INTONATION DEVELOPMENT OF A TAIWANESE CHILD IN HER FIRST YEAR

Pei-Yu Hsieh & Jane Tsay

Institute of Linguistics, National Chung Cheng University, Taiwan
Peggy2001@gmail.com; Lngtsay@ccu.edu.tw

ABSTRACT

This paper investigates the intonation development of an infant during the first year. Three stages include the goo stage (2-3 months), the canonical babbling stage (7-9 months), and the variegated babbling stage (10-12 months). Falling contour was found to be the most common intonation at the goo stage. Rising contour was found to be the dominant intonation both at the canonical babbling and the variegated babbling stage. The mean *f0* at the goo stage is 400 Hz, 390 Hz at the canonical babbling stage, and 360 Hz at the variegated babbling stage. It is because the lengthening of the vocal folds as infants grow up.

Keywords: infant vocalization, intonation, Taiwanese

1. INTRODUCTION

This paper studies the development of intonation of a Taiwanese infant at the prelinguistic stage. The phonation of intonation is about the vibration of vocal folds, tension, and cross-sectional mass. [23]. Intonations are classified as basic contour and complex contour [23]. Basic contour include Level, Rise, and Fall. Complex contour are the combination of basic contours. It has been reported that Infants at the prelinguistic stage are able to manipulate the prosody of the vocalizations by altering the pitch of voice during vocalizations [5].

Studies have shown that before the babbling stage, the intonation made by infants is physiologically-based [10]. Fall [19] and Rise-fall [11, 12] was found to be common. From physiology, Fall is likely to occur, when the vocal folds are not in an adducted state as larynx muscles are more relaxed [16, 17]. Fall takes the least effort to produce, and Fall is the easiest to make [16, 18]. Fall also occurs at the end of normal breath group because of the decline of subglottal air pressure [14]. So, Fall is predicted to be most dominant intonation at the goo stage.

Whether the intonation made at the babbling stage is influenced by the infant-directed speech [20] or by an ambient language [9, 13, 22] has been controversial. The prosodic features of infant-directed speech include rising contour at the end of an utterance, greater *f0* range, and higher *f0* [15, 20]. Therefore, the most common intonation at the canonical babbling stage and the variegated babbling stage is Rise.

On the other hand, it has been reported that the sound pattern of the native language has effects on intonation made from the babbling stage to the early word stage [9, 13, 22]. Final-lengthening effect has been reported to be more apparent in French than in English, and it was found to be true in infant vocalization at the babbling stage [9, 13]. [22] studied Mandarin infants, and found Fall was the most common as in adult data. In Taiwanese Fall has been reported to be the most frequent tone [21]. If the intonation of infant vocalization is influenced by the ambient language, then Fall is expected to be the most common.

What is interesting about this study is that, unlike the previous studies, the mother tongue of the infant under investigation is a tone language, a variety of Southern Min spoken in Taiwan. Taiwanese is a language with seven lexical tones —three level tones, rising tone, falling tone, and two short tones [8]. It would be interesting to see the intonation development at these critical periods of the first year.

2. METHODOLOGY

2.1. The child

XJ is a girl growing up in a Taiwanese speaking family. Her caretakers, including the parents and the nanny, are Taiwanese speakers, and speak Taiwanese to the infant.

2.2. Data collection

The recording devices consist of an OLYMPUS linear PCM recorder, and one high-quality microphone.

The recordings were made from the infant was 6-week old. The recording interval was once a

week. Audio recordings were obtained when the infant was in a comfort state, talking to her dolls or caretakers. During the recordings, the caretakers try to elicit the infant's production by asking her questions, e.g. "What else do you want to say?" The recording time ranged from seven minutes to sixty-six minutes. The total recording duration of goo, canonical babbling, and variegated babbling stages are shown in Table 1.

Table 1: Recording duration for three stages.

	Age	Durations
Goo stage	1-3 months	186 mins
Canonical babbling stage	7-9 months	202 mins
Variegated babbling stage	10-11 months	131 mins

2.3. Identification of intonational units

The software used for acoustic measurement was Praat [4]. Few steps were taken to edit the recording. First, a pause, which is longer than 100 milliseconds between vocalizations, was taken to segment continuous sounds [6]. Secondly, unnecessary data was excluded, for example, noise from the external environment, vocalizations overlapping with other speakers, and silence. After that, vegetative and reflexive sounds such as breathing noise, coughing, or hiccoughs were excluded [12]. Narrow-band (45 Hz) spectrograms were employed for the determination of *f0*. Following [12], two criteria were used to identify the *f0* contour of vocalizations. The first one was that a vocalization must have clear F1-F2 pattern; the second one was that it must be longer than 100 millisecond (ms), but shorter than 2 second. Under these criteria, 504 vocalizations were recognized for the goo stage, 379 tokens for the canonical babbling stage, and 388 for the variegated babbling stage.

2.4. Intonation analysis

The method used for intonational analysis is based on [2, 3]. Three parameters are taken to judge intonation types. The parameters include *f0* directionality, pitch change (accent range), and complexity. The first one is the *f0* directionality, which refers to the direction of the prominent contour. When the maximum *f0* value precedes the minimum *f0*, it is regarded as a fall. If the minimum *f0* value is before the maximum *f0*, then it is a rise. The second parameter is pitch change. Pitch change is the range between the maximum *f0* value and the minimum *f0* value of a dominant part of intonation. Then, pitch change is transferred into logarithmic value via the algorithm-- *[12/log(2)] *[log (max f0/min f0)]* [2]. If the *f0* values expressed in semitone is less then one, the intonation is regarded as a level. If the *f0* value in semitone is bigger than one, it is either a fall or a rise based on *f0* directionality. The last parameter is complexity. It refers to the second directional change of intonation, and the degree of the *f0* change in semitone of the smaller portion of intonation must be larger than one. It is due to the fact that one semitone is considered to be "just noticeable difference" by perception [7].

3. RESULTS & DISCUSSION

Table 2 displays the intonation and the occurring frequency in percentage made at three stages.

Table 2: Intonation made at three stages.

stages	Level	Fall	Rise	Rise-fall	Total
Goo stage	11%	41%	21%	27%	100%
Canonical babbling stage	31%	21%	39%	9%	100%
Variegated babbling stage	29%	20%	43%	7%	100%

Some observation can be made from the table above. The basic contours were found at three stages, including Level, Rise, and Fall. Complex contours were not common. Rise-fall was the only complex contour produced at these three stages. Basic contours held a larger majority of intonation. They took up to about 90 percent, as expected from physiology [23]. Complex contours are more difficult to make comparing with basic contours.

As far as the occurring frequency at the goo stage is concerned, Fall was the most common intonation, and Level was the least common. Rise-fall was the second high in terms of the frequency. It is consistent with our hypothesis and prediction. The intonation made at the goo stage is physiologically-driven [18]. Fall is predicted to be the predominant intonation. Fall is produced when the vocal folds are slightly opened, and the larynx muscles are in a more relaxing status [16, 17]. Making Fall takes the least efforts, comparing with other intonation [16, 18]. In terms of Rise-fall with the second high frequency, it is also physiologically-based. It is because of the subglottal air pressure change during a respiratory cycle. This phenomenon is found to be common during the first year [14], because the cycle of

inspiration and expiration of newborns is intensive. Rise is with the third high frequency. The mechanism to produce Rise is more complex. While Rise is made, muscles of the larynx have to be tense in order to make the vocal fold closely adduct. When the air passes the adducted vocal folds, the pitch is increased [16]. Level (11%) was found to be rare at the goo stage. Level is produced, while the muscles of larynx are in a tense state, and a breath needs to be held for a while [16]. It is difficult for newborns to make.

As far as the canonical babbling stage and the variegated babbling stage are concerned, the most dominant intonation is Rise. The second most frequently occurring intonation is Level, and Rise-fall is the least common intonation. It can be explained by the influenced from the infant-directed speech [20]. When adults talk to infants, they are more likely to employ a raising contour at the end of an utterance rather than the falling pitch in order to attract the infant's attention [1]. The raising contour is used by adults to infants when making a calm statement, making a request, making a intonation of happiness, not to mention intonation of question [20]. The raising contour at the end of an utterance is communicative-oriented, not linguistic-meaningful [1]. It is a feature of infant-directed speech. Infant intonation also demonstrates this characteristic. Therefore, Rise was found to be the most common contour at the babbling stage. Rise-fall was found to occur rarely at this stage, because the respiratory cycle at the babbling stage is not as intensive as occurring at the goo stage. Fall is with the third high frequency. It has been reported in [21] that the most frequent tone in Taiwanese is falling tone, the second high is level. Based on our reports of two babbling stages, Rise was the most common one. In other words, the effect of the sound pattern of Taiwanese is not apparent at the babbling stages.

The mean *f0* at the goo stage is 400 Hz, ranging from 350 Hz to 450 Hz. The mean *f0* at the canonical babbling stage is 394 Hz, ranging from 360 Hz to 443 Hz. The mean *f0* at the variegated babbling stage is 358 Hz, ranging from 330 Hz to 408 Hz. Tables 3-5 show the mean *f0* of basic contours at three stages.

Table 3 shows the mean *f0* of Level at the goo stage is 448 Hz, 421 Hz, and 413 Hz. That at the canonical babbling stage is 392 Hz, 387 Hz, and 394 Hz. That for the variegated babbling stage is 364 H, 364 Hz, and 372 Hz. The mean *f0* at the goo is the highest, and that at the variegated babbling stage is the lowest. It is physiologically-driven. It is because of the lengthening of the vocal folds as infants grow up [23].

Table 3: Mean *f0* of Level at three stages.

In Hz	onset	midpoint	offset
Goo stage	448	421	413
Canonical babbling stage	392	387	394
Variegated babbling stage	364	364	372

Table 4: Mean *f0* of Fall at three stages.

In Hz	onset	midpoint	offset
Goo stage	453	395	351
Canonical babbling stage	402	376	360
Variegated babbling stage	347	330	308

Table 5: Mean *f0* of Rise at three stages.

In Hz	onset	midpoint	offset
Goo stage	362	392	424
Canonical babbling stage	381	412	443
Variegated babbling stage	354	378	408

The mean *f0* of Fall at three stages is similar to that of Level. The *f0* of onset of Fall at the goo stage is around 453 Hz, and decreases along the f0 contour. For the canonical babbling stage, the *f0* onset is around 402 Hz, midpoint 376 Hz, and offset 360 Hz.

As far as Rise is concerned, the *f0* onset at the goo stage is around 362 Hz, midpoint 392 Hz, and offset 424 Hz. The mean *f0* at the canonical babbling stage is 381 Hz at the onset, 412 Hz at the midpoint, and 443 at the offset. The mean *f0* at the variegated babbling stage is 354 Hz at the onset, and increases to 408 Hz at the offset. It has been reported that the mean *f0* should be lower as infants grow up [23]. Yet, it is not the case for Rise at the canonical babbling stage. The mean *f0* at the goo stage is lower than that at the canonical babbling stage. It results from the influence from the raising *f0* feature of infant-directed speech [20]. The whole *f0* contour of Rise at the canonical babbling stage is raised, so it is even higher than that at the goo stage. As far as the variegated babbling stage, the mean *f0* is lower due to physiology [23]. The influence from infant-directed speech is not that strong as that at the canonical babbling stage. The effect is on the later portion of the f0 contour rather than the whole, resulting in the increase in number of Rise.

4. CONCLUSION

We predicted the most common intonation at the goo stage was Fall, and the second high was Rise-fall. After the babbling stage, previous studies show infant intonation is influenced either by the infant-directed speech or the sound pattern of a native language. Fall is predicted to be the most common intonation if the effect is from the native language. Rise is predicted to be the most dominant if the effect is from infant-directed speech. Our results show that at the goo stage, Infant intonation pattern is constrained by physiology. At the babbling stages, intonation pattern is influenced by the infant-directed speech. At the goo stage, Fall was the most common intonation due to the easy mechanism of making Fall [14, 15], Rise-fall was the second high because of the intensive respiratory cycle [21], and Level was rare. At the canonical babbling and the variegated babbling stages, Rise was both found to occur most frequently because of the imitation of infant-directed speech [20], and Rise-fall was the least common intonation.

It would be very interesting as this longitudinal study goes on to see how intonation at the prelinguistic stage develops into tone as infants entering verbal stage, and when ambient language comes to play a role.

5. REFERENCES

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