses (see Subsection 2.5.3). Following data visualisation and spot-checks of the data, a high proportion of the values for the 10_{th} and 90^{th} percentile pitch values appeared to be pitch-tracking errors. Based on these pitch-tracking errors, the pitch-ceiling was raised for all mothers and F0 measures were extracted again; however, these errors were still present in the 10^{th} and 90^{th} percentile pitch values, so these were discarded from analyses. The 10^{th} and 90^{th} percentile were replaced with the 25^{th} and 75^{th} percentile, respectively, as the new criteria for the F0 minimum (Q_1) and F0 maximum (Q_3). F0 range was re-calculated from these more conservative measures (Q_3-Q_1). In addition to adopting more conservative measures for minimum and maximum F0, the mean F0 and the SD F0 values were discarded as unreliable measures, due to the prevalence of pitch-tracking errors. The median F0 (Q_2) was used in place of the mean F0 to represent the average pitch.

3. Results

3.1 Prelude to Results

The analyses reported here assess the effect of parent gender on the difference between IDS and ADS in utterance-level pitch properties, across-conversation pitch variability and perceived voice quality. All statistical analyses were conducted in the *R* statistical programming environment (R Core Team, 2013).

3.1.1 Independent Variables

The independent variables of interest in all analyses were Register (ADS vs IDS) and Parent Gender (father vs mother). In all models, the fixed effect of Register was contrast-coded, with ADS coded as -1 and IDS coded as 1. The fixed effect of Parent Gender was also contrast coded, with fathers coded as -1 and mothers coded as 1.

3.1.2 Dependent Variables

The dependent variables in the analyses addressing the utterance-level pitch properties were the Median F0 (Second Quartile: Q_2), Minimum F0 (First Quartile: Q_1), Maximum F0 (Third Quartile: Q_3), and F0 Range (Maximum - Minimum F0; Q_3-Q_1) in the parents' individual utterances (see Subsection 3.3). The dependent variables in the analyses on across-conversation pitch variability were the SD of F0 (Hz & ST) and the F0 Coefficient of Variation (Hz), computed from the utterance-level Median F0 per register and participant (see Subsection 3.4). Analyses of voice quality were conducted on three dependent variables of interest, encoding the presence versus absence of Breathy voice, Creaky voice and Whispered speech (see Subsection 3.5).

3.1.3 Navigating the Results

Subsection 3.2 provides an overview of the corpus that formed the basis of the data analyses. Subsections 3.3, 3.4, and 3.5 provide the analytical approach, descriptive results, statistical models and outcomes for, respectively, the analyses of utterance-level pitch properties, across-conversation pitch variability and voice quality.

3.2 Overview of Corpus

3.2.1 Data Exclusion

Utterances were excluded from the corpus if there was evidence of laughter, speech-laughter, exclaims, acting or sound effects (see Table 5 in Subsection 2.5.3.1). Table 6 provides counts of utterances in the corpus per participant and register. The columns labelled "Verbal Tokens" provide counts of all utterances in the corpus that were coded as Question or Statement (IDS = 2140, ADS = 2579). The voice quality analyses were conducted on all Verbal Tokens. Utterances in the corpus were excluded from the analyses of utterance-level pitch properties and across-conversation pitch variability if there was evidence of sound overlap from the infant, the other speaker, or external sounds. The columns labelled "Pitch Tokens" provide counts of all utterances that were included in the statistical analyses of utterance-level pitch properties and across-conversation pitch variability, prior to outlier checks (IDS = 1804, ADS = 1735).

3.2.2 Data Exclusion

Inspection of the data revealed 13 utterances with undefined values; these utterances were excluded from further analysis for all measures. Outlier checks were conducted with the Tukey method, per participant and register, for the Median F0 (Q_2), Minimum F0 (Q_1), Maximum F0 (Q_3), and F0 Range (Q_3-Q_1). F0 values were identified as outliers if they were more than 1.5 × the interquartile range from the quartile values (Q_3 & Q_1) of that dependent

variable. F0 Range outlier checks were conducted after exclusion of values computed from Minimum F0 (Q_1) or the Maximum F0 (Q_3) values that had been identified as outliers.

Table 6

Overview of Utterances Included in Corpus, Prior to Outlier Checks

Dyad Code [a]	IDS				ADS			
	Mothers		Fathers		Mothers		Fathers	
	Verbal Tokens	Pitch Tokens	Verbal Tokens	Pitch Tokens	Verbal Tokens	Pitch Tokens	Verbal Tokens	Pitch Tokens
#1	69	63	103	96	154	106	124	67
#5	110	72	105	92	115	67	158	102
#14	149	142	183	182	118	104	126	110
#15	171	154	147	96	177	116	147	83
#21	115	94	123	105	166	123	171	131
#22	142	136	156	151	155	114	125	78
#36	142	96	109	77	237	162	176	103
#39	150	133	166	115	203	128	227	141
Total =	1048	890	1092	914	1325	920	1254	815

[a] Participant-dyads were randomly allocated a Dyad Code from 1- 40

3.3 Utterance-Level Pitch Properties

The analysis of utterance-level Pitch Properties was conducted on an initial total of 3539 utterances before removal of outliers (1804 in IDS and 1735 in ADS; see under "Pitch Tokens" in Table 6 for a breakdown of counts per Dyad, Parent Gender, and Register). Exclusion counts on the basis of NA values and following outlier checks are provided per dependent variable in each respective section. The results of Mean F0, which was discarded as a dependent variable due to observed pitch-tracking errors, are reported in Appendix K, for comparability with previous work. The figures in this sub-section present boxplots for each dependent variable: the Median F0 (Q_2), Minimum F0 (Q_1), Maximum F0 (Q_3), and F0 Range (Q_3-Q_1). Each speakers' mean is plotted as an individual measure and matched across registers with a dotted line.

3.3.1 Utterance-Level Pitch Properties Models

Four mixed-effects linear regression models analysed the effects of two interacting fixed factors, Register (ADS= -1; IDS= 1) and Parent Gender (father = -1; mother = 1) on the four aforementioned utterance-level pitch properties. Each model had a maximal random-effects structure, with by-speaker intercepts and by-speaker slopes for Register. The significance of fixed effects was determined on the basis of the *t* statistic, using the Satterthwaite approximation as implemented in the lmerTest package for the estimation of degrees of freedom (Kuznetsova, Brockhoff, & Christensen, 2017).

3.3.2 Median F0 (Q_2) (ST)

3.3.2.1 Median F0 (Q_2) (ST) Descriptive Results

Through data inspection, 106 utterances were identified as outliers and excluded from statistical analyses. The analysis of the Median F0 (ST) was thus conducted on a total of 3421 utterances (1769 in IDS and 1652 in ADS). Figure G presents the Median F0 (ST) per parent gender and register, and suggests that the Median F0 (ST) increases in IDS compared to ADS for both fathers (IDS M = -6.058, SD = 0.554, ADS M = -10.896, SD = 0.6) and mothers (IDS M = 3.982, SD = 1.048, ADS M = -1.41, SD = 0.682). Figure G suggests that all mothers are similar to each other in the extent to which they increase Median F0 (ST) in IDS, while fathers appear differ more from each other.

3.3.2.2 Median F0 (Q_2) (ST) Model Outcomes

The mixed-effects linear regression model revealed a significant main effect of Register, indicating that parents increase the Median F0 (ST) in IDS, compared to ADS (B = 2.563, SE = 0.316, $t(13.964) = 8.11$, $p < 0.001$). The significant main effect of Parent Gender shows that mothers use a higher Median F0 (ST), compared to fathers (B = 4.879, SE = 0.479, $t(13.978) = 10.179$, $p < 0.001$). This Parent Gender effect is unsurprising as female speakers typically have a

higher-pitched voice than male speakers. There was no significant Register × Parent Gender interaction (B = 0.139, SE = 0.316, t(13.964) = 0.439, p = 0.667). This indicates that there is no evidence of a difference between mothers' and fathers' increase of Median F0 (ST) in IDS, compared to ADS.

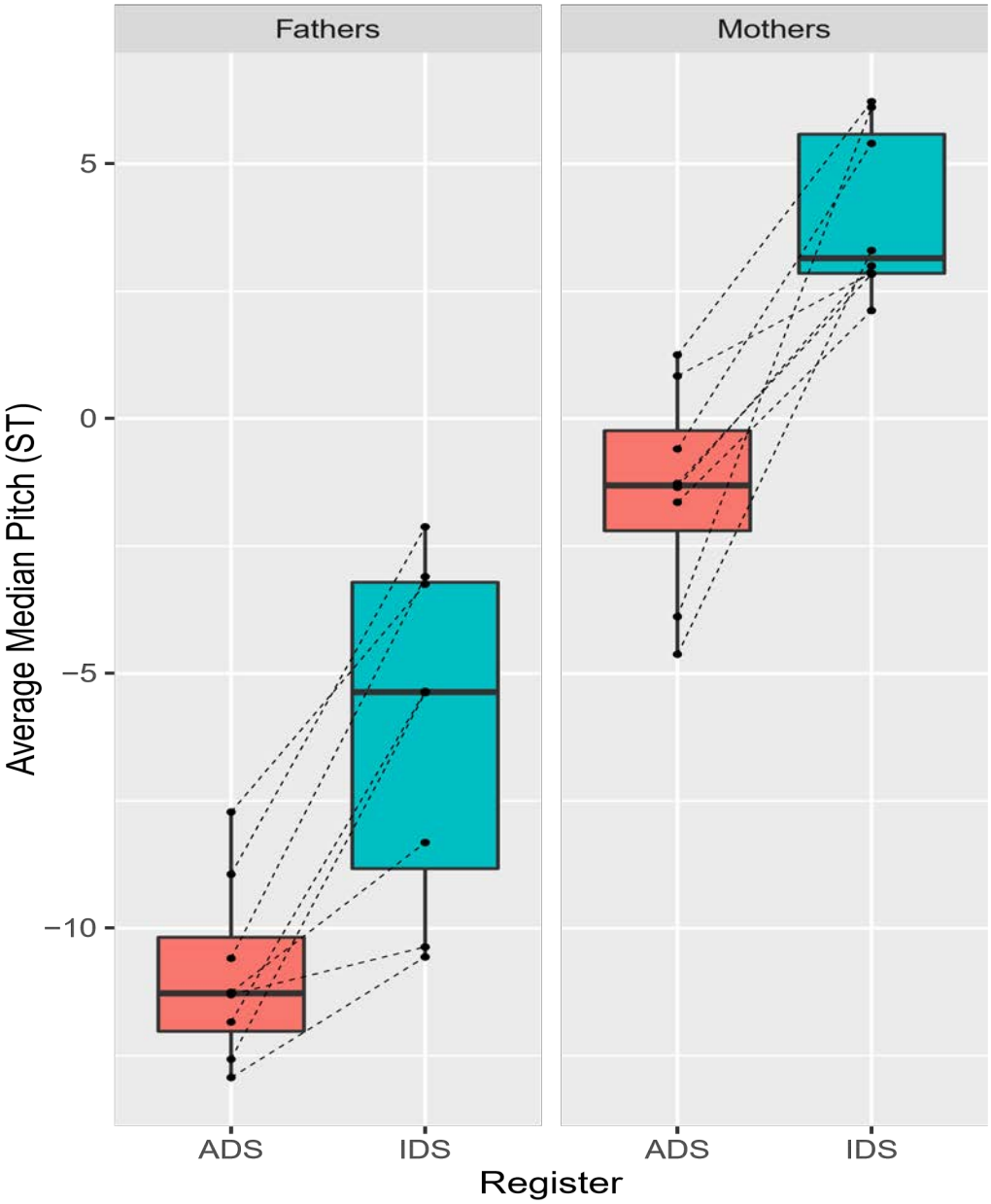

Figure G- Average Median (Q_2) Pitch (Semitone Scale) per Parent Gender & Register. Individual speakers' averaged Q_2 values are plotted as individual points and matched across registers with dotted lines

3.3.3 Minimum F0 (Q_1) (ST)

3.3.3.1 Minimum F0 (Q_1) (ST) Descriptive Results

Following data inspection, 132 utterances were identified as outliers and excluded from statistical analyses. The analysis of the Minimum F0 (ST) was thus conducted on a total of 3395 utterances (1760 in IDS and 1635 in ADS). Figure H presents the Minimum F0 (ST) per parent gender and register, and suggests that the Minimum F0 (ST) increases in IDS compared to ADS for both fathers (IDS M = -8.147, SD = 0.621; ADS M = -12.004, SD = 0.466) and mothers (IDS M = 1.56, SD = 1.267; ADS M = -2.745, SD = 0.365). An increased Minimum F0 in IDS, compared to ADS, is observed for all speakers, with more variation between fathers, compared to mothers. Figure H indicates that one father has only a slight increase in Minimum F0 in IDS, compared to ADS.

3.3.3.2 Minimum F0 (Q_1) (ST) Model Outcomes

The mixed-effects linear regression model found a significant main effect of Register, indicating that parents increase the Minimum F0 (ST) in IDS, compared to ADS (B = 2.046, SE = 0.302, t(13.993)= 6.784, $p < 0.001$). The significant main effect of Parent Gender shows that mothers use a higher Minimum F0 (ST), compared to fathers (B = 4.738, SE = 0.51, $t(13.988)$ = 9.296, $p < 0.001$). There was no significant Register × Parent Gender interaction (B = 0.112, SE = 0.302, t(13.993) = 0.372, p = 0.715). This indicates that there is no evidence of a difference between mothers' and fathers' increase of Minimum F0 in IDS, compared to ADS.

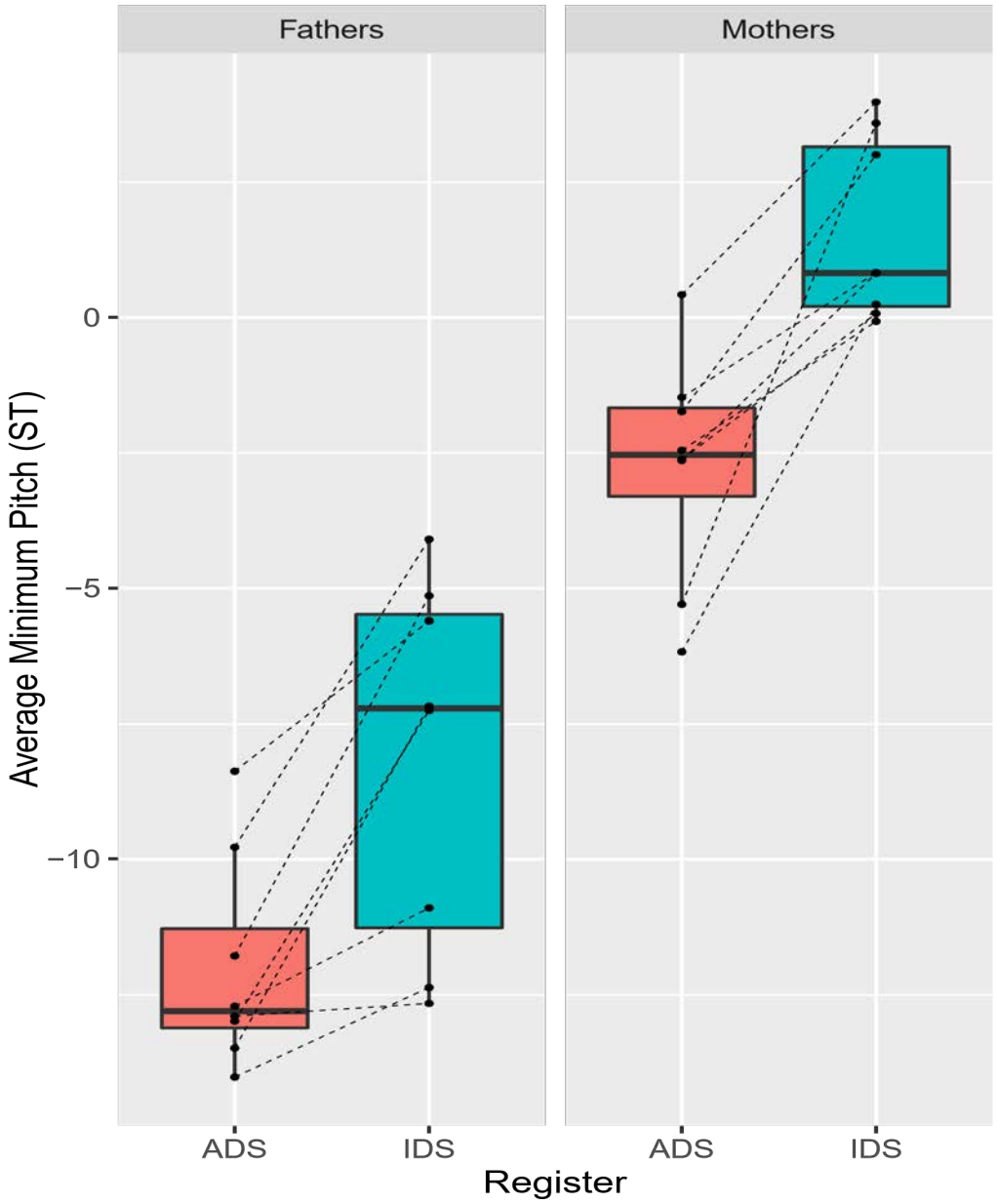

Figure H- Average Minimum (Q_1) Pitch (Semitone Scale) per Parent Gender & Register. Individual speakers' averaged Q_1 values are plotted as individual points and matched across registers with dotted lines

3.3.4 Maximum F0 (Q_3) (ST)

3.3.4.1 Maximum F0 (Q_3) (ST) Descriptive Results

Following data inspection, 99 utterances were identified as outliers and excluded from statistical analyses. The analysis of the Maximum F0 (ST) was thus conducted on a total of 3428 utterances (1771 in IDS and 1657 in ADS). Figure I presents the average Maximum F0 (ST) per parent gender and register, and suggests that the Maximum F0 (ST) increases in IDS compared

to ADS for both fathers (IDS M = -3.56, SD = 0.925, ADS M = 9.419, SD = 0.736) and mothers (IDS M = 7.209, SD = 1.187, ADS M = 0.353, SD = 0.889). Figure I indicates that the extent to which parents increase their Maximum F0 in IDS is consistent between mothers, but varies between individual fathers.

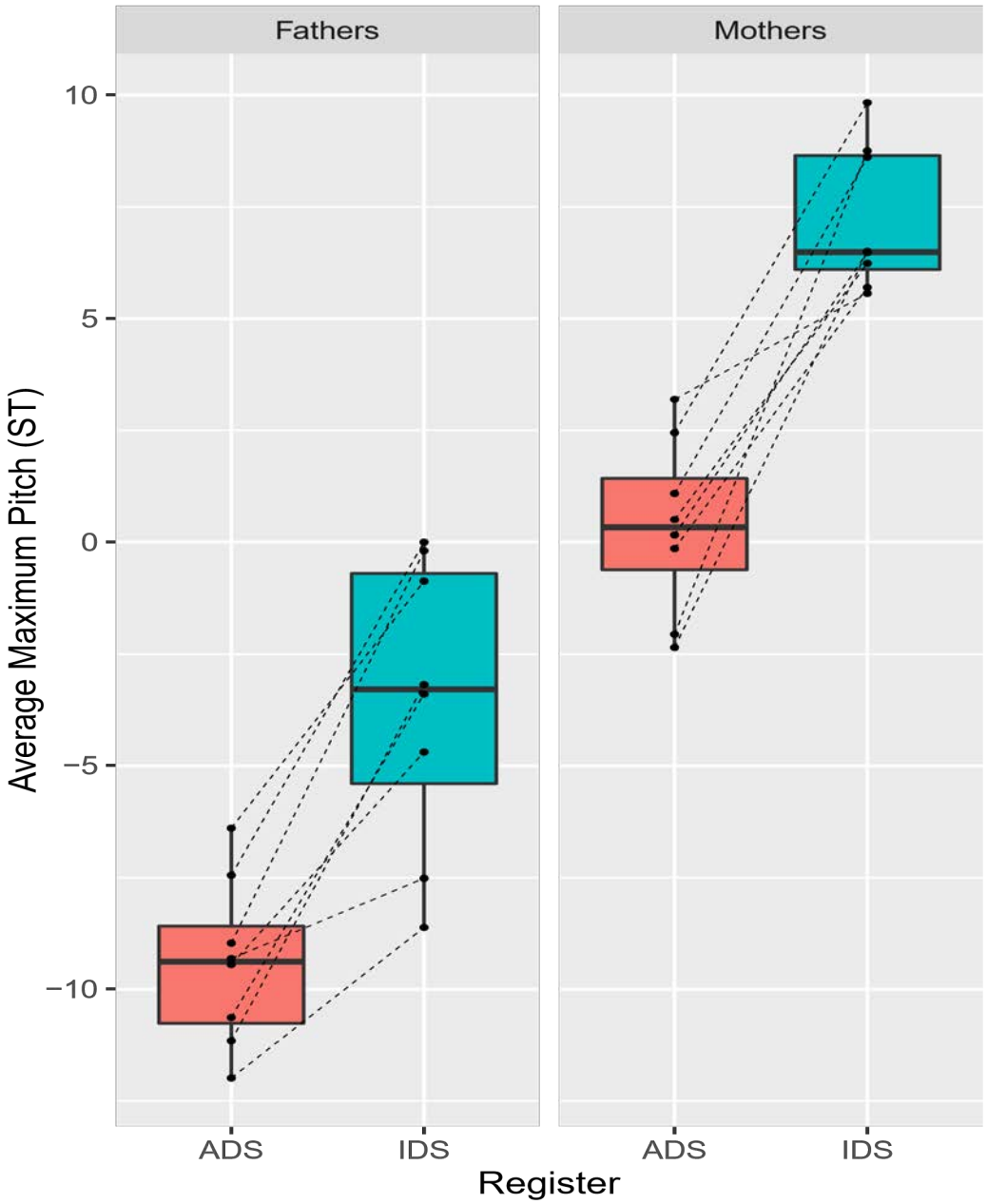

Figure I- Average Maximum (Q_3) Pitch (Semitone Scale) per Parent Gender & Register. Individual speakers' averaged Q_3 values are plotted as individual points and matched across registers with dotted lines

3.3.4.2 Maximum F0 (Q_3) (ST) Model Outcomes

The mixed-effects linear regression model revealed a significant main effect of Register, indicating that parents increase the Maximum F0 (ST) in IDS, compared to ADS (B = 3.185, SE = 0.307, $t(13.91)$ = 10.376, $p < 0.001$). The significant main effect of Parent Gender shows that mothers use a higher Maximum F0 (ST), compared to fathers (B = 5.133, SE = 0.474, $t(13.968)$ = 10.838, $p < 0.001$). There was no significant Register × Parent Gender interaction (B = 0.251, SE = 0.307, t(13.91) = 0.817, p = 0.428), indicating no evidence of a difference between mothers' and fathers' increase of Maximum F0 (ST) in IDS, compared to ADS.

3.3.5 F0 Range (Q_3-Q_1) (ST)

3.3.5.1 F0 Range (Q_3-Q_1) (ST) Descriptive Results

Inspection of the data revealed 203 utterances with undefined values; these utterances were excluded from further analysis. Following exclusion of outliers for Q1 and Q3, a further 126 utterances were identified as outliers and excluded from statistical analyses. The analysis of the F0 Range (ST) was thus conducted on a total of 3211 utterances (1702 in IDS and 1509 in ADS). Figure J presents the average F0 Range (ST) per parent gender and register, and suggests that the F0 Range (ST) increases in IDS compared to ADS for both fathers (IDS M = 4.024, SD = 0.531, ADS M = 2.264, SD = 0.362) and mothers (IDS M = 5.37, SD = 0.521, ADS M = 2.745, SD = 0.789). Figure J indicates that mothers, with the possible exception of one, may increase the pitch range in IDS, compared to ADS, to a greater extent than fathers.

3.3.5.2 F0 Range (Q_3-Q_1) (ST) Model Outcomes

In the mixed-effects linear model, the significant main effect of Register indicates that parents increase the F0 Range (ST) in IDS, compared to ADS (B = 1.096, SE = 0.106, $t(13.565)$ = 10.39, $p < 0.001$). The significant main effect of Parent Gender shows that mothers have a wider F0 Range (ST), compared to fathers (B = 0.462, SE = 0.097, $t(13.398)$ = 4.757, $p < 0.001$). There was a non-significant Register × Parent Gender interaction (B = 0.217, SE = 0.106,

$t(13.565) = 2.06$, $p = 0.059$). Although this is a non-significant interaction, the p-value is sufficiently close to 0.05 to warrant the tentative interpretation that mothers, compared to fathers, may have a larger increase in F0 range (ST) in IDS, compared to ADS.

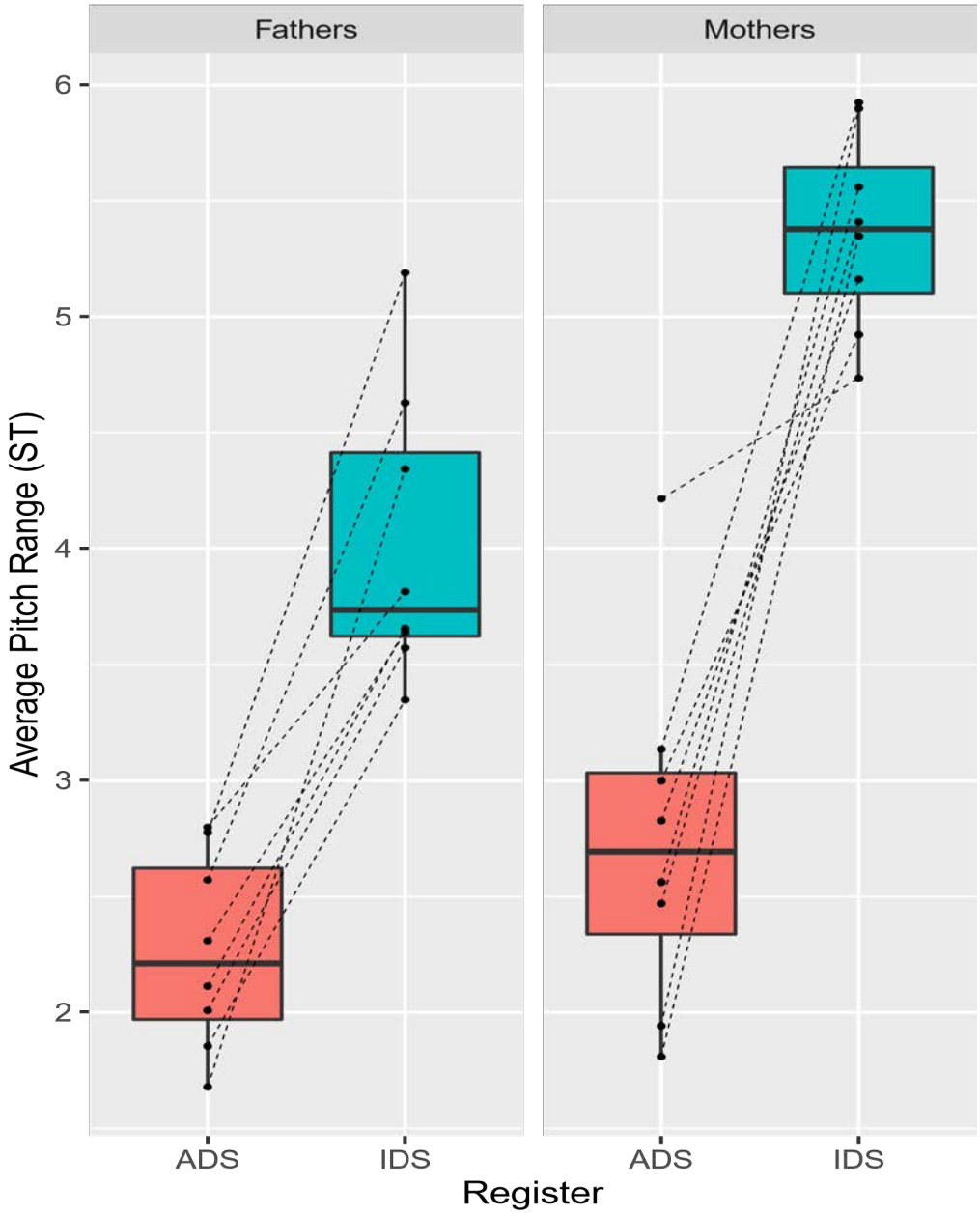

Figure J- Pitch Range (Semitone Scale) per Parent Gender & Register. Individual speakers' averaged Range values are plotted as individual points and matched across registers with dotted lines

3.4 Across-Conversation Pitch Variability

Across-conversation pitch variability on both the Hz and ST scale was quantified as each participant's standard deviation of their by-utterance Median F0 values per register. On the Hz scale only, this standard deviation was divided by the overall mean to obtain a coefficient of variation (SD/M) in both registers. Analyses of across-conversation pitch variability were conducted on an initial total of 3539 utterances (1804 in IDS and 1735 in ADS; see under "Pitch Tokens" in Table 6 for a breakdown of counts per dyad, parent gender, and register), minus the aforementioned 13 utterances with undefined values. Following inspection of the Hz data, 178 utterances were identified as outliers and excluded from statistical analyses. Following inspection of the ST data, 106 utterances were identified as outliers and excluded from statistical analyses.

3.4.1 Across-Conversation Pitch Variability Models

Analyses of across-conversation pitch variability were conducted using 2x2x2 mixed-effects Anovas on three dependent variables: the SD of F0 (Hz), the SD of F0 (ST), and the F0 Coefficient of Variation (Hz), with the independent variables: Register (ADS= -1; IDS= 1) and Parent Gender (father = -1; mother = 1).

3.4.2 Standard Deviation (SD) (Hertz Scale)

3.4.2.1 SD (Hertz Scale) Descriptive Results

Analyses of across-conversation pitch variability (SD) using the Hertz scale were conducted on a total of 3349 utterances (1723 in IDS and 1626 in ADS). Figure K presents the SD (Hz) per parent gender and register, and suggests that across-conversation pitch variability increases in IDS, compared to ADS, for all fathers (IDS M = 30.614, SD = 7.715; ADS M = 11.875, SD = 3.036) and all mothers, but one (IDS M = 74.14, SD = 24.605; ADS M = 21.594, SD = 9.364).

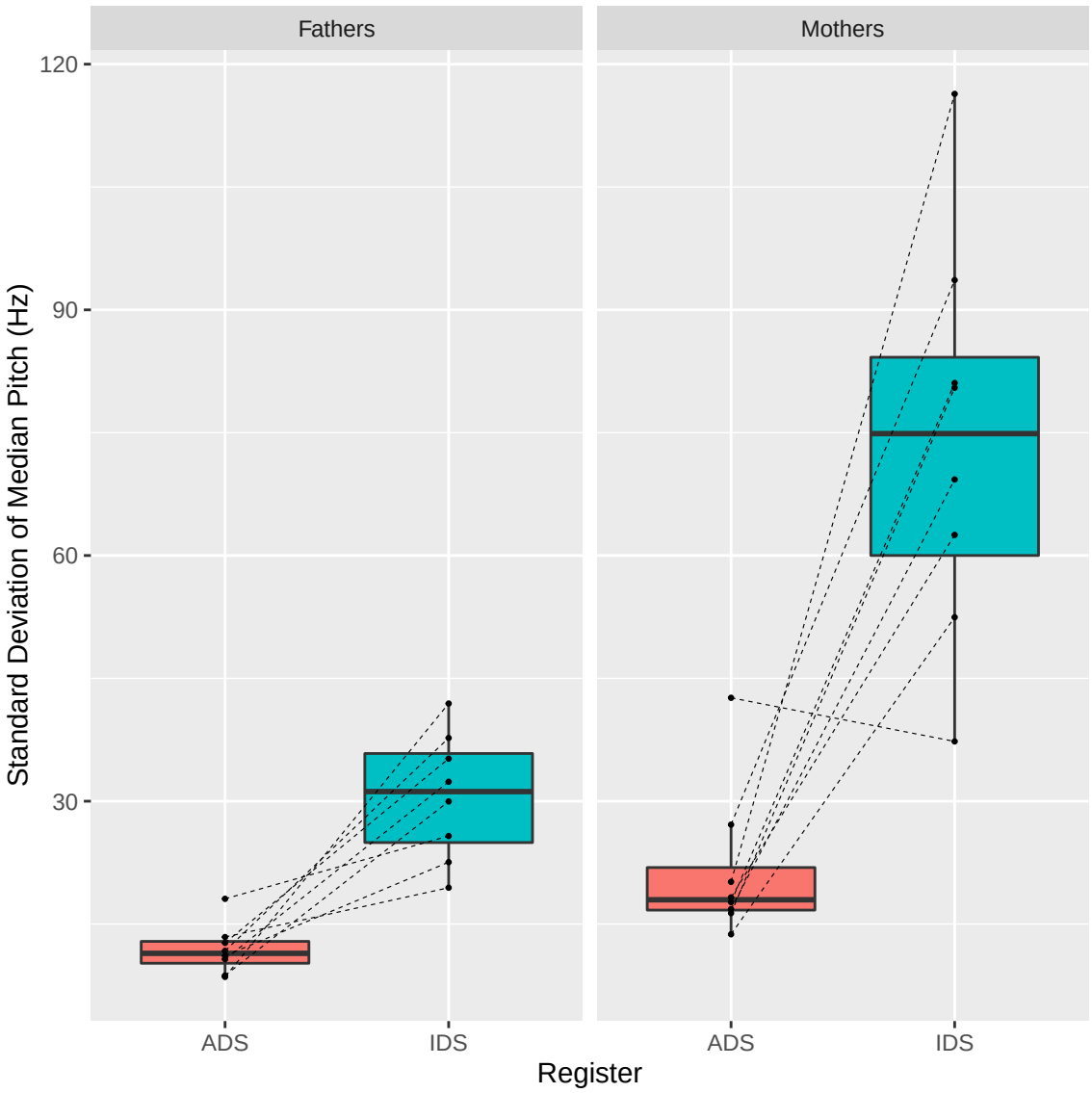

Figure K- SD of Median Pitch (Hertz Scale) per Parent Gender & Register. Individual speakers' SD values are plotted as individual points and matched across registers with dotted lines

3.4.2.2 SD (Hertz Scale) Model Outcomes

Using the SD on the Hertz scale, a significant main effect of Register was observed ($F(1,14) = 43.133$, $p < 0.001$), indicating that across-conversation pitch variability increases in IDS, compared to ADS. A significant main effect of Parent Gender was observed ($F(1,14) = 39.025$, $p<0.001$), indicating that mothers increase across-conversation pitch variability more than fathers. There was a significant Register × Parent Gender interaction ($F(1,14) = 9.701$, $p < 0.01$), indicating that mothers increase across-conversation pitch variability in IDS, compared to

ADS, to a larger extent than fathers. The subsequent analyses will reveal that this interaction is specific for values on the Hertz scale, which are not corrected for increases in SD with Mean F0.

3.4.2.2 SD (Hertz Scale) Post-hoc Analyses

Following up on the significant Register X Parent Gender interaction, the effect of the fixed factor Register (ADS= -1; IDS= 1) on across-conversation pitch variability was analysed separately for each Parent Gender. The paired samples t-test on the fathers' data found a significant effect of Register ($t(7) = -5.57$, $p < 0.001$), with a mean difference of -18.74, 95% CI [-26.695, -10.784]. This indicates that fathers increase across-conversation pitch variability in IDS, compared to ADS. The paired samples t-test on the mothers' data found a significant effect of Register ($t(7) = -5.092$, $p < 0.01$), with a mean difference of -52.546, 95% CI [-76.948, -28.144]. This indicates that mothers increase across-conversation pitch variability in IDS, compared to ADS.

3.4.3 Standard Deviation (SD) (Semitone Scale)

3.4.3.1 SD (Semitone Scale) Descriptive Results

It is possible to correct for the positive relationship between SD and Mean F0 on the Hertz scale, by analysing the SD values on the Semitone Scale. Analyses of across-conversation pitch variability (SD) using the Semitone scale were conducted on a total of 3421 utterances (1769 in IDS and 1652 in ADS). Figure L presents the SD (ST) per parent gender and register, and suggests that across-conversation pitch variability increases in IDS, compared to ADS, for fathers (IDS M =3.866, SD = 0.554; ADS M = 1.985, SD = 0.6) and most mothers (IDS M = 5.012, SD = 1.048; ADS M = 2.064, SD = 0.682).

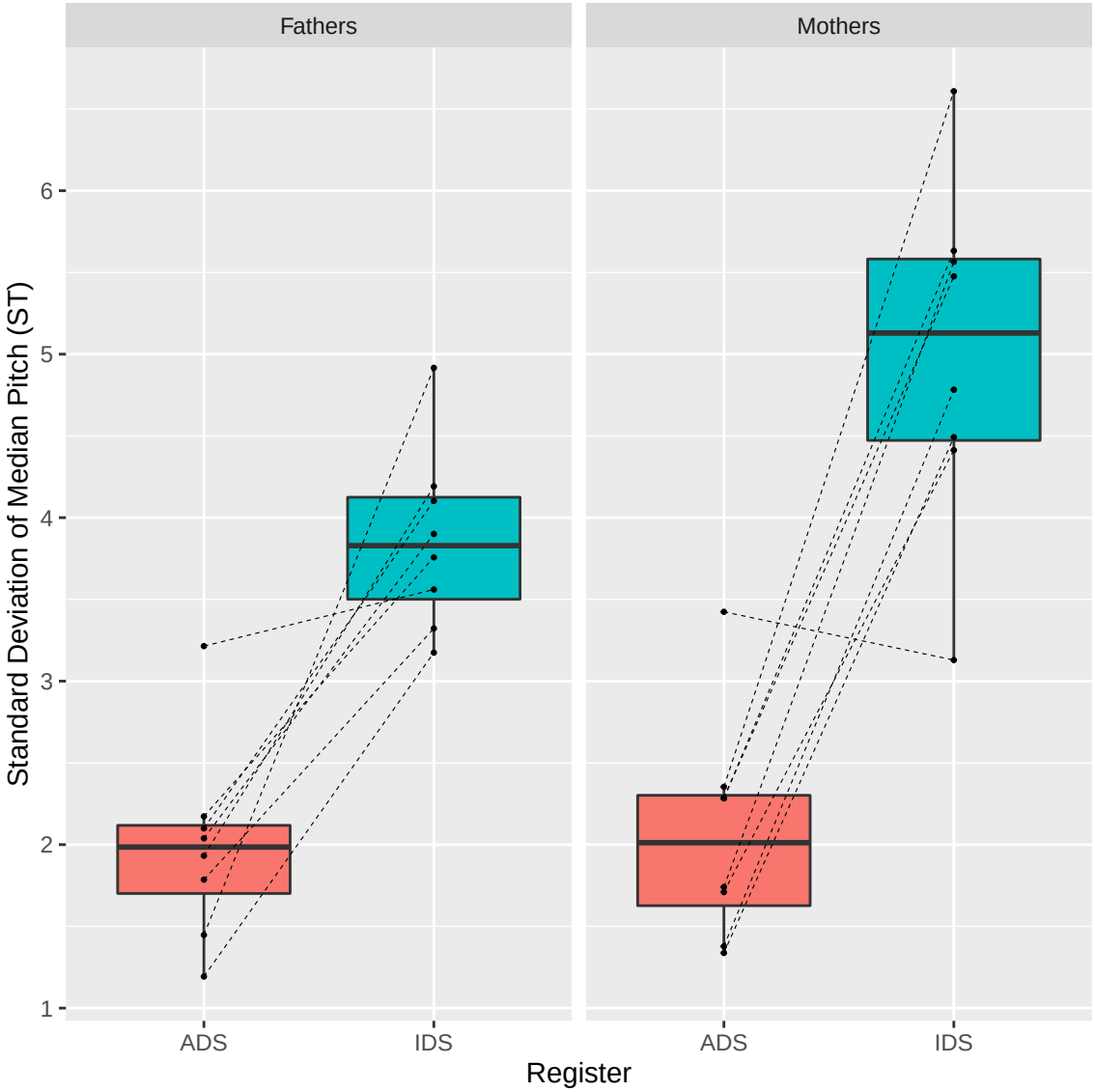

Figure L- SD of Median Pitch (Semitone Scale) per Parent Gender & Register. Individual speakers' SD values are plotted as individual points and matched across registers with dotted lines

3.4.3.2 SD (Semitone Scale) Model Outcomes

Using the SD on the Semitone values, there was a significant main effect of Register ($F(1.14) = 69.541$, $p < 0.001$), indicating that across-conversation pitch variability increases in IDS, compared to ADS. There was also a significant main effect of Parent Gender ($F(1,14) = 6.757$, $p < 0.05$), indicating that mothers increase across-conversation pitch variability more than fathers. There was no significant Register × Parent Gender interaction ($F(1,14) = 3.404$, $p = 0.086$). The absence of an effect indicates there no evidence of a gender difference in the increase of across-conversation pitch variability in IDS, compared to ADS.

3.4.4 Coefficient of Variation (SD/M) (Hertz Scale)

3.4.4.1 SD/M (Hertz Scale) Descriptive Results

It is also possible to account for the relationship between SD and Mean F0 (Hz) using the Coefficient of Variation (SD/M) for Hertz values. Analyses of across-conversation pitch variability (SD/M) using the Hertz scale were conducted on a total of 3349 utterances (1723 in IDS and 1626 in ADS). Figure M presents the SD/M (Hz) per parent gender and register, and suggests that across-conversation pitch variability increases in IDS, compared to ADS, for all fathers (IDS $M = 0.213$, $SD = 0.033$; ADS $M = 0.112$, $SD = 0.031$) and most mothers (IDS $M = 0.282$, $SD = 0.068$; ADS $M = 0.116$, $SD = 0.042$). Figure M also suggests that increased across-conversation pitch variability in IDS, compared to ADS, occurs to a greater extent for most mothers (n=7) than fathers.

3.4.4.2 SD/M (Hertz Scale) Model Outcomes

Using this dependent variable, there was a significant main effect of Register ($F(1,14) = 54.562$, $p < 0.001$), indicating that across-conversation pitch variability increases in IDS, compared to ADS. There was a significant effect of Parent Gender ($F(1,14) = 6.634$, $p < 0.05$), indicating that mothers, compared to fathers, increase across-conversation pitch variability. There was no significant Register × Parent Gender interaction ($F(1,14) = 3.265$, $p = 0.092$). The absence of a significant effect indicates there is no evidence of a gender difference in across-conversation pitch variability in IDS, compared to ADS.

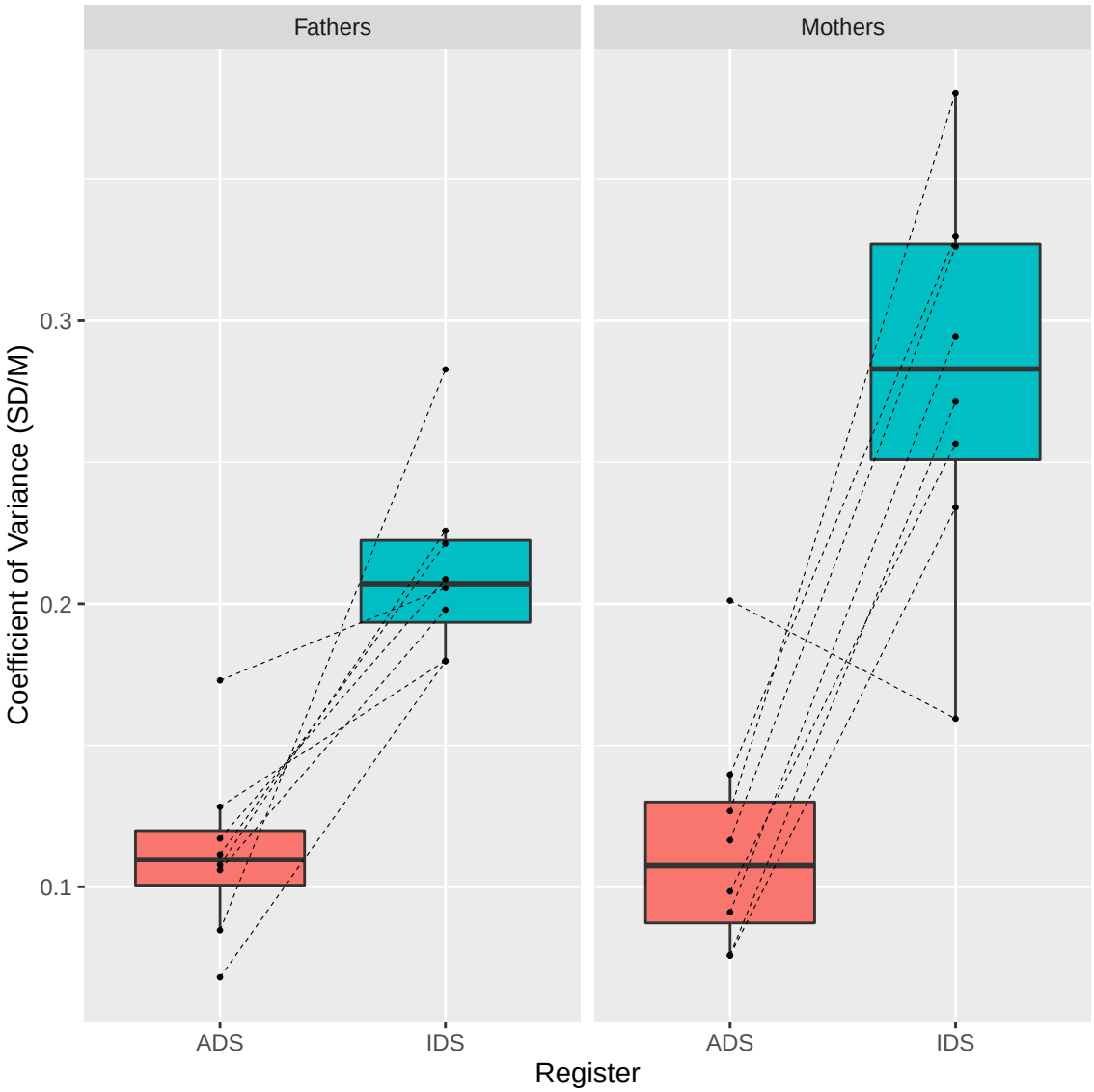

Figure M- SD/M of Median Pitch (Hertz Scale) per Parent Gender & Register. Individual speakers' SD/M values are plotted as individual points and matched across registers with dotted lines

3.5 Voice Quality

The analysis of Voice Quality was conducted on a total of 4719 utterances (IDS = 2140, ADS = 2579; see under "Verbal Tokens" in Table 6 for a breakdown of counts per dyad, parent gender, and register). Figure N presents the distribution of voice quality types in the corpus, per dyad, parent gender, and register; Figure O presents these distributions per parent gender and register, aggregated over dyads.

3.5.1 Voice Quality Models

The prevalence of Breathy voice, Creaky voice, and Whispered speech was analysed in three mixed-effects logistic regression models with fixed factors Register (ADS= -1; IDS= 1) and Parent Gender (father = -1; mother = 1). The binomial dependent variables in these analyses contrasted between utterances in which the voice quality of interest was present (coded as 1) versus those in which it was not present (coded as 0). Each model had a maximal random-effects structure, with by-speaker intercepts and by-speaker slopes for Register.

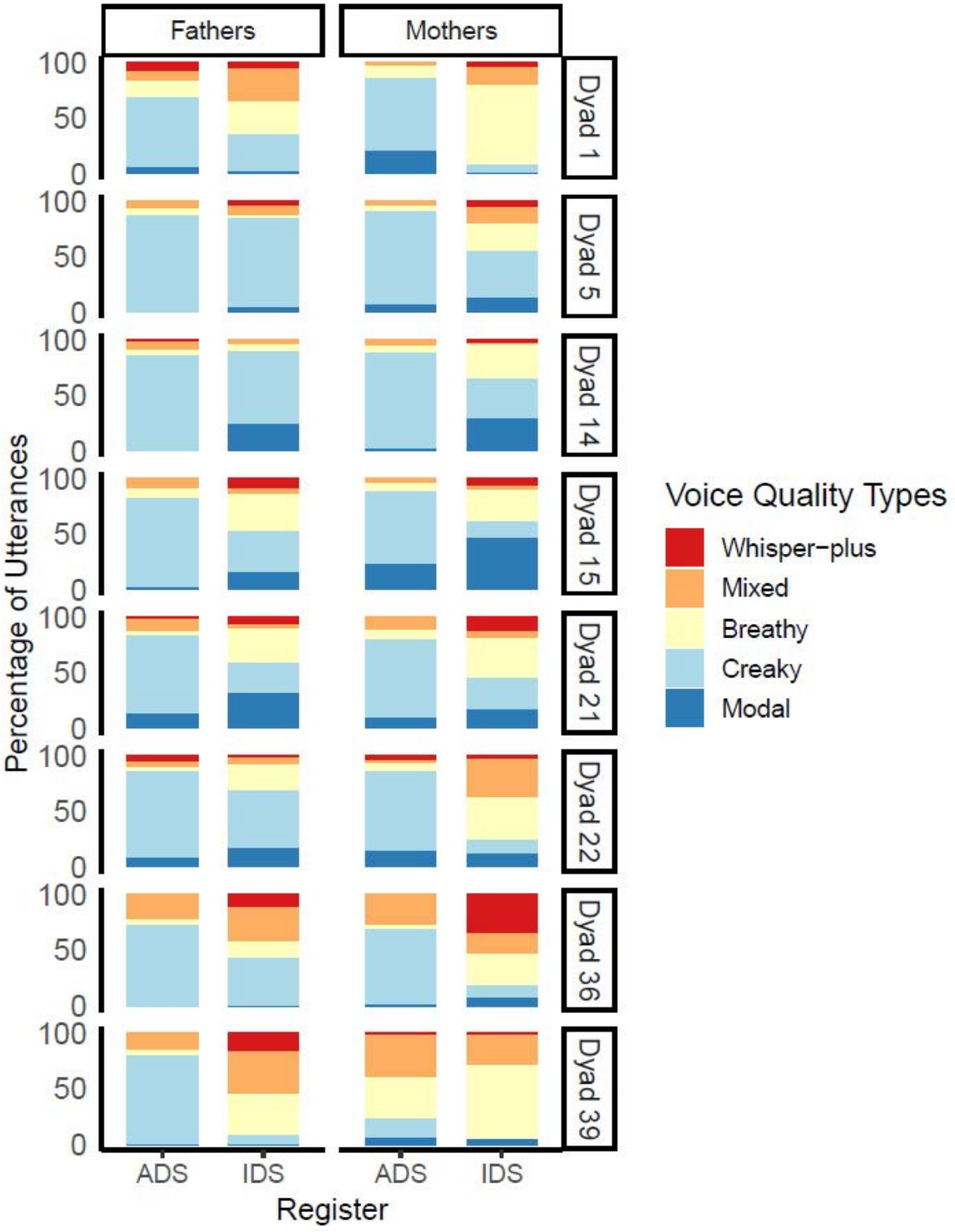

Figure N- Voice Quality Type Distributions per Dyad, Parent Gender and Register.
Notes- [a] Whisper-plus refers to utterances consisting only of whispered speech or a combination of whispered speech & other voice quality types. [b] Mixed refers to utterances with presence of breathy and creaky types. [c] Modal refers to utterances with absence of whisper, breathy & creaky types.

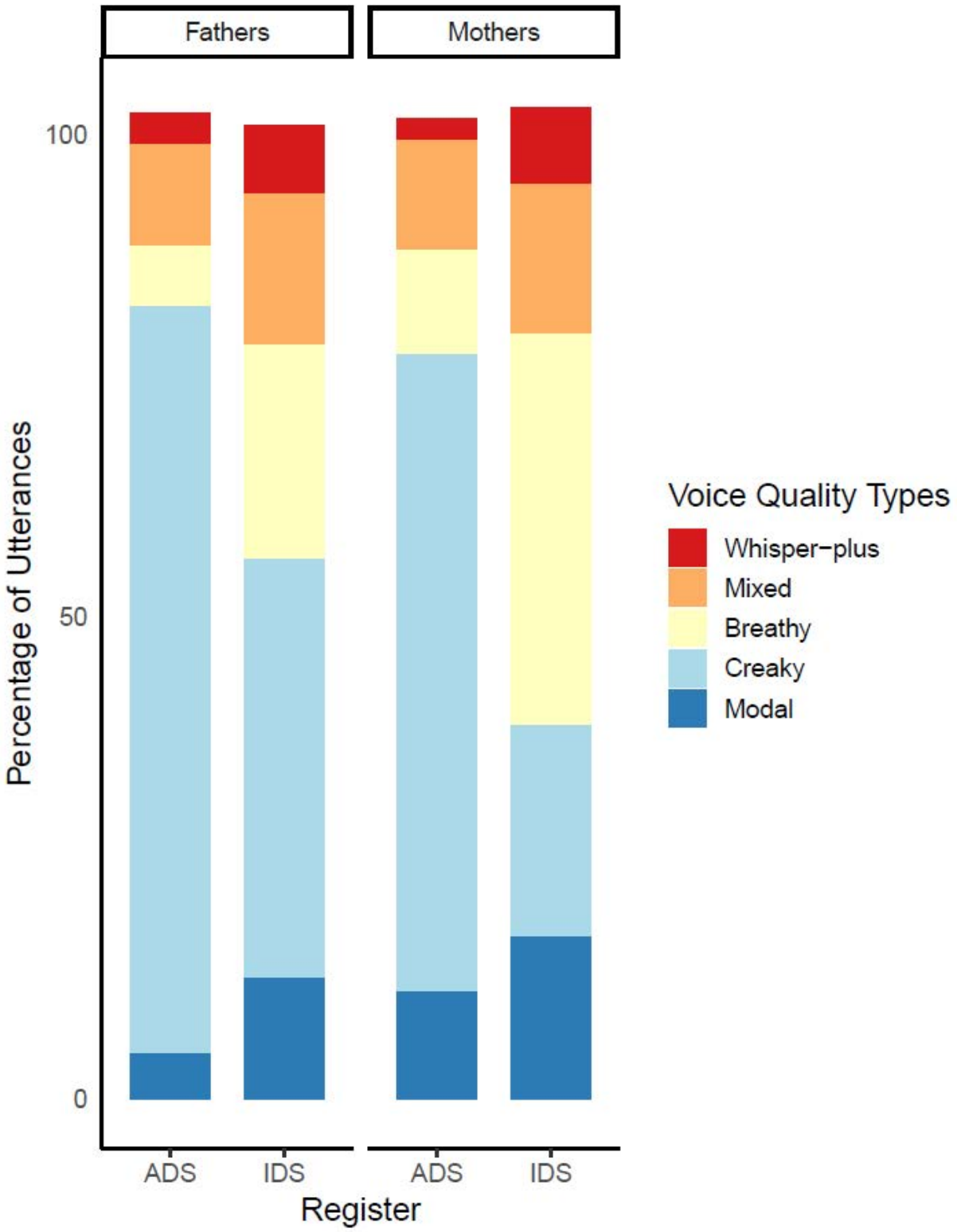

Figure O- Voice Quality Type Distributions per Parent Gender and Register, Aggregated over Dyads.
Notes- [a] Whisper-plus refers to utterances consisting only of whispered speech or a combination of whispered speech & other voice quality types. [b] Mixed refers to utterances with presence of breathy and creaky types. [c] Modal refers to utterances with absence of whisper, breathy & creaky types.

3.5.2 Whispered Speech

3.5.2.1 Whispered Speech Descriptive Results

The aggregated data in Figure O suggest that the use of Whispered speech increases in IDS compared to ADS for both fathers (IDS *M* = 6.67%, *SD* = 4.5; ADS *M* = 3.13%, *SD* = 3.14) and mothers (IDS *M* = 7.55%, *SD* = 10.66; ADS *M* = 2.09%, *SD* = 1.57%), although to a larger extent for mothers (fathers' increase = 3.54%, mothers' increase = 5.46%). Inspection of the individual data in Figure N indicates that some mothers and fathers increase use of Whispered speech in IDS, to a much larger extent than other parents. One mother did not use Whispered speech in ADS, and compared to all parents, had the highest proportion of Whispered speech use in IDS (mother Dyad 36; 32.67% of utterances). Similarly, one father did not use Whispered speech in ADS, and compared to all parents, had the second highest proportion of Whispered speech use in IDS (father Dyad 39; 14.36% of utterances).

3.5.2.2 Whispered Speech Model Outcomes

The logistic mixed-effects model found a significant effect of Register, indicating that parents are more likely to use Whispered speech in IDS, compared to ADS (*B* = 1.741, *SE* = 0.621, z = 2.805, $p < 0.01$). There was no significant main effect of Parent Gender (*B* = -0.374, *SE* = 0.343, *z* = -1.092, *p* = 0.275), nor a Register × Parent Gender interaction (*B* = 0.391, *SE* = 0.491, *z* = 0.796, *p* = 0.426). The absence of significant effects indicates there is no evidence of a gender difference for the prevalence of Whispered speech, and no evidence of a gender difference for the increase of Whispered speech in IDS, compared to ADS.

3.5.3 Breathy Voice

3.5.3.1 Breathy Voice Descriptive Results

The aggregated data in Figure O suggest that the use of Breathy voice increases in IDS compared to ADS for both fathers (IDS *M* = 22.88%, *SD* = 13; ADS *M* = 6.38%, *SD* =3.78) and

mothers (IDS M = 40.58%, SD = 18.52; ADS M = 10.99%, SD = 10.96), although to a larger extent for mothers (fathers' increase = 16.5%, mothers' increase = 29.59%). Inspection of the individual data in Figure N furthermore suggests that all mothers (n = 8) and most fathers (n = 7) increase use of breathiness in IDS, with one father being the exception with a slight decrease in use of breathiness in IDS (see voice quality proportions of father Dyad 5; decrease = 2.87%). Figure N also shows that within each dyad, most mothers (n = 5) increase use of breathiness in IDS to a larger extent than their partner (see mothers' vs fathers' proportions for Dyad 1, Dyad 5, Dyad 14, Dyad 22 & Dyad 36). However, some fathers (n = 2) increased their use of breathiness in IDS to a larger extent compared to their partner as well as most other mothers in the corpus (father Dyad 21, increase = 31.08 % & father Dyad 39, increase = 31.13%), with one mother increasing her use of breathiness substantially more than all other parents (mother Dyad 1, increase = 60.36%).

3.5.3.2 Breathy Voice Model Outcomes

The logistic mixed-effects model found a significant main effect of Register, indicating that parents are more likely to use Breathy voice in IDS, compared to ADS (B = 0.766, SE = 0.117, z = 6.952, $p < 0.001$). There was no significant main effect of Parent Gender (B = 0.333, SE = 0.229, z = 1.452, p = 0.147), indicating that there is no evidence of a gender difference for the prevalence of Breathy voice. The model revealed a significant Register × Parent Gender interaction (B = 0.24, SE = 0.117, z = 2.055, $p < 0.05$), indicating that mothers, compared to fathers, have a higher increase of Breathy voice in IDS, compared to ADS.

3.5.3.3 Breathy Voice Post-Hoc Analyses

Following up on the significant Register X Parent Gender interaction, the effect of the fixed factor Register (ADS= -1; IDS= 1) on the prevalence of Breathy voice was analysed separately for each Parent Gender. The logistic mixed-effects model on the fathers' data found a significant main effect of Register, indicating that fathers are more likely to use Breathy voice in

IDS, compared to ADS (B = 0.513, SE = 0.159, z = 3.218, p < 0.01). The logistic mixed-effects model on the mothers' data found a significant main effect of Register, indicating that mothers are more likely to use Breathy voice in IDS, compared to ADS (B = 1.013, SE = 0.174, z = 5.830, p < 0.001).

3.5.4 Creaky Voice

3.5.4.1 Creaky Voice Descriptive Results

Finally, Figure O suggests that the use of Creaky voice decreases in IDS compared to ADS, for both fathers (IDS M = 42.45%, SD = 22.57%; ADS M = 76.62%, SD = 8.54%) and mothers (IDS M = 21.54%, SD = 13.51%; ADS M = 65.9%, SD = 21.26%), and this is again seen to a larger extent for mothers (fathers' decrease = 34.17%, mothers' decrease = 44.36%). Inspection of the individual data in Figure N suggest that most fathers (n = 7) and all mothers (n = 8) decrease use of creakiness in IDS. Figure N also shows a similar trend within dyads, with all mothers (n = 8) decreasing use of creakiness in IDS to a larger extent than their partner. Yet, the prevalence of utterances with creaky voice is very high in both registers, especially in fathers, although one mother had a complete absence of creaky utterances in IDS (see mother Dyad 39, Figure N). The individual data show all fathers, and all but one mother use Creaky voice in more than 65% of ADS utterances, and in 21.54% - 42.45% of IDS utterances.

3.5.4.2 Creaky Voice Model Outcomes

The logistic mixed-effects model found a significant effect of Register, indicating that parents are more likely to use Creaky voice in ADS, compared to IDS (B = -0.954, SE = 0.106, z = 9.047, p <0.001). The model also found a significant effect of Parent Gender, indicating that fathers are more likely to use Creaky voice, compared to mothers (B = -0.476, SE = 0.156, z = -3.053, p < 0.01). There was no significant Register × Parent Gender interaction (B = -0.075, SE = 0.105, z = -0.712, p = 0.48), indicating that there is no evidence of a gender difference in the decrease of Creaky voice in IDS, compared to ADS.

4. Discussion

4.1 Discussion Overview

This thesis aimed to describe the acoustic characteristics of Australian English speaking parents' IDS, as compared to ADS, in terms of utterance-level pitch properties, across-conversation pitch variability and voice quality. This discussion will first present the similarities and differences between the results of the current and previous studies. Following the discussion of the results, the procedural aspects of this study are appraised, with specific reference to maintaining interlocutor familiarity and design-matching tasks across register elicitation. One of the aims of this thesis was to investigate the impact of task on acoustic characteristics in IDS, compared to ADS. However, it was not possible to address this aim; the rationale for the exclusion of the Story Task data will be examined with regards to the implications of investigating task effects in IDS, compared to ADS. Finally, considerations for measuring pitch in IDS research will be provided, in addition to the limitations of this study and suggestions for future research.

4.2 Utterance-level Pitch Properties

4.2.1 Utterance-level Pitch Properties in Australian English Mothers' IDS

The results of this study found that in IDS, compared to ADS, Australian English mothers increased all utterance-level pitch properties, specifically, the median F0 (Q_2), minimum F0 (Q_1), maximum F0 (Q_3) and F0 range (Q_3-Q_1). These findings will be compared with previous studies on Australian English mothers' IDS; cross-linguistic differences have previously been noted in IDS and there is a sufficient quantity of IDS studies on Australian English mothers (n=6) to warrant a restricted appraisal. It should be noted that IDS studies typically report on parametrically computed measures of utterance-level pitch (mean and SD of F0), while the current study conducted analyses on non-parametric measures of utterance-level

pitch (median and range of F0). However, as we found highly similar results for the mean and median F0 in the current study (see Appendix K for mean F0 results), we can provide a viable comparison with the parametric measures reported in previous studies.

4.2.1.1 Consistency with Previous Australian English Studies: Mean/Median Pitch

The results of the current study provide further evidence that in IDS, compared to ADS, Australian English mothers use a higher pitch, as indicated in previous studies (Burnham, Kitamura & Vollmer-Conna, 2002; Burnham et al., 1998; Kalashnikova & Burnham, 2018; Kitamura & Burnham, 2003; Kitamura et al., 2002; Lee, Kitamura, Burnham & McAngus Todd, 2014). Table 7 provides the mean F0 values that have been reported in previous studies, alongside the median and mean F0 values reported in the current study. Studies listed in Table 7 were limited to those which reported mean F0 values in IDS and ADS (Lee et al., 2014), or studies that provided graphs which allowed for approximations of mean F0 values in IDS and ADS (Burnham et al., 1998, p.2, Fig.1a; Kitamura et al., 2002, p.380, Fig.1). Studies are ranked in descending order in Table 7, based on the differences observed between F0 in IDS and ADS.

Table 7

Comparison of Reported Mean F0 Values in Australian English Mothers' IDS vs ADS

Study	**Infant Age**	**IDS Mean F0**	**ADS Mean F0**	**IDS – ADS =**
Burnham et al. (1998)[a]	6 months	19.6 ST (310 Hz)	14 ST (225 Hz)	5.6 ST
Kitamura et al. (2002)	6 – 12 months	18.4 ST (290 Hz)	12.9 ST (210 Hz)	5.5 ST
Current Study (2019)	6 – 12 months	Median = 4 ST Mean = 4.5 ST	Median = -1.4 ST Mean = -0.8 ST	Median = 5.4 ST Mean = 5.3 ST
Lee et al. (2014)[b]	6 – 12 months	18.1 ST	15 ST	3.1 ST

Notes- Values that were converted to Semitones are presented alongside the estimated F0 value (Hz). [a] Burnham et al. (1998) do not explicitly state that mothers spoke Australian English; this is assumed based on the authors' affiliation with the University of NSW (Australia). [b] Mean F0 value for Lee et al. (2014) was obtained by averaging the Mean F0 values for IDS directed towards 6, 9 and 12-month-old infants. Results provided for Burnham et al. (1998) and Kitamura et al. (2002) were the approximated Mean F0 (Hz) values for IDS and ADS, based on the graphs presented in each article. Median F0 and Mean F0 are provided for the current study, to allow consistent comparisons with previous studies.

As per Table 7, it appears that the difference between IDS and ADS in the current study is similar to the difference reported in Burnham et al. (1998) and Kitamura et al. (2002), but more than one Semitone larger than the difference reported by Lee et al. (2014). However, the observed similarities between the current study and previous studies warrant cautious interpretation. Firstly, Burnham et al. (1998) only report on IDS directed towards 6-month-old infants, and previous studies on Australian English mothers have suggested that mean F0 in IDS peaks at 6 months (Kitamura et al., 2002; Kitamura & Burnham, 2003). This may be one reason why Burnham et al. (1998) have observed the largest F0 difference between IDS and ADS. Secondly, the F0 values provided in Table 7 for Burnham et al. (1998) and Kitamura et al. (2002) were estimations based on graphs; it is possible that we have provided underestimations or exaggerated mean F0 values for these studies. Therefore, if we compare the current findings only to those presented by Lee et al. (2014), we find that the current study has reported a larger difference between mothers' IDS and ADS F0 values. We can speculate that pitch increases in Australian English mothers' IDS, compared to ADS, may occur to a larger extent than has previously been reported.

4.2.1.2 Inconsistency with Previous Australian English Studies: Pitch Range

The present study found that Australian English mothers did increase F0 range in IDS, compared to ADS. This study does not support the finding in previous studies that Australian English mothers do not increase F0 range in IDS, compared to ADS (Burnham et al., 1998; Kitamura & Burnham, 2003; Kitamura et al., 2002). One possibility is that this discrepancy between our study and previous Australian English studies is due to pitch-tracking errors. As noted previously (see Subsection 2.5.4), we discarded the 10^{th} and 90^{th} percentile of F0 values in an utterance as unreliable measures of its minimum and maximum F0, and calculated the F0 range from the even more conservative 25^{th} and 75^{th} percentile values. Kitamura et al. (2002) stated that the F0 range measure was calculated from the maximum F0 and minimum F0, which we are presuming were the most extreme values in each utterance. Based on the pitch-tracking

errors experienced in the current study, it is plausible that similar pitch-tracking difficulties have resulted in incorrect measures of the absolute F0 minimum and maximum, and thus the F0 range in previous Australian English studies (Burnham et al., 1998; Kitamura & Burnham, 2003; Kitamura et al., 2002). If the F0 range of many utterances is not measured correctly, a true difference between IDS and ADS may not be detected. The present result is consistent with the cross-linguistic literature that has consistently reported an increased F0 range in mothers' IDS. This can provide some confidence in the present finding, although it is based on an admittedly unorthodox approach to dealing with pitch-tracking errors. As far as we are aware, this is the first Australian English study to report the typical increase of F0 range in IDS, compared to ADS.

4.2.2 Utterance-level Pitch Properties in Australian English Fathers' IDS

The results of this study revealed that in IDS, compared to ADS, Australian English fathers increased all utterance-level pitch properties, specifically, the median F0 (Q_2), minimum F0 (Q_1), maximum F0 (Q_3) and F0 Range (Q_3-Q_1). This is consistent with the vast majority of previously published studies on fathers' IDS, which have reported that fathers' IDS is characterised by an increased mean F0, compared to ADS (Amano et al., 2006; Benders et al., under revision; rural fathers only, Broesch & Bryant, 2017; Fernald et al., 1989; Gergely et al., 2017; Jacobson et al., 1983; Kaplan et al., 2007; McRoberts & Best, 1997; Niwano & Sugai, 2003; Papousek et al., 1987; Reissland, 1998; Sheehan, 2008; during conversation; Shute & Wheldall, 1999; Van de Weijer, 1997; Warren-Leubecker & Bohannan, 1984). The two exceptions to this overwhelming pattern are Broesch & Bryant (2017) who found that urban fathers did not increase the mean F0 in IDS, compared to ADS, and Shute & Wheldall (1999) who found that British fathers did not increase the mean F0 during reading tasks. It is unclear why the results of the present study differ from those of Broesch & Bryant (2017); the results of Broesch & Bryant (2017) appear to be an outlier within the literature on fathers' IDS. The inconsistency between the present results and those reported by Shute & Wheldall (1999) for the

reading task can be understood in terms of task effects, as Shute & Wheldall (1999) reported that fathers' mean F0 did increase during conversational tasks, which is more akin to the play task of the current study.

This study found that Australian English fathers expand the F0 range within-utterances in IDS, compared to ADS, which is consistent with some previous studies (Benders et al., under revision; Gergely et al., 2017; Kaplan et al., 2007; Papousek et al., 1987; van de Weijer, 1997). However, not all studies find increased within-utterance pitch variability in fathers' IDS, compared to ADS (Amano et al., 2006; Broesch & Bryant, 2017; Fernald et al., 1989; Sheehan, 2008; Shute & Wheldall, 1999; Warren-Leubecker & Bohannon, 1984).

One possible reason why the present study found a range increase in IDS, in contrast to some previous studies, may lie in the different methods for calculating range or pitch-tracking errors, as mentioned previously in Subsection 4.2.1. The differences observed between our results and Shute & Wheldall (1999) may also be a reflection of infant age effects. The infants in that study were 24 months old, and fathers may decrease the amount of pitch variability in IDS as the infant grows older (see Subsections 1.2.6 & 1.4.5; Gergely et al., 2017, Kitamura & Burnham, 2003; Stern et al., 1983). Another plausible explanation may be that the lack of a range increase in fathers' IDS in some previous studies, especially, Fernald et al. (1989) and Warren-Leubecker & Bohannon (1984), is a reflection of the era in which those studies were conducted, and that fathers may have been less exuberant in past decades than work conducted in the 1990's and beyond consistently reveals they currently are (Benders et al., under revision; Gergely et al., 2017; Kaplan et al., 2007; van de Weijer, 1997).

4.3 Across-conversation Pitch Variability

The present study found that Australian English fathers and mothers increased across-conversation variability in IDS, compared to ADS. This is consistent with previous studies that have found an increase in maternal and paternal across-conversation variability in IDS,

compared to ADS (maternal & paternal, Benders et al., under revision; maternal, Lee et al., 2014). However, there is a point of difference between the current results and Benders et al. (under revision) regarding the direction of the gender difference. Our study found that Australian English mothers increased across-conversation variability to a greater extent than Australian English fathers in IDS, compared to ADS; however, Benders et al. (under revision) found that Dutch fathers increased across-conversation variability to a greater extent than Dutch mothers in IDS, compared to ADS.

It should be noted that this gender difference was only found in the current study for the SD measure on the Hertz scale, and not the SD measure on the Semitone scale, while Benders et al. (under revision) found a gender difference using the SD measure on the Semitone scale. The Semitone scale provides an adjusted logarithmic value to take into account that the perception of pitch is non-linear. Nevertheless, the opposite directions of the gender effect across languages suggest that Dutch fathers may be more exuberant than Australian English fathers. Alternatively, it is possible that the observed difference between the present study and Benders et al. (under revision) may stem from ADS elicitation differences related to interlocutor familiarity. For instance, men may be more subdued than women, while conversing with an unfamiliar female interlocutor, such as the female experimenter who elicited ADS in Benders et al. (under revision). The large difference observed between Dutch fathers' IDS and ADS, may thus partly reflect this more subdued speaking style in ADS. In the present study, fathers' ADS was elicited during interactions with a familiar female interlocutor, namely their spouse. This may have reduced the difference between fathers' IDS and ADS in the present study, as both registers were elicited in the presence of familiar interlocutors (as discussed further in Subsection 4.6.2)

4.4 Voice Quality in Australian English Parents' IDS vs ADS

The results of the present study revealed that Australian English mothers and fathers had a higher prevalence of whispered speech and breathiness in IDS, compared to ADS. Mothers

were found to increase breathiness in IDS, compared to ADS, to a greater extent than fathers. Increased prevalence of breathiness in IDS, compared to ADS, appears to be consistent with the acoustic measures reported in some studies (Malloch et al., 1997; Miyazawa et al., 2017; Shinya et al., 2009). Mothers and fathers were also found to decrease the prevalence of creakiness in IDS, compared to ADS.

The present study is the first to report on whispered speech in this amount of detail, and the first to provide proportions of whispered speech in IDS and ADS for mothers and fathers. This study is also the first to present data regarding whispered speech directed towards infants aged 6-12 months. Previous studies provided proportions of whispered speech in German IDS, directed towards newborns and 3-month-old infants (Fernald & Simon, 1984; Papousek et al., 1987). Other studies allude to the presence of whispered speech when discussing exclusion criteria, but this study appears to be the first to provide proportions of utterances that contain whispered speech for English.

While breathiness and whispered speech in IDS has received some attention in the literature, voice quality has not been one of the traditional features included in IDS research. This study supports previous suggestions (Malloch et al., 1997; Miyazawa et al., 2017; Shinya et al., 2009) that a breathy voice quality may be a key acoustic characteristic of IDS. The results of this study are inconsistent with Benders et al. (2018), which found that Dutch mothers' IDS, compared to ADS, was not characterised by increased breathiness. However, Dutch mothers' IDS, compared to ADS, was more variable in voice quality (Benders et al., 2018). Piazza et al. (2017) reported that mothers' IDS, compared to ADS, had a more variable voice quality across a range of languages (see Subsection 1.2.4). This suggests that although there may be cross-linguistic differences in the prevalence of specific voice quality types in IDS, parents appear to differentiate use of voice quality types between IDS and ADS.

In addition to the increased prevalence of breathiness in IDS observed in this corpus, there was also a decreased prevalence of creakiness in IDS. To the best of our knowledge, this is the first study to discuss the presence of creakiness in IDS, compared to ADS. It is possible that the observed decrease in the prevalence of creakiness in IDS may be a specific voice quality characteristic of Australian English speakers. For instance, if Australian English speakers have a higher prevalence of creakiness in ADS, compared to speakers of other varieties of English or other languages, then the decrease in creakiness in IDS may be more salient for Australian English speakers.

4.4.1 Perceptual Ratings of Voice Quality vs Acoustic Measures

To the best of our knowledge, the present study is the first to present perceptual voice quality ratings in IDS, compared to ADS, for Australian English mothers and fathers. Perceptual ratings provide clarity regarding the phonation types that speakers use, which can supplement the interpretation of acoustic measurements, such as the H1-H2 measure. The H1-H2 measure of voice quality is associated with the amount of constriction in the vocal folds during phonation (Keating & Esposito, 2007; Keating et al., 2015; Szakay, 2012). Typical phonation (modal voice) is associated with H1-H2 values around 0, high amounts of constriction (creaky voice) is associated with low H1-H2 values below 0, and low amounts of constriction (breathy voice) is correlated with H1-H2 values exceeding 0 (Keating & Esposito, 2007; Keating et al., 2015; Szakay, 2012).

Previous IDS studies have interpreted the higher H1-H2 values in IDS compared to ADS as an indicator that IDS is breathier (Miyazawa et al., 2017; Shinya et al., 2009). The perceptual voice quality results of the present study suggests that this appears to be an accurate, although incomplete interpretation; a difference in H1-H2 values merely indicates a difference in the amount of constriction during phonation in IDS, compared to ADS. The creaky voice quality

results in this study reveal that a more complete interpretation of the higher H1-H2 values in IDS might partly reflect a decrease of creakiness in IDS, compared to ADS.

The current study only coded for creaky voice as a generic voice quality. However, multiple types of creaky voice have been identified, and each creaky variation has unique perceptual and acoustic features (see Keating et al., 2015 for an overview of the different types of creaky voice). For example, while creaky voice with constriction is correlated with low H1-H2 values, creaky voice without constriction is correlated with H1-H2 values that are higher than modal H1-H2 values (Keating et al., 2015). This indicates the potential for inaccurate interpretations of H1-H2 values, as these can be associated with more than one voice quality type. However, perceptual ratings of creaky voice without attention to the specific acoustic features can also miss critical variation in the type of creak that speakers employ. Future studies would benefit from incorporating both acoustic measures and perceptual judgements to provide a more complete picture of the voice quality characteristics that speakers employ in IDS.

4.4.2 Future Research on Voice Quality

In addition to the voice quality types presented in the results, the corpus contained utterances for which it was not possible to accurately identify the voice quality type. Some of these tokens were presented to members of the Phonetic Lab at Macquarie University; despite the high level of expertise on voice quality amongst the lab members, (i.e., see Benders et al., 2018; Penney, Cox, & Szakay, 2019; Szakay, 2012), the voice quality type of these tokens could not be identified. Tokens with such an unidentifiable voice quality were coded as both creaky and breathy, and could be coded as whispered, if whisper was present. Future research should take into account the possibility of irregular voice quality use in IDS, particularly as these tokens are likely to impact F0 measures. Future research should also aim to document irregular voice quality use in IDS, to illuminate the full extent of voice quality use in IDS.

The voice quality results of this study and recent related work indicate that an important area for future research is whether infants perceive the differences between voice quality types and how they respond to them. Trainor and Zacharias, in their 1998 study on Infant Directed Singing, postulated that infants may prefer the voice quality and timbre changes that occur as a side effect of a higher pitch in speech or singing. Such voice quality and timbre changes might also play a role in infants' preference for IDS. Newborn infants did not display a preference for whispered speech in IDS, compared to ADS, which was suggested to stem from the absence of the typical IDS acoustic markers in whispered speech (Spence & Freeman, 1996). Future research on older infants' perception of whispered speech is warranted, particularly considering the higher prevalence of whispered speech in IDS, compared to ADS. Another avenue of research is the role of voice quality fluctuations in the parent-infant interaction. In the emotional speech literature, a breathy voice quality has been associated with intimacy and the expression of positive affect (Gobl & Ní Chasaide, 2003); it is plausible that the expression of affect may similarly play a role in the prevalence of breathiness in IDS, compared to ADS.

4.5 Methodological Considerations

Comparing IDS and ADS can be difficult if the speaking tasks are not matched across registers. Moreover, any conclusions about the difference between IDS and ADS may be restricted to the context in which the speech was elicited, as previous studies have indicated that task type can impact acoustic measurements (Gergely et al., 2017; Shute & Wheldall, 1999). In order to address both issues, a play task and a story task were design-matched for IDS and ADS register elicitation. In addition to matching the type of tasks that speakers engaged in, they interacted in both registers with a highly familiar interlocutor to whom they had an intimate relationship.

The familiarity and intimacy during the ADS elicitation, when parents of an infant interacted with each other, was evident from impressionistic observations of the data. For

instance, parent-dyads were observed to engage in playful teasing and also frequently interrupted each other, as indicated by the presence of overlapping speech. It is unlikely that these features, particularly playful teasing, would be observed during ADS elicitation with an unfamiliar experimenter. This means that the results of the present study are reflecting genuine differences between IDS and ADS, which are not confounded by the degree of familiarity or intimacy with the interlocutor.

The IDS and ADS task appear to match appropriately in this study, in that both can be considered to be types of 'play'. The ADS task critically differs from the typical ADS elicitation speech task in other IDS studies; parent-dyads were engaged in a fun activity, as indicated by participants' reporting. Audio recordings of both the IDS and ADS play tasks contained laughter as well as speech-laughter (see Table 5 in Subsection 2.5.3), indicating that both tasks elicited genuinely playful interactions. Moreover, although parents were not instructed to do so, they tended to 'build the blocks up' in the IDS play task, creating further similarity with the ADS play task, where parents constructed a Lego koala.

Overall, these methodological choices can be considered a strength of this study. It is recommended that future research similarly aims to reduce the potential for extraneous variables, such as speaker unfamiliarity and across-register task differences, by incorporating the methodological choices presented here wherever possible.

4.5.1 ADS Play Task Critique

Although the ADS play task was piloted prior to participant recruitment, there were some issues that participants raised during the completion of this task. These issues were revealed during the coding stage of the study, following data collection. For example, one father commented that the compartments of the foam-lined container were too small for his hands. Another participant mentioned that the colour of the manufacturer-provided Lego instructions did not appear to match closely with the colour of the provided blocks. A third participant

commented that the instructions were difficult to read as they had not brought their reading glasses to the session. These “meta-comments” are unlikely to represent the speech produced during a genuine play interaction outside of the laboratory context, which may have impacted on the data. Study design improvements could reduce the likelihood of these “meta-comments”, with consideration of factors such as the size of provided materials, consistency of colour across materials (particularly if these have been taken directly from the manufacturer) and ease of access to materials for all individuals. Future studies should address these considerations, if the aim is to elicit speech that is typical of a playful interaction.

The ADS task was designed to mimic everyday conversations and be aligned with the IDS task with respect to the physical proximity between conversation partners. This set-up resulted in overlapping parent speech for all dyads, despite parents receiving instructions to only speak once their partner had finished speaking. Because overlapping speech cannot be reliably analysed, a large number of utterances in ADS were thus excluded from the analyses. While it may have been possible to avoid overlapping speech in the recording by employing an audio-visual loop set up, with parents interacting via video screens in separate rooms, we preferred to err towards eliciting as natural speech as possible, in both the ADS and IDS tasks. Future research should consider strategies to reduce overlapping speech, and whether they prefer to sacrifice natural elicitation in favour of more data.

4.5.2 IDS Play Task Critique

A limitation of the design of the IDS play task is that its 7-minute duration may have led to infant distractibility and disengagement. The 7-minute duration was set in order to align with the expected ADS play task length, based on the pilot stage of the study. This time is also typical for the duration of IDS elicitation in previous studies (e.g., Benders, 2013; Broesch & Bryant, 2017; Kalashnikova & Burnham, 2018). However, parents struggled to keep their infant on task, reportedly because infants had little interest in the silent foam blocks. Infants also had a tendency

to express interest in other unfamiliar objects, such as the microphone on their parent's face, the Go-pro cameras located in two separate corners of the room and other objects in the room (such as images on the walls of the lab). The IDS elicited during these moments of infant distractibility may not be reflective of a genuine play interaction outside of the laboratory context. Such distractions are unproblematic for studies of IDS that only intend to compare IDS to ADS. However, future IDS studies that target specific interaction types should carefully consider the duration of each task and remove potential distractors from the recording setting whenever possible.

4.5.3 Story Task Overview

While the IDS and ADS play task were successful in eliciting comparable speech for the play context, eliciting story-telling speech in IDS and ADS resulted in unforeseen difficulties. The data from the story task for both IDS and ADS was excluded from analyses, as the data were not deemed valid instances of story-telling speech in both registers.

4.5.3.1 IDS Story Task Critique

In the IDS story task, we aimed to elicit a story-telling speech style with an abridged version of The Very Hungry Caterpillar. We expected parents to be familiar with this well-known book and tell a variation of this story during interactions with their infant. Although this book was targeted towards the age group of infants in the present study, parents did seem to interact as expected.

Perhaps one reason for the difficulty of eliciting story-telling speech in IDS is that some parents may not have experience elaborating on the minimal text in picture books designed for infants. For instance, one parent asked what she was meant to do after receiving instructions. Other parents commented that the books they usually read with their infant are more complex, with multiple sentences and a plot. Elicitation of story-telling speech was thus less effective than expected on the basis of the books targeted to infants aged six to 12 months.

4.5.3.2 ADS Story Task Critique

In the ADS story task, we aimed to elicit a story-telling speech style by providing parents with a set of picture prompts, and instructions to tell their partner a story based on the prompts or recount a memory that the images may have evoked. Despite these picture prompts and specific instructions being successfully piloted with adults prior to recruitment of parents, the interactions between the parents did not unfold as intended. Some parents veered into conversation about upcoming holiday plans, others turned the task into a picture-guessing game. Overall, the picture prompts in the ADS story task were generally ignored, which suggests that either the verbal instructions were insufficient, or the task itself was too abstract. One possibility is that participant disengagement with the story task reflects the realities of parenting in the present day; parents may have taken advantage of the time they could spend together to plan their schedules.

The disengagement observed in the story task did not occur with the play task, presumably because it had concrete instructions. Future research wishing to elicit story-telling speech in ADS should consider providing a less-abstract task, such as providing images from a well-known historical event, or a folklore story or legend that is common-knowledge within the participants' cultural group.

4.6 Considerations for Pitch Measures

4.6.1 Manual Coding vs Automated Coding

The present study conducted manual coding of the speech data, which is a point of difference with other IDS research, where there tends to be a reliance on predominantly automated coding. This study had a relatively small corpus, in comparison to the typical sample size of present-day lab-based studies of IDS (e.g., Benders, 2013; Lamm, et al., 2014), as well as home-based studies that rely on LENA to capture and analyse big speech data (e.g., Dwyer, Jones, Davis, Kitamura, & Ching, 2019; Ko, Seidl, Cristia, Reimchen, & Soderstrom, 2016). The

smaller corpus made manual checks, and where needed, adjustments of utterance boundaries feasible within the scope of the present project.

The coding in this study included manual annotations and adjustments of the utterance boundaries, which were automatically generated based on the amplitude contours of the speech signal. Manual adjustments were necessary, as whispered speech, fricated sounds and breathy segments were often not included within utterance boundaries. These sounds have a relatively low amplitude, as compared to other sounds in the speech signal, and sometimes had an insufficient intensity to pass the threshold for inclusion in the automatically generated utterance boundaries.

Relying purely on automated coding of utterances might have implications for the pitch measures obtained therein. For example, breathy speech is likely to have a high pitch; if breathy segments are not captured within utterance boundaries, the Maximum pitch of an utterance may be underestimated. This would then have a cumulative effect and impact on other measures, including mean F0, median F0 and F0 range. Thus, any analyses of measures that are derived from inaccurate utterance boundary marking will be inherently prone to error.

4.6.2 Pitch Tracking Errors

Another consideration for measuring pitch in IDS is the potential for pitch tracking errors. Following observation of the F0 distributions and inspection of the raw data, the pitch ceiling for mothers was raised to account for the high proportion of pitch-tracking errors (see Subsection 2.5.4). Nevertheless, pitch-tracking errors were still present, necessitating the adoption of the 25th and 75th percentile of the F0 values in the pitch track as conservative estimates of the minimum and maximum F0 in an utterance, and using these to calculate the F0 range. It is thus likely that our analyses of range do not capture the full extent of the pitch range in IDS. However, as suggested in subsection 4.2.1, these conservative values may have resulted

in robust measure of the utterance range and enabled finding a range difference between Australian English IDS and ADS.

Due to the pitch tracking errors evidenced in the measurement of minimum and maximum F0, the mean F0 and SD F0 were also discarded as unreliable measures, as these would have been computed on the basis of all pitch values in the pitch track, including the potentially unreliable extremes. Consequently, it is not possible to provide a direct comparison to studies reporting these measures. Future work on the present data as well as further research on IDS would benefit from conducting manual checks of all automated pitch tracks. If this is not feasible, as was the case for the present study, then researchers should consider favouring non-parametric measures over parametric measures (e.g. median over mean), and adopting conservative measures of maximum, minimum and range, and be sceptical of the SD F0 measure.

4.7 Audio-Visual Corpus

Another limitation of this study is that the video data recorded during each session was not included in these analyses. The video data was recorded with the intention of analysing the physical interactions between parent-infant dyads, in order to supplement the acoustic analyses of the audio data. However, due to time constraints, it was not feasible to include analyses of the visual data within this thesis. Despite this limitation, we now have a rich audio-visual corpus of Australian-English speakers' IDS and ADS, with parental consent for this corpus to be shared amongst other researchers. Even though we were unable to provide analysis of the visual data, the corpus itself is a significant contribution for IDS research, and research on Australian-English speech in general.

4.8 Concluding Statements

The present study has revealed that Australian English fathers, as well as mothers, increase utterance-level pitch properties and across-conversation pitch variability in IDS, compared to ADS. This study is the first to report on a decrease in the prevalence of creakiness in IDS, compared to ADS and supports earlier reports on increased breathiness in IDS with perceptually coded data. The results presented in this thesis raise questions about infants' discrimination between and reactions to the different voice quality types. Furthermore, this study provides a procedure to match IDS and ADS elicitation, maintaining consistency in interlocutor familiarity and the type of activity engaged in by dyads, thus isolating the effect of the infant's presence on both mothers' and fathers' speech.

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Appendix A

Language Questionnaire

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SYDNEY·AUSTRALIA

Language Questionnaire
The Acoustic Profile of Australian English Infant Directed Speech

[No._____]

1. Where do you live? (your suburb, your neighborhood)

_____

2. How long have you lived in that neighborhood? _____

3. Where did the child's primary caregiver (circle one: mother/father/other _____) grow up?

_____ (state, city/town, suburb, country)

4. Where did the child's other primary caregiver (circle one: mother/father/other _____) grow up?

_____ (state, city/town, suburb, country)

5. Do you speak any languages other than English? _____

If so, which ones, and how many hours per day, for each language spoken?

_____

6. Do you speak to your child in languages other than English? _____

If so, which ones, and how many hours per day?

_____

7. Does the child's mother speak any languages, other than English, with your child? _____

If so, which ones, and how many hours per day, for each language spoken?

_____

8. How many hours a week (on average) do you spend with your child?

_____

9. How many hours a week is your child in daycare/preschool outside the home? _____

Thank you!

Appendix B

Sociodemographic Questionnaire

Sociodemographic Questionnaire- Australian English IDS

Participant No.____ Date: _____

The following is a questionnaire that will ask questions about basic socio-demographics related to you, your partner, and your child. It will also ask questions related to your medical and family history. All information in this questionnaire is confidential and will only be used for research purposes.

Personal Details

1. What is *your* date of birth(DD/MM/YYYY):
____/____/_____

2. What is your country of birth? (please state):
_____

Infant Information

3. Infant's gender (please tick): ☐Male ☐Female
4. Infant's date of birth (DD/MM/YYYY): _____/_____/_____
5. Do any siblings live with your child? (if yes, please state how many):
(please tick) ☐No ☐Yes _____
   Sibling 1: Age: _____ Sex: M/F (please circle)
   Sibling 2: Age: _____ Sex: M/F
   Sibling 3: Age: _____ Sex: M/F
   Sibling 4: Age: _____ Sex: M/F
   Sibling 5: Age: _____ Sex: M/F
6. Is your child:
   ☐Breastfed only
   ☐Bottle only
   ☐Both breastfed and bottle
7. If the mother has stopped breast feeding:
How old was your child when the mother stopped breastfeeding? _____
How old was your child when they started solids? _____
8. Does any close biological family member of your child suffer from:

☐ Parkinson's Disease	☐ Depression
☐ Huntington's Disease	☐ Bipolar Disorder
☐ Multiple Sclerosis	☐ Schizophrenia
☐ Epilepsy or seizures	☐ Other psychiatric illness
☐ Other neurological disease	☐ Speech or language disorder
☐ Alzheimer's Disease or other dementia	☐ Learning or behaviour problems

☐ Other (please specify): _____

If you marked any boxes, please specify the relation of the person to your child:
_____

Education and Occupation Information

9. What is the highest level of education **you** have **completed**? (E.g. School Certificate, Higher School certificate, TAFE Diploma, Bachelor's degree): _____	11. What is the highest level of education **your partner** has **completed**? (E.g. School Certificate, Higher School certificate, TAFE Diploma, Bachelor's degree): _____
10. What is **your** current occupational status? (please circle all that apply): Employed: Full-time / Part-time / Casual Unemployed Job searching Stay at home parent On Maternity leave Home-maker Student Retired	12. What is **your partner's** current occupational status? (circle all that apply): Employed: Full-time / Part-time / Casual Unemployed Job searching Stay at home parent On parental leave Home-maker Student Retired

Medical History

13. Do you suffer from any chronic illnesses or mental health conditions?
☐ No ☐ Yes (please specify)

_____

14. Are you currently in counselling or psychiatric care? ☐ No ☐ Yes
15. Have you ever been in counselling or psychiatric care? ☐ No ☐ Yes

Now thinking about the child's mother...
16. Does the mother suffer from any chronic illnesses or mental health conditions?
☐ No ☐ Yes (please specify)

_____

14. Is the mother currently in counselling or psychiatric care? ☐ No ☐ Yes
15. Has the mother ever been in counselling or psychiatric care? ☐ No ☐ Yes

Family History

*Please respond about **your biological** mother, father, brothers and sisters* 16. What is their highest level of education? Mother:_____ Father: _____ 17. What is/was their occupation? Mother:_____ Father: _____ 18. Do **you** have brothers and/or sisters? ☐ No ☐ Yes If yes, how many? _____	*Please respond about **the mother's biological** mother, father, brothers and sisters* 19. What is their highest level of education? Mother:_____ Father: _____ 20. What is/was their occupation? Mother:_____ Father: _____ 21. Does **she** have brothers and/or sisters? ☐ No ☐ Yes If yes, how many? _____

Comments *If you have any comments, please write them below:*

_____
_____

Acknowledgement: This sociodemographic questionnaire was adapted from the sociodemographic questionnaire used in "Breathing for Life" studies (supplied by Alix Woolard).

Appendix C

PROMIS-29 Profile Questionnaire

PROMIS–29 Profile v2.1

Please respond to each question or statement by marking one box per row.

	Physical Function	**Without any difficulty**	**With a little difficulty**	**With some difficulty**	**With much difficulty**	**Unable to do**
PFA11	Are you able to do chores such as vacuuming or yard work?	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
PFA21	Are you able to go up and down stairs at a normal pace?	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
PFA23	Are you able to go for a walk of at least 15 minutes?	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
PFA53	Are you able to run errands and shop?	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
	Anxiety **In the past 7 days…**	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
EDANX01	I felt fearful	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EDANX40	I found it hard to focus on anything other than my anxiety	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EDANX41	My worries overwhelmed me	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EDANX53	I felt uneasy	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
	Depression **In the past 7 days...**	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
EDDEP04	I felt worthless	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EDDEP06	I felt helpless	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EDDEP29	I felt depressed	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EDDEP41	I felt hopeless	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
	Fatigue **During the past 7 days…**	**Not at all**	**A little bit**	**Somewhat**	**Quite a bit**	**Very much**
HI7	I feel fatigued	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
AN3	I have trouble starting things because I am tired	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

PROMIS–29 Profile v2.1

Fatigue

	In the past 7 days…	Not at all	A little bit	Somewhat	Quite a bit	Very much
FATEXP41	How run-down did you feel on average? ...	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
FATEXP40	How fatigued were you on average?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Sleep Disturbance

	In the past 7 days…	Very poor	Poor	Fair	Good	Very good
Sleep109	My sleep quality was.....	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1

	In the past 7 days…	Not at all	A little bit	Somewhat	Quite a bit	Very much
Sleep116	My sleep was refreshing.....	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
Sleep20	I had a problem with my sleep	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Sleep44	I had difficulty falling asleep	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Ability to Participate in Social Roles and Activities

		Never	Rarely	Sometimes	Usually	Always
SRPPER11_CaPS	I have trouble doing all of my regular leisure activities with others.....	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
SRPPER18_CaPS	I have trouble doing all of the family activities that I want to do	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
SRPPER23_CaPS	I have trouble doing all of my usual work (include work at home)	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
SRPPER46_CaPS	I have trouble doing all of the activities with friends that I want to do	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1

Pain Interference

	In the past 7 days…	Not at all	A little bit	Somewhat	Quite a bit	Very much
PAININ9	How much did pain interfere with your day to day activities?.....	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PAININ22	How much did pain interfere with work around the home?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PAININ31	How much did pain interfere with your ability to participate in social activities? .	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PAININ34	How much did pain interfere with your household chores?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Pain Intensity

	In the past 7 days…											
Global07	How would you rate your pain on average?.....	☐ 0 No pain	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10 Worst pain imaginable

Retrieved from: http://www.healthmeasures.net/explore-measurement-systems/promis

Appendix D

Paternal Index of Childcare Inventory (PICCI) Questionnaire

Activities Scale/RESPONSIBILITIES

Who usually does the following activities?

1 = Mother Always Does
2 = Mother Usually Does
3 = Father and Mother Equally Do
4 = Father Usually Does
5 = Father Always Does

_____ Takes the child to preventative health care appointments

_____ Buys clothes for child

_____ Buys toys, books, videos for the child

_____ Determines appropriate clothes for the child to wear

_____ Makes the child's daycare arrangements

_____ Makes the child's babysitting arrangements

_____ Makes childcare arrangements when the child is ill

_____ Plans the child's meals

_____ Takes the child to birthday parties, etc.

_____ Plans the child's birthday party

_____ Keeps track of the child's toys, clothes, etc.

_____ Determines when to take the child to the pediatrician due to illness

_____ Drops the child off at daycare

_____ Picks the child up from daycare

_____ Determines appropriate activities

for the child (e.g., TV/videos, play activities, etc.)

_____ Does child-related errands (e.g., picks up prescriptions for child, etc.)

_____ Takes responsibility for child's safety

_____ Gets up during the night when the child is ill

Who usually does the following activities? ENGAGEMENT/INTERACTION

1 = Mother Always Does
2 = Mother Usually Does
3 = Father and Mother Equally Do
4 = Father Usually Does
5 = Father Always Does

_____ Reads to child

_____ Plays with child indoors (e.g., dolls, trucks, games, coloring, etc.)

_____ Plays with child outdoors (e.g., bubbles, swing, park, etc.)

_____ Assists child in dressing

_____ Bathes child

_____ Teaches child manners (e.g., please and thank you, etc.)

_____ Sings songs with child (e.g., ABCs, etc.)

_____ Assists the child with feeding (e.g., cutting food, etc)

_____ Calms the child when s/he is upset

_____ Assists the child with toileting (e.g., potty training, etc.)

_____ Teaches child about getting along with others (e.g., sharing)

_____ Puts the child to bed

Who usually does the following activities? AVAILABILITY

1 = Mother Always Does
2 = Mother Usually Does
3 = Father and Mother Equally Do
4 = Father Usually Does
5 = Father Always Does

____ Is available to child when he or she is playing

_____ Watches TV/videos with the child

_____ Takes the child along when shopping

_____ Available to the child if he/she becomes upset

_____ Is available to the child while cooking dinner

_____ Supervises morning routine

_____ Supervises bedtime routine

_____ Takes the child to park/play area

_____ Stays with child when s/he is playing with friends (e.g., at park or play areas)

Appendix E

Beliefs Concerning the Parental Role (BCPR) Questionnaire

Please use the scale below.

1 = Agree Strongly

2 = Agree Mildly

3 = Neither Agree Nor Disagree

4 = Disagree Mildly

5 = Disagree Strongly

____ 1. A father should pursue the career of his choice even if it cuts into the time he has to spend with his family.

____ 2. Responsibility for the discipline of the children should be equally divided between the mother and the father.

____ 3. It is more important for a mother rather than a father to stay home with an ill child.

____ 4. With women being employed outside the home, men should share with child care such as bathing, feeding, and dressing the child.

____ 5. The mother and father should equally share in toilet training.

____ 6. It is mainly the mother's responsibility to make sure that the children get ready for daycare/school in the mornings.

____ 7. In general, the father should have more authority than the mother in deciding what extra-curricular activities are appropriate for the child.

____ 8. It's better for women with children not to work outside the home if they don't have to financially.

____ 9. Fathers should attend birthing classes with their pregnant wives (partners).

____ 10. Divorced men should share joint custody of their children.

____ 11. Fathers should participate in the delivery (birth) of their children.

____ 12. Mothers should be more involved than fathers in the physical care of the children (e.g., dressing, feeding, bathing).

____ 13. Fathers should attend parent-teacher conferences.

____ 14. A father's primary responsibility is to financially provide for his children.

____ 15. It is important for a father to spend quality time (one to one) with his children every day.

____ 16. Fathers should attend prenatal doctor's visits with his partner (wife) (e.g., ultrasound appointment).

____ 17. Fathers should take the majority of responsibility for setting limits and discipline children.

____ 18. A father should be emotionally involved with his children (e.g., nurturant, supportive, understanding).

____ 19. It is mainly the mother's responsibility to change diapers.

____ 20. It is equally as important for a father to provide financial, physical, and emotional care to his children.

____ 21. Mothers and fathers should share equally with the late night feedings during infancy.

____ 22. It is mainly the mothers responsibility to toilet train the children.

____ 23. Mothers and fathers should equally share the responsibility of taking care of a sick child in the middle of the night.

____ 24. When a child becomes ill at daycare/school it is primarily the mothers responsibility to leave work or make arrangements for the child.

____ 25. A mother should pursue the career of her choice even if it cuts into the time she has to spend with her family.

____ 26. It is more important for a father to have a successful career than it is to have a family that is closely knit.

Appendix F

Questionnaires Scoring Description

Scoring: Beliefs concerning the Parental Role (BCPR)

Reverse code only the following items as indicated (**2, 4, 5, 9, 10, 11, 13, 15, 16, 18, 20, 21, 23, 25**). 1 = 5 2 = 4 3 = 3 4 = 2 5 = 1

After rescoring only the above items, then add up all items to create a total beliefs concerning the parental role score. Higher scores reflect *more* liberal beliefs (i.e. the respondent believes fathers should be more involved in parenting).

Scoring: Paternal Index of Child Care Inventory (PICCI)

Add up all scores- no reverse coding necessary. Higher scores indicate fathers perform activity more than mothers.

Notes for BCPR and PICCI Questionnaires:

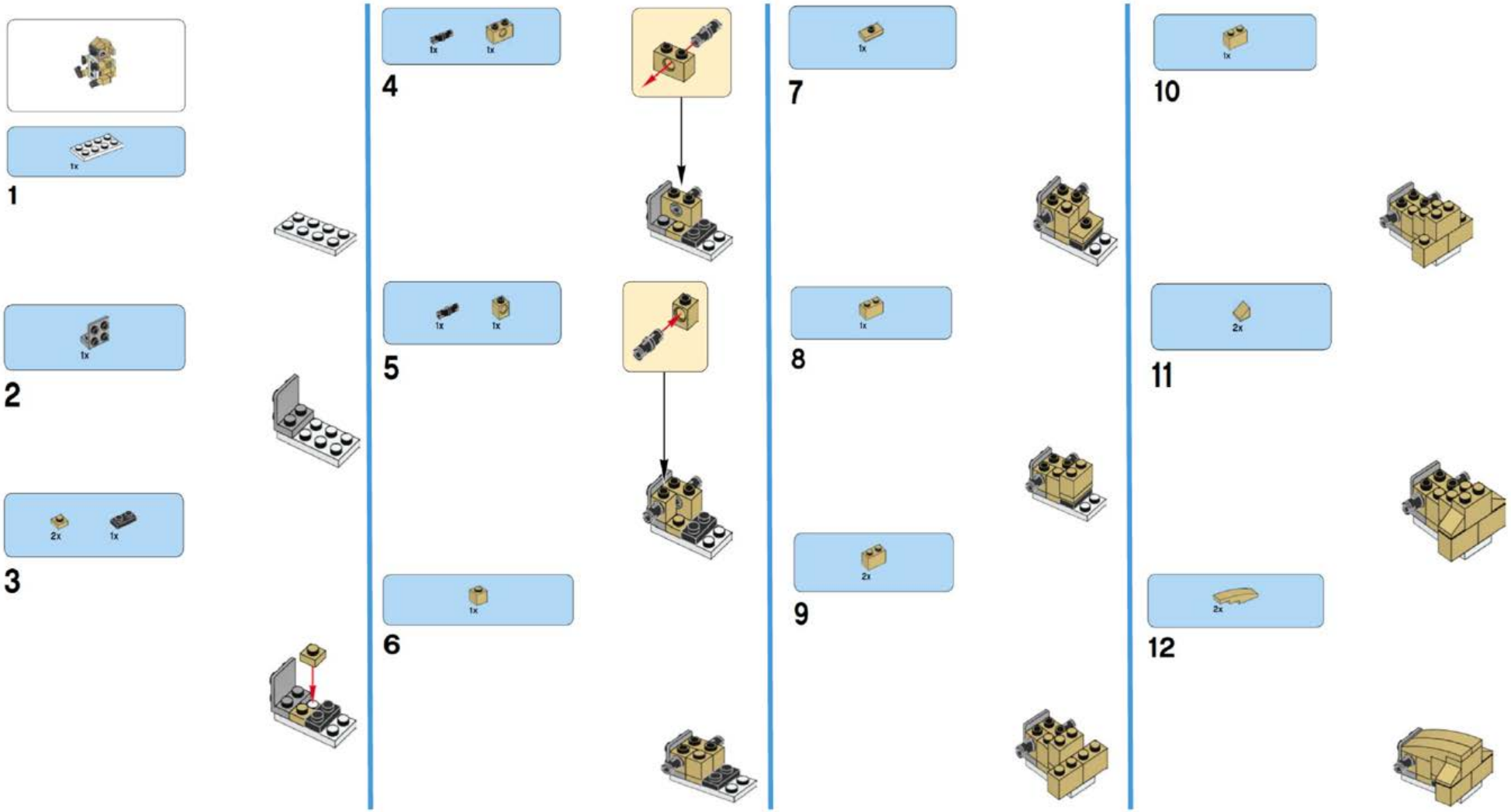
The BCPR, PICCI and the scoring descriptions presented above, were provided directly by the author, Michelle Kelley. We are grateful for her willingness to share these instruments with us.

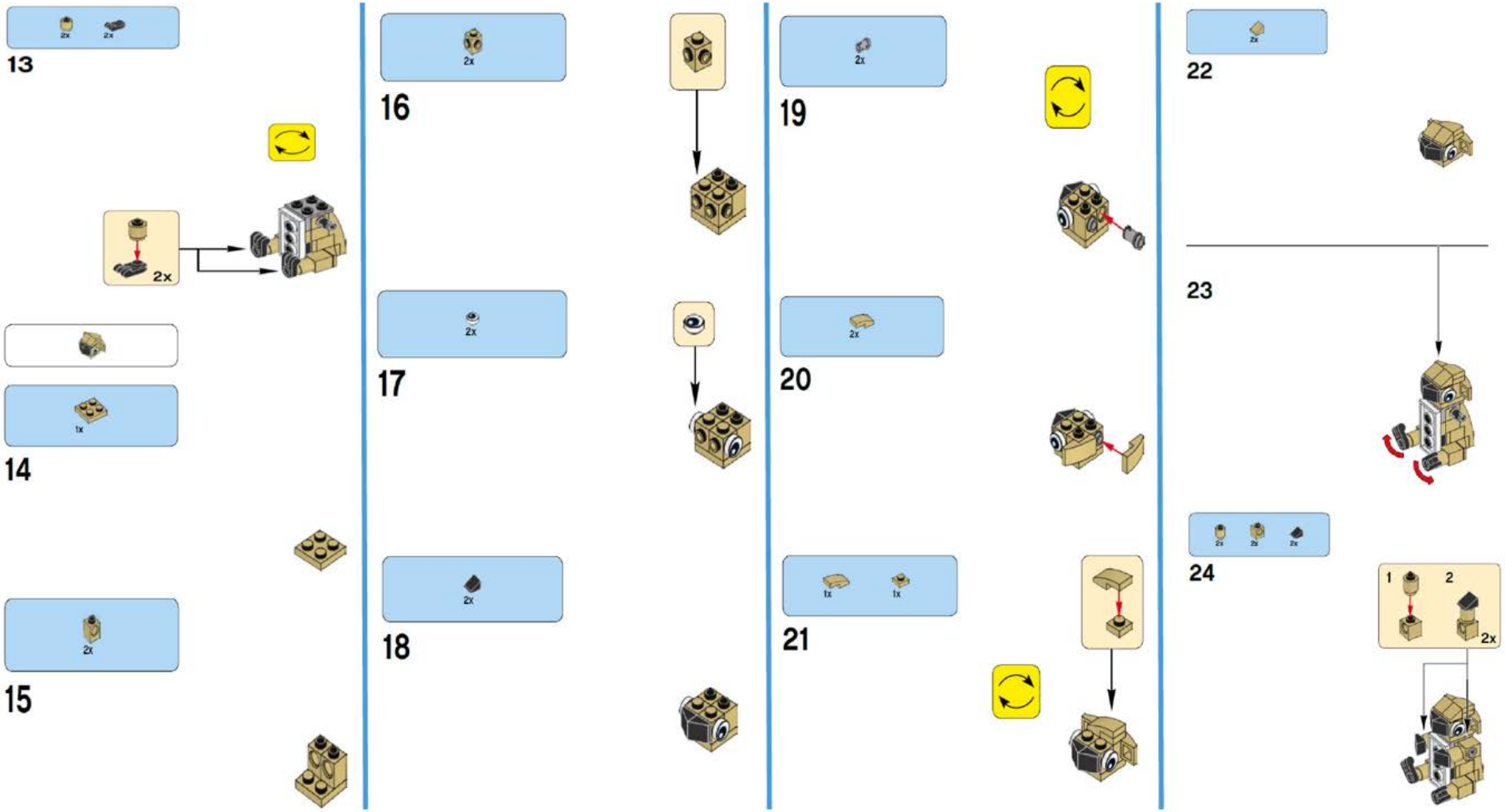
Scoring: PROMIS- 29 Profile

- Add up scores within each domain.
- High scores on symptom oriented domains (anxiety, depression, fatigue, pain interference and sleep disturbance) = worse symptomatology.
- High scores on function oriented domains (physical functioning and social role) = better functioning.

Appendix G

Manufacturer Provided Instructions for ADS Play Task (Speaker 1)

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2x
14
1x
15
2x
16
2x
17
2x
18
2x
19
2x
20
2x
21
1x
1x
22
2x
23
24
2x
2x
2x
1
2
2x

Appendix H

Additional Instructions for ADS Play Task

Instructions for Lego Task

Do not look at your partner's Lego **instructions**!

Try to talk **one at a time**- wait until your partner has finished speaking before you respond.

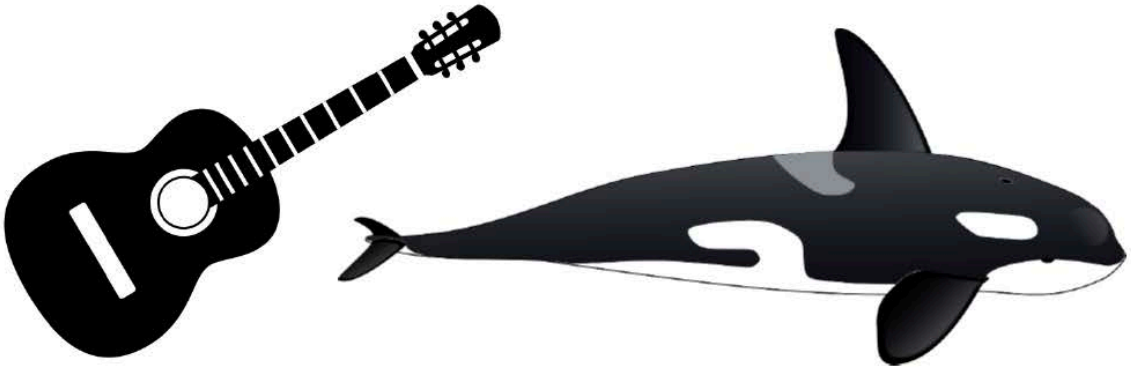
You may describe the Lego pieces however you like- feel free to use words such as colour, shape, number etc

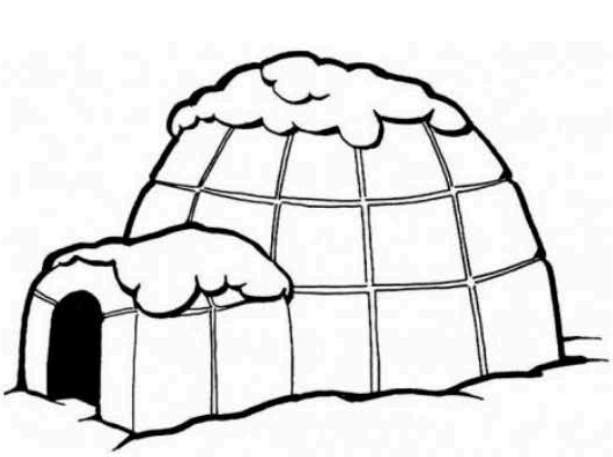
You can show your partner what you have built after each step.

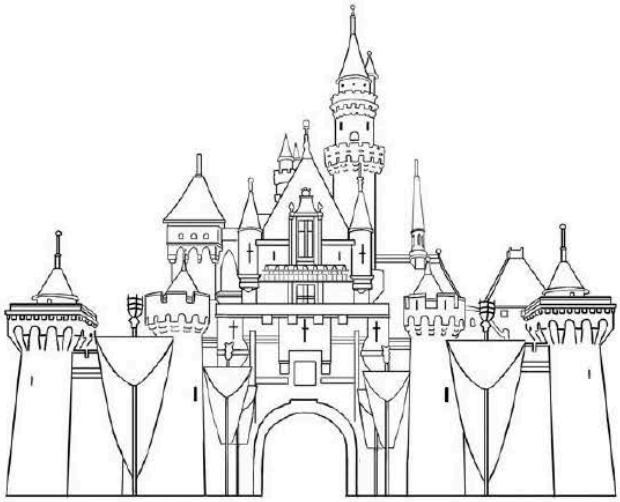
Have Fun!

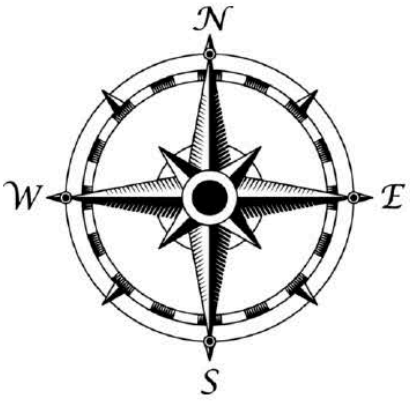
Appendix I

Picture Prompts for ADS Story Task

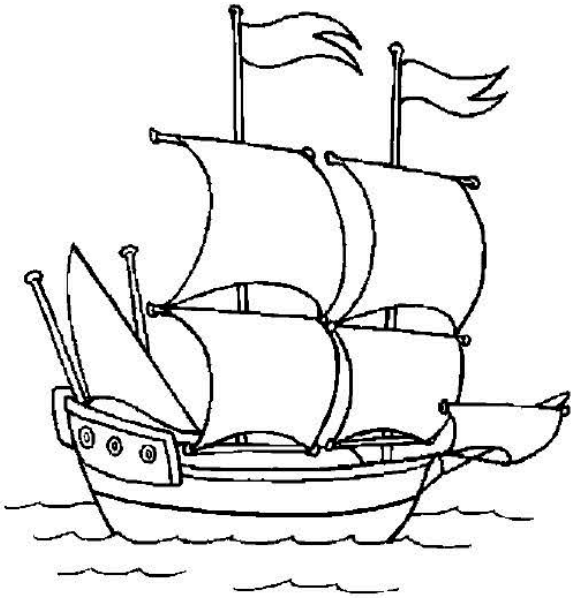


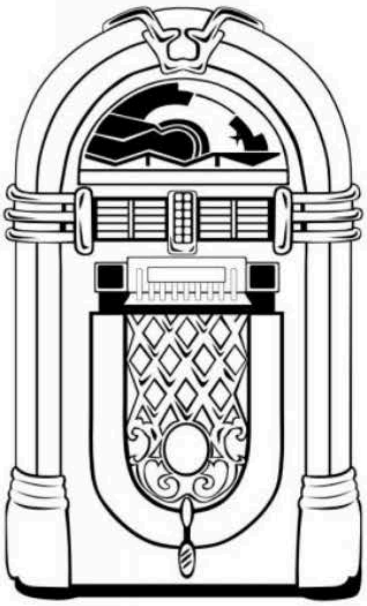


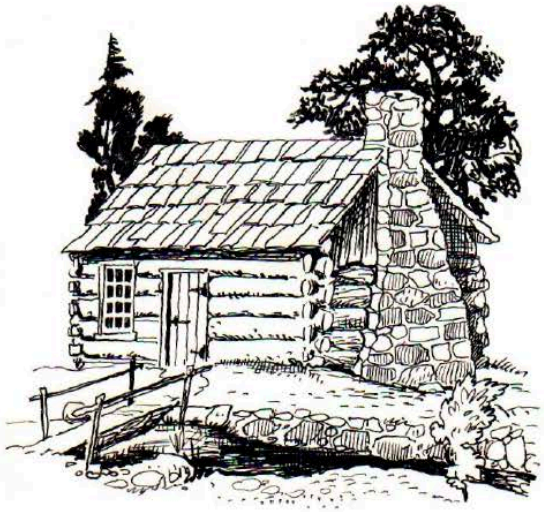


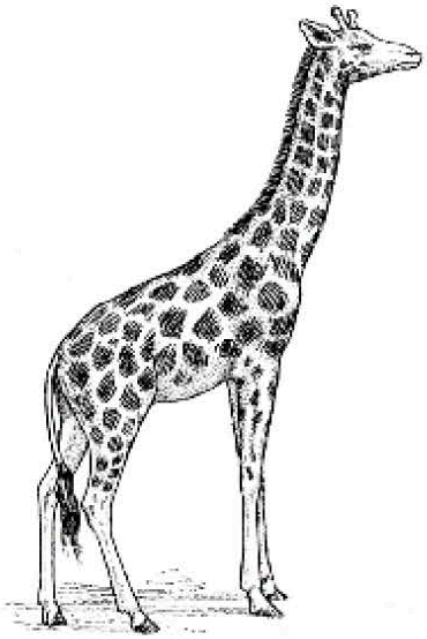


Picture Prompts for ADS Story Task









Appendix J

Task Sequences for Counterbalanced Lists

List 1 Task Sequence

	Register	*Parent*	*Task Type*
1.	IDS	Mother	Story
2.	IDS	Mother	Play
3.	IDS	Father	Story
4.	IDS	Father	Play
5.	ADS	Mother	Story
6.	ADS	Father	Story
7.	ADS	Mother	Play
8.	ADS	Father	Play

List 2 Task Sequence

	Register	*Parent*	*Task Type*
1.	IDS	Father	Play
2.	IDS	Father	Story
3.	IDS	Mother	Play
4.	IDS	Mother	Story
5.	ADS	Father	Play
6.	ADS	Mother	Play
7.	ADS	Father	Story
8.	ADS	Mother	Story

List 3 Task Sequence

	Register	*Parent*	*Task Type*
1.	IDS	Mother	Play
2.	IDS	Mother	Story
3.	IDS	Father	Play
4.	IDS	Father	Story
5.	ADS	Father	Play
6.	ADS	Mother	Play
7.	ADS	Father	Story
8.	ADS	Mother	Story

List 4 Task Sequence

	Register	*Parent*	*Task Type*
1.	IDS	Father	Story
2.	IDS	Father	Play
3.	IDS	Mother	Story
4.	IDS	Mother	Play
5.	ADS	Mother	Story
6.	ADS	Father	Story
7.	ADS	Mother	Play
8.	ADS	Father	Play

List 5 Task Sequence

	Register	*Parent*	*Task Type*
1.	ADS	Mother	Story
2.	ADS	Father	Story
3.	ADS	Mother	Play
4.	ADS	Father	Play
5.	IDS	Mother	Story
6.	IDS	Mother	Play
7.	IDS	Father	Story
8.	IDS	Father	Play

List 6 Task Sequence

	Register	*Parent*	*Task Type*
1.	ADS	Father	Play
2.	ADS	Mother	Play
3.	ADS	Father	Story
4.	ADS	Mother	Story
5.	IDS	Father	Play
6.	IDS	Father	Story
7.	IDS	Mother	Play
8.	IDS	Mother	Story

List 7 Task Sequence

	Register	*Parent*	*Task Type*
1.	ADS	Mother	Play
2.	ADS	Father	Play
3.	ADS	Mother	Story
4.	ADS	Father	Story
5.	IDS	Father	Play
6.	IDS	Father	Story
7.	IDS	Mother	Play
8.	IDS	Mother	Story

List 8 Task Sequence

	Register	*Parent*	*Task Type*
1.	ADS	Father	Story
2.	ADS	Mother	Story
3.	ADS	Father	Play
4.	ADS	Mother	Play
5.	IDS	Mother	Story
6.	IDS	Mother	Play
7.	IDS	Father	Story
8.	IDS	Father	Play

Appendix K

Supplementary Results: Mean F0 Analysis

Utterance-level Pitch Properties

The analysis of the Mean F0 (ST) was conducted on a total of 3437 utterances (1774 in IDS and 1663 in ADS). Figure 1 presents the average Mean F0 (ST) per parent gender and register. Figure 1 suggests that the Mean F0 (ST) increases in IDS compared to ADS for both fathers (ADS M = -10.522, SD = 0.542; IDS M = -5.768, SD = 0.543) and mothers (ADS M = -0.834, SD = 0.575; IDS M = 4.523, SD = 1.108).

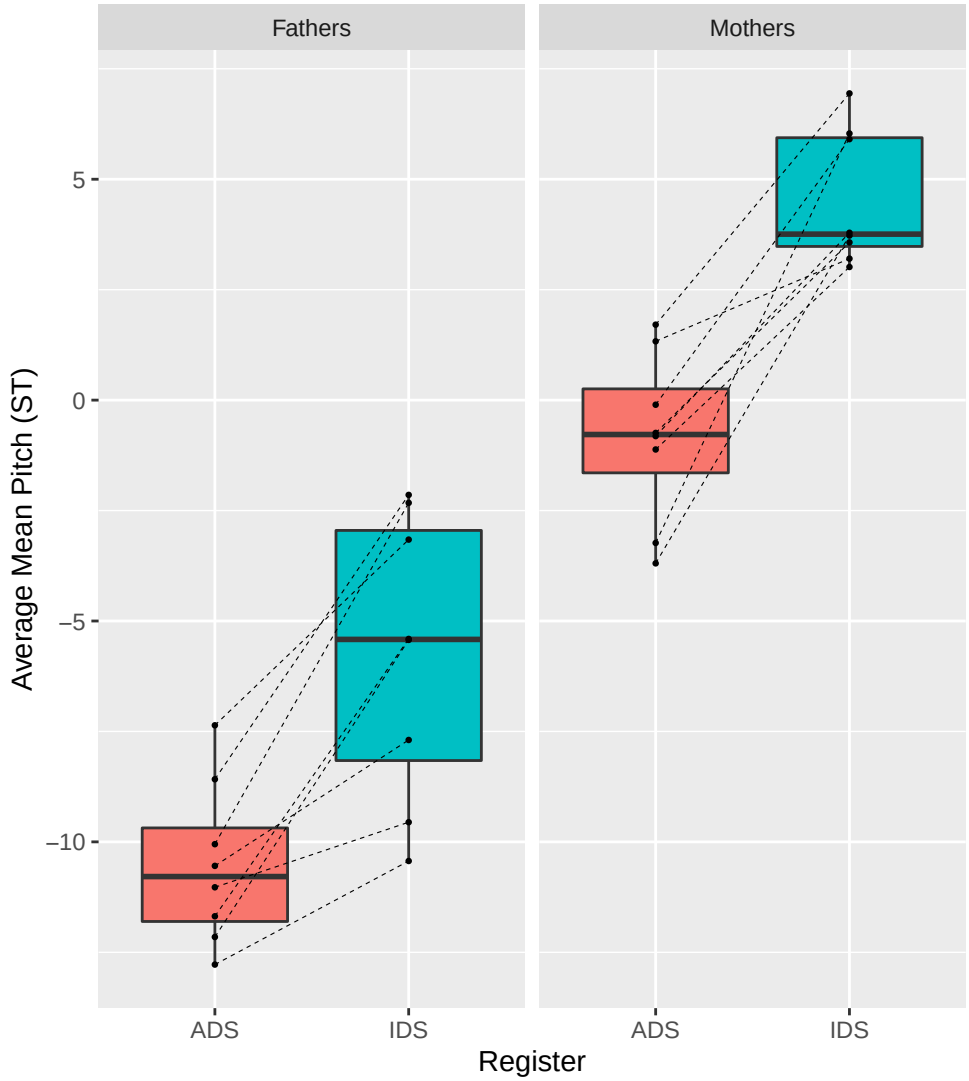


Figure 1- Average Mean Pitch (Semitone Scale) per Parent Gender and Register. Individual speakers' M F0 values are plotted as individual points and matched across registers with dotted lines

Mixed-effects Linear Regression Model:

The significant main effect of Register indicates that parents increase the Mean F0 in IDS, compared to ADS (B = 2.533, SE = 0.287, $t(13.961)$ = 8.822, $p < 0.001$). The significant main effect of Parent Gender shows that mothers use a higher Mean F0, compared to fathers (B = 4.993, SE = 0.473, $t(13.986)$ = 10.555, $p < 0.001$). This Parent Gender effect is unsurprising as female speakers typically use a higher Mean F0 than male speakers. There was no significant Register × Parent Gender interaction (B = 0.151, SE = 0.287, t(13.961) = 0.527, p = 0.607). This indicates that there is no evidence of a difference between mothers' and fathers' increase of Mean F0 in IDS.

Appendix L

Ethics Clearance Letter

Human Sciences Subcommittee
Macquarie University, North Ryde
NSW 2109, Australia

MACQUARIE University

12/11/2018

Dear Dr Benders,

Reference No: 5201833405057
Project ID: 3340
Title: The Acoustic Profile of Australian English Infant Directed Speech

Thank you for submitting the above application for ethical review. The Human Sciences Subcommittee has considered your application. Please see the panel comment.

I am pleased to advise that ethical approval has been granted for this project to be conducted by Dr Anne Benders, and other personnel: Ms Elise Tobin.

This research meets the requirements set out in the National Statement on Ethical Conduct in Human Research 2007, (updated July 2018).

Standard Conditions of Approval:

1. Continuing compliance with the requirements of the National Statement, available from the following website: https://nhmrc.gov.au/about-us/publications/national-statement-ethical-conduct-human-research-2007-updated-2018.

2. This approval is valid for five (5) years, subject to the submission of annual reports. Please submit your reports on the anniversary of the approval for this protocol. You will be sent an automatic reminder email one week from the due date to remind you of your reporting responsibilities.

3. All adverse events, including unforeseen events, which might affect the continued ethical acceptability of the project, must be reported to the subcommittee within 72 hours.

4. All proposed changes to the project and associated documents must be submitted to the subcommittee for review and approval before implementation. Changes can be made via the Human Research Ethics Management System.

The HREC Terms of Reference and Standard Operating Procedures are available from the Research Services website: https://www.mq.edu.au/research/ethics-integrity-and-policies/ethics/human-ethics.

It is the responsibility of the Chief Investigator to retain a copy of all documentation related to this project and to forward a copy of this approval letter to all personnel listed on the project.

Should you have any queries regarding your project, please contact the Faculty Ethics Officer.

The Human Sciences Subcommittee wishes you every success in your research.

Yours sincerely,

Dr Naomi Sweller

Chair, Human Sciences Subcommittee

The Faculty Ethics Subcommittees at Macquarie University operate in accordance with the National Statement on Ethical Conduct in Human Research 2007, (updated July 2018), [Section 5.2.22].