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Analysis of Kannada speaker's tongue profile for articulatory simulation

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Abstract

Improper articulation of the tongue would result in incorrect pronunciation of speech sounds. Articulatory correction involves correcting the positioning and movement of the tongue for each of the misarticulated sounds. The present study attempts to profile the movement of the tongue during the production of selected set of speech sounds uttered by native Kannada speakers, who don't have any speech, language or hearing disorder. Phonemes for the study were selected based on the place and manner of articulation. Ultrasound imaging technique is used to track the tongue contour from the tip to the root of the tongue. The obtained tongue image of each speech sound was segmented into five regions. The shape and movement profile of the segmented tongue were analyzed in terms of the initial position, target position and slope as well as angle of deviation at the root of the tongue, for each segment. Analysis of the segmented profiles showed that the retroflex sounds have relatively maximum angular deviation from the tip of the tongue in rest position. Palatal sounds have maximum deviation from the tongue rest position in terms of coordinates. Documentation of profile in the Cartesian plane paves the way for better understanding of tongue dynamics in speech production. The present study resulted in profiling the contour of tongue based on the angle of deviation and slope of the tongue segments for dental, retroflex, velar and palatal sounds. This would further help in developing robotic tongue movement for articulatory simulation, which can be used as an effective tool for articulatory training of children with articulation disorders.

Keywords: Articulatory simulation, place and manner of articulation, segmentation, angle of deviation, tongue profiling.

1. Introduction

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Articulation is the process of producing speech sounds by the movement of articulators such as tongue, lips, jaw and other speech organs. When a person has articulation disorder, his/her speech may not be intelligible to the listener, which may lead to the poor quality of life of the person with disorder. Incorrect positioning of the tongue is one of the major reasons for articulation disorder, which may result in errors such as substitution, omission and distortion of sounds. Thus, correcting tongue position and movement is essential for treatment planning and posttreatment stability.

Speech-language pathologists (SLPs) correct articulation disorders through several sessions of speech therapy, by using several techniques such as manual demonstration of producing sounds, modelling of the sounds etc. But for effective articulatory correction, demonstration of the precise articulation is important. In the conventional method of articulatory correction, though the speech therapist demonstrates place and manner of articulation, tongue of the therapist is not visible during the production of back phonemes. A dynamic and complete view of production of each sound with three dimensional representation can help children with articulatory disorders to understand the entirety of the speech act (Rathinavelu et al., 2007). This will facilitate in learning the production of speech sounds in a quicker and effortless manner.

Development of technology in health sciences has opened the way for effective services for persons with articulatory disorders (Stokes et al., 2001). To help them attain proper articulation, a robotic model which depicts the tongue movements in real time is planned in the present study. This will facilitate the teaching learning process for effective articulation. The places of articulation include bilabial, dental, alveolar, retroflex, palatal, velar, uvalar, pharyngeal and glottal. It is expected that the robotic model would simulate the tongue movements and facilitate better understanding of the tongue placement during production of these phonemes by children with misarticulation. However, for this purpose, the anatomic aspect of the tongue and the corresponding movements have to be profiled.

Some researchers have made attempts in this area. Vagmi Software, (Voice and Speech Systems, n.d.) displays shapes of tongue and lip for pronunciation of selected phonemes. The persons with the articulation disorder have to see the articulatory movements on the computer screen (2 D images) and try to imitate the same. An audio output is also provided for each sound which can be played as many numbers of times as required. To win the child's attention and wanting the child to participate in the session is a challenge faced while using this software. Stone & Lundberg (1996) reconstructed tongue surfaces in three dimensions from different coronal cross sectional slices of tongue. They classified tongue shapes into four categories and showed that the front raising is for alveolar and palatal sounds, groove shaped movement occurs for alveolar and dental sounds, back raising of the tongue is found in velar and two point displacement occurs for lateral sounds.

Through the analysis of 450 vocalic and consonantal sequences from Canadian and American English, Iskarous (2005) showed that there exists a pivot pattern for tongue movements. The pattern obtained by the edge tracing of tongue from ultrasound motion pictures looked like a rotational movement, where one point of tongue body remains fixed, and the other points rigidly rotate around it. They have traced the pattern for [k-a], [ih-t], [u-e], [o-ae] and [a-i]. The authors pointed out that the deformation of the tongue during a transition depends on the starting and ending configurations.

Results of the comparative study of coronal consonants in Arrernte and Kannada (Tabain et al., 2016), showed that when a Kannada speaker produces dental stop, the tongue becomes more flatter compared to the tongue profile for alveolar, nasal and lateral sounds. The study found that the flatter tongue profile seen in Kannada speakers for dental stop is consistent compared to Arrernte speakers while producing stop, nasal and lateral sounds. The study showed that the tongue profile varies across languages.

Shape of the tongue while producing /ʧ/, dental /t̪a/, retroflex /ʈa/and velar /ka/ was investigated by Kochetev et al. (2012) on the basis of ultrasound images. Data from four normal participants (2 females and 2 males) revealed that for phoneme /ʧ/, anterior tongue body showed a significant raising whereas fronting of the tongue was moderate compared to the shape for dental /t̪a/. The authors observed that for /ʧ/ and /t̪a/sounds, the tongue blade was either at the alveolar ridge or very close to it. For /ʧ/ sound, the constriction occurred with greater angle whereas for /t̪a/, the constriction was either at the front part or at the tip of the blade. They showed that the shape and movement of the tongue plays a major role in precise production of the sound.

A systematic and in-depth review of the above studies highlight the influence of tongue profiling of different phonemes in speech articulation. However, specifically for speech sounds in Kannada, only a few studies have been conducted in this direction. The study conducted by Kochetov et al. (2012) has considered only four sounds such as /ʧ/, dental /t̪a/, retroflex /ʈa/, and velar /kɑ/. Moreover their study concentrated on tracing the edge of the tongue blade. Information regarding angles, initial and final positions etc., are missing. The profiling of the tongue based on the angle of deviation and coordinates have not been explored by any of the previous studies. Wei et al. (2012) measured tongue deviation angle from the still photographs of tongue. They attempted to predict the occurrence of stroke by estimating the deviation angle.

Ultrasound has been widely used in speech research and therapy, partly due to its relative non-invasiveness and low equipment cost compared to electromagnetic articulograph (EMA), electropalatograph (EPG), and functional magnetic resonance imaging (Bernhardt et al., 2005). Kansy et al. (2018) found ultrasound as a valid alternative to Magnetic Resonance Imaging to visualize and quantify the movement of the tongue during articulation. Also acquisition of the information regarding shape of the tongue is comparatively easy as there is no need for head to transducer stabilization (Zharkova, 2013). Midsagittal plane is the most meaningful and significant plane for ultrasound imaging. The image obtained would be intuitive and can be compared between different speakers (Bressmann, 2008). The shape of the tongue including root obtained in midsagittal plane is profiled in the present study. With a set of collected ultrasound imaging data, segmentation and profiling of images of the tongue were performed using angle of deviation and co-ordinates obtained during speech production. It is expected that, this work will aid in the

development of an artificial tongue which would further help in the implementation of robotic systems for articulation training which are essential for effective and faster rehabilitation.
Thus the present study attempts to obtain the tongue profile for selected speech sounds expressed in terms of angle of deviation and co-ordinates of five segments of the tongue for native Kannada speakers through ultrasound imaging.

The objectives of the present study are

- *1.1* To obtain the profile of the tongue in rest position and the target position for each of the selected speech sounds.
- *1.2* To segment the tongue into five regions and obtain the endpoints for each segment.
- *1.3* To represent the end points of each segment through [x, y] coordinates and angle of deviation with respect to a fixed reference point.
- *1.4* To obtain the deviation of tongue profile in terms of coordinates and angle with reference to its initial position.
- *1.5* To find the sounds having maximum and minimum deviation from the initial position of the tongue for each of the segments.

2. Methodology

2.1 Participants

A total of 10 Kannada speakers were included in the study. The group comprised of equal number of male and female adults in the age range of 23-27 years. Only those adults with no history of sensory, neurological, communicative, academic, cognitive, intellectual or emotional and oro facial abnormalities were included. The mean age of the participants was 25.70 years. Ethical protocol of All India Institute of Speech and Hearing was followed. The purpose and procedures of the study were explained to the participants and an informed verbal and/or written consent was obtained.

2.2 Stimuli

Images of tongue movement corresponding to twelve different speech sounds uttered by the participants were recorded using Ultrasound diagnostic imaging system DP6600. Eleven lingual sounds combined with vowel /ɑ/ as depicted in Table 1 were selected for the study. All the sounds were chosen based on place and manner of articulation (Wayland, 2019).

Table 1
Syllables selected based on place and manner of articulation

Manner of Articulation	Dental		Retroflex		Alveolar		Palatal		Velar	
	V	UV	V	UV	V	UV	V	UV	V	UV
Stop Consonants	/d̪ɑ/	/t̪ɑ/	/ɖɑ/	/ʈɑ/					/gɑ/	/kɑ/
Affricates								/ʧ/		
Laterals			/ɭɑ/		/lɑ/					
Glides							/jɑ/ /rɑ/			

Note-V: Voiced sounds, UV: unvoiced sounds, */ɑ/ is used for representing vowels*

2.3 Procedure

The approach used to segment and quantify tongue contour is as follows. A set of Ultrasound images were collected using Mindray DP6600 digital Ultrasonic diagnostic imaging system. The participant was informed to sit straight with the diagnostic ultrasound probe (Ultrasonic transducer with an imaging frequency of 10MHZ) tightly placed below the chin (Figure 1). Then he/ she was instructed to utter each of the twelve sounds three times, one after the other with pauses of 2 seconds in between. Images of the tongue, which appeared on the screen, were recorded with a frame rate of 60 fps. The images obtained were processed using the software, Articulate Assistant Advanced Version 2.14 (Articulate Instruments Ltd., 2012). The midsagittal image obtained for the tongue in rest position is given in Figure 2. Bright white line represents the tongue contour. Left side of Figure 2 represents front of the oral cavity (tongue tip) and right side represents backside of the oral cavity (root).

Figure 1. Participant with ultrasound probe

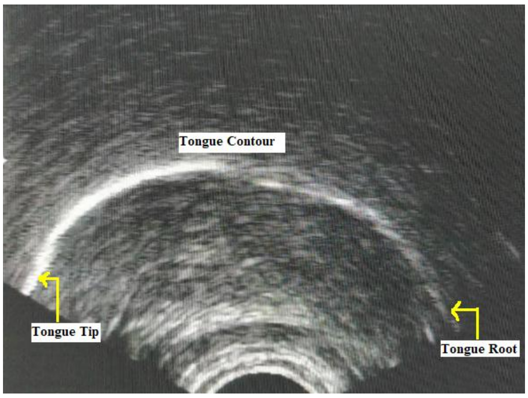

Figure 2. Ultrasound Image taken for the tongue in rest position

The tongue contour was highlighted and segmented into five [A-B], [B-C], [C-D], [D-E], [E-F] as shown in Figure 3. Yellow line highlights tongue contour with A B C D E F segmented points (6 points). Segmentation was performed using Digimizer software version 4.3 (Digimizer, n.d.) For each of the segments, corresponding [x, y] coordinates and angle of deviation were found with respect to the reference point (0,0) as the tip of the tongue. Tangents for all the segments and a vertical reference line through the tip of the tongue were made. The angle of deviation was calculated from vertical reference line to the marked tangent. The reference line and tangent were made manually whereas angle was found by means of the digimizer software. Slope is calculated by taking the ratio of difference of x coordinates and y coordinates of the end points of each segment. Graphs representing the mean slope and angle of deviation were plotted for all the twelve sounds with reference to the tongue in rest position.

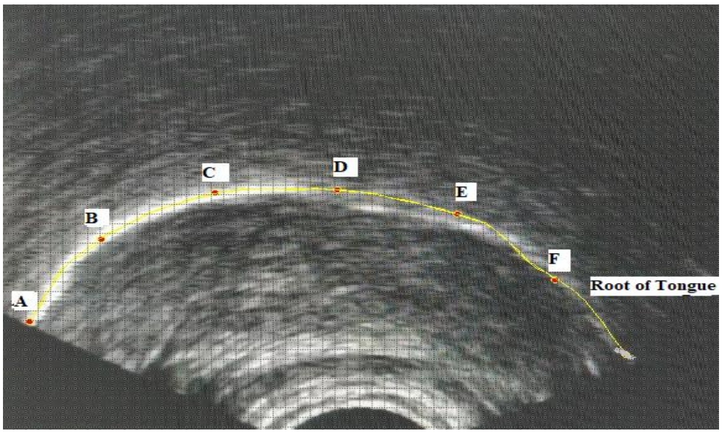

Figure 3. Segmented Ultrasound Image for the tongue rest position

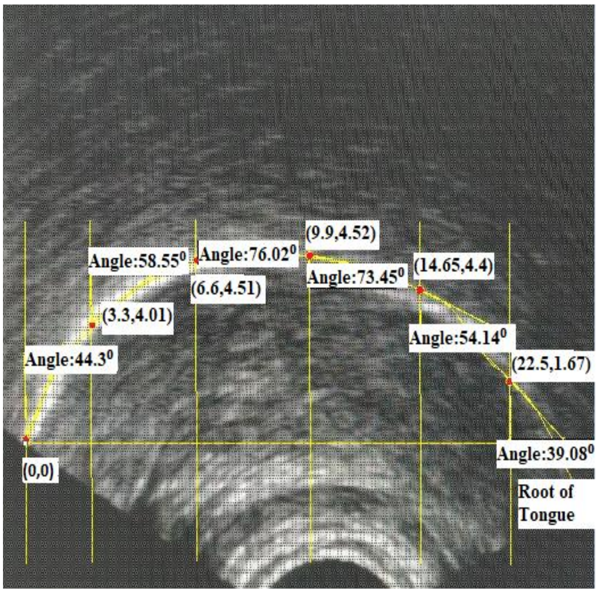

Figure 4. Angle of Deviation and cordinates marked for tongue in rest position

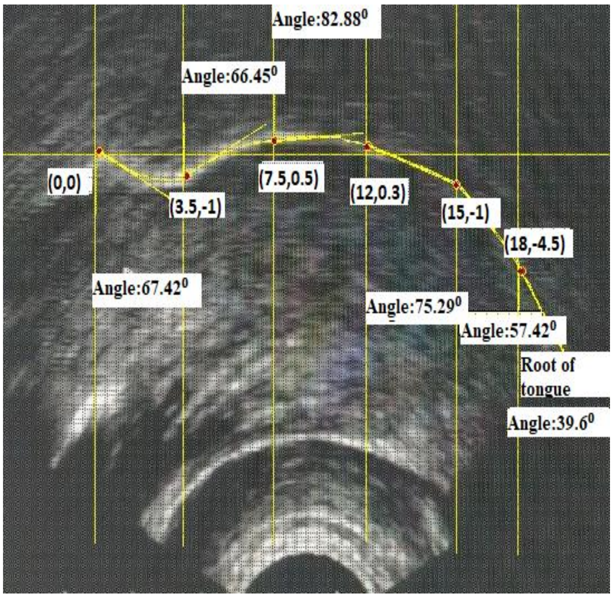

Figure 5. Angle of deviation and coordinates marked for /tɑ /

Angle of deviation and coordinates were marked for the tongue rest position (Figure 4) and for each sounds. Figure 5 represents the angle of deviation and coordinates marked for the speech sound /t̪a/. Negative sign for the coordinates indicate that the x coordinate is towards the left with respect to the zero reference line and y coordinate is down from the zero reference line.

3. Results and Discussion

3.1 Mean slope for the tongue

The mean slope of the coordinates [x,y] for the tongue in rest position at each point was calculated and is tabulated in Table 2. Slope values in the rest position of the tongue is taken as the reference for depicting the change in slope of each segment during production of target sounds. The slope at F is negative as F represents the root of the tongue and has a negative slope at rest position as evident in Figure 3.

Table 2
Mean slope values obtained for tongue in rest position.

	A	B	C	D	E	F
Slope	0.82	1.46	2.18	3.32	17.47	-7.94

Table 3
The deviation for maximum and minimum slope at each point from the tongue rest position.

A		B		C		D		E		F	
Max	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**
/d̪a̯/ 19.18	/ka/ 0.11	/la/ 21.54	/ka/ 0.01	/ḷa/ 27.32	/ka/ 0.02	/ʧ/ 52.18	/ka/ 1.18	/ka/ 16.53	/ja/ 3.47	/ka/ 6.49	/ɑ/ 3.51

The maximum and minimum mean slope of the coordinates [x, y] at each point during the production of target sounds were calculated and has been tabulated in Table 3. For points B and C maximum slope is observed for /la/ and minimum slope for /ka/. /ka/ has minimum slope in points A and D, maximum slope in points E and F. /d̪a̯/ shows maximum slope for point A and /ʧ/ for point D. For points E and F, /ja/ and /ɑ/ phonemes show minimum slope respectively.

Figure 6 was obtained by plotting the mean slope of all coordinates for the tongue in rest position and the target positions. Each point for each sound (in each line) represents dental, alveolar, retroflex, palatal and velar zones respectively. Dotted line represents the slope plot in rest position and solid line represents the target contour of tongue during the production of different speech sounds.

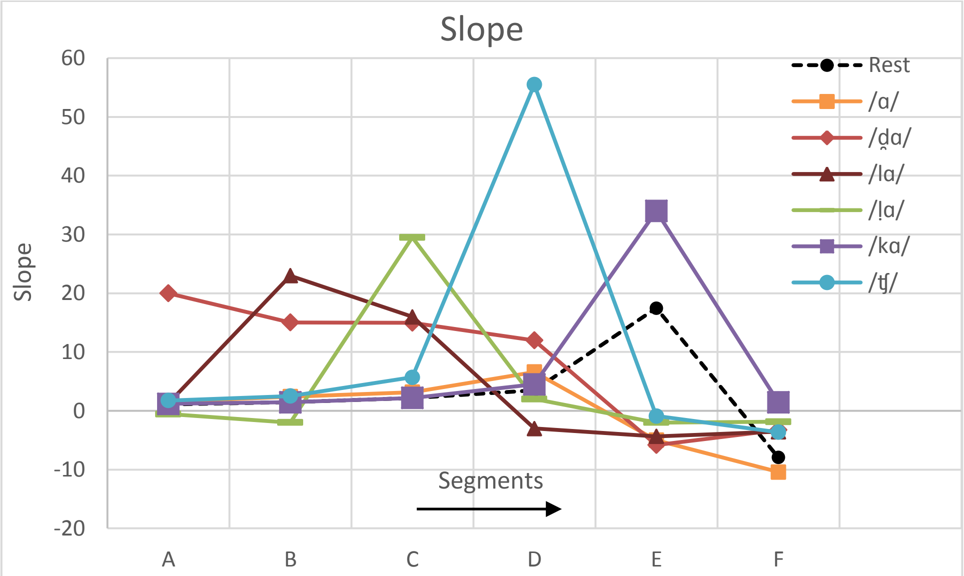

Figure 6. Mean slope plot for selected phonemes along with tongue in rest position

Point A in Figures 6 and 7 depicts the dental zone where the tip of the tongue acts. From both the plots it is evident that, compared to all phonemes /d̪ɑ/ has maximum mean slope value at the point A. /d̪ɑ/ is a dental sound for which the tongue tip is raised to touch the back of the upper front teeth to obstruct the airflow. Zhao (2010) reported that, for dental sounds the tongue touches behind the back of the upper teeth. The speech sound/t̪ɑ/ also belongs to dental place of articulation and has values nearing the /d̪ɑ/ value, though slightly lesser. Figure 7 depicts the plot of mean slope obtained from coordinates [x, y] for dental sounds /t̪ɑ/ and /d̪ɑ/.

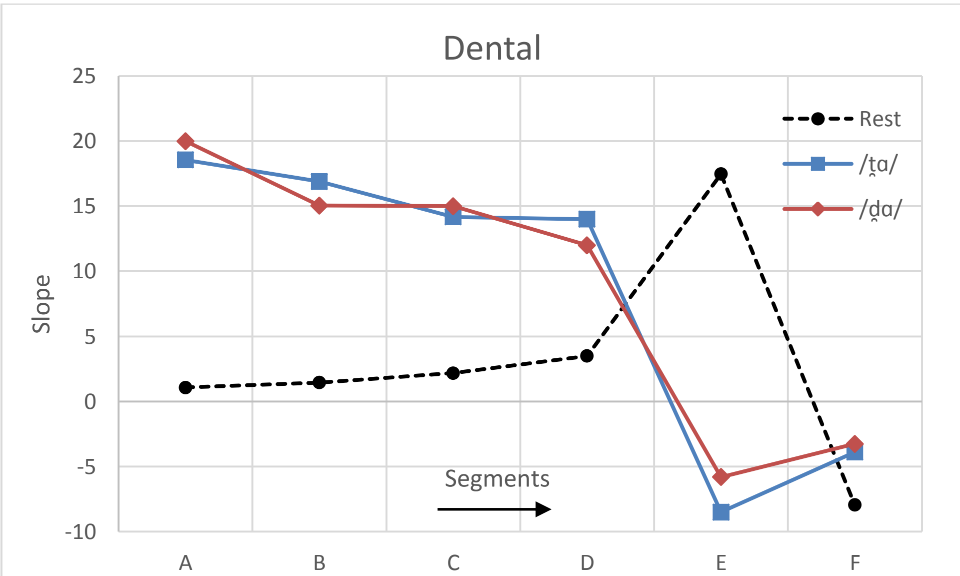

Figure 7. Mean slope plot for dental sounds such as /t̪ɑ/ and /d̪ɑ/

Point B in Figure 6 depicts the alveolar zone of articulation, where the phoneme /lɑ/ has maximum mean slope value compared to all the other phonemes. According to Edwards (1999), the tongue tip and part of blade comes in contact with the upper ridge behind the front teeth during the production of alveolar sound /lɑ/. Point C in Figure 7 depicts the retroflex zone of articulation. According to Hamann and Fuchs (2010), the retroflex sounds are produced with raised and retracted tongue tip. The retroflex sounds have maximum value for slope in the plot at the point C, in comparison to all other categories of phonemes. Amongst the retroflex sounds, the sound /ḷɑ/ has maximum slope at point C, though the phonemes /ṭɑ/, /ḍɑ/ have near similar values to that of /ḷɑ/ as depicted in Figure 8, as all these three phonemes comes under retroflex place of articulation.

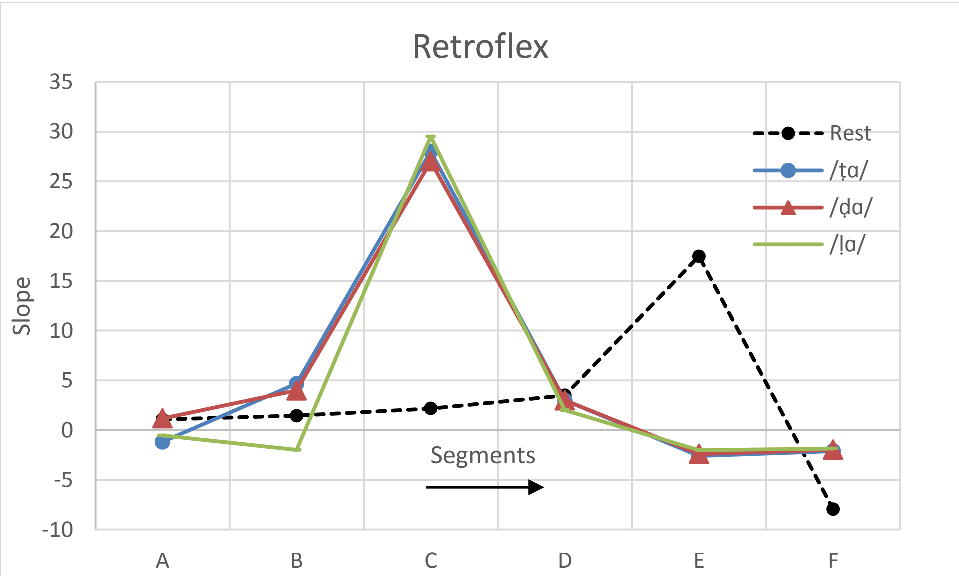

Figure 8. Mean slop plot for retroflex sounds such as /ṭɑ/,/ḍɑ/ and /ḷɑ/

Upadhyaya (1972) classified /ʧ/ as voiceless palatal phoneme for which the tongue is raised towards the hard palate, just behind the alveolar ridge. Hence compared to the rest of the phonemes, the sound /ʧ/ has maximum slope at point D [palatal zone]. Also, /ʧ/ and /jɑ/comes under same place of articulation and for both the phonemes tongue raises to touch the hard palate in the similar pattern. The mean slope values are almost similar and the contour for /ʧ/ and /jɑ/does not show much variations. Figure 9 depicts the mean slope plot for palatal sounds.

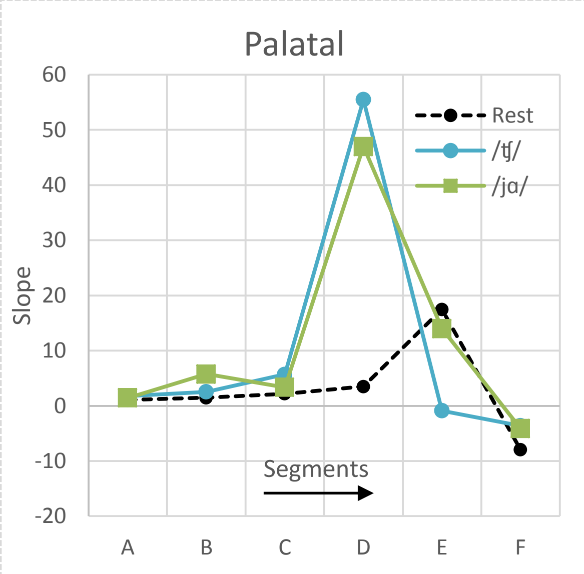

Figure 9. Plot of mean slope for palatal sounds such as /ʧ/and /jɑ/

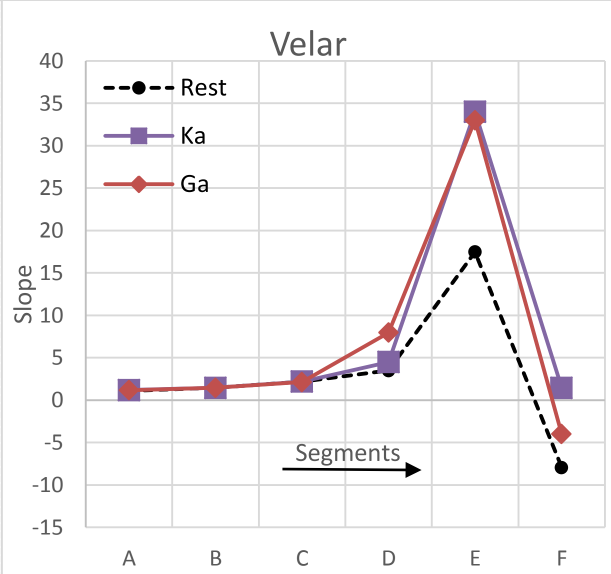

Figure 10. Plot of slope for velar sounds such as /kɑ/ and /ga/

Deviation for /kɑ/ and /ɡɑ/ phonemes are clearly visible from E and F zones in Figure 10. In agreement with the findings made by Kochetov et al. (2012), points E and F represents velar place of articulation, where the phonemes are produced with the back of the tongue raised towards soft palate. The mean slope plot for both of these phonemes reveals that the tongue is raised at point E to the maximum compared to rest of the phonemes to touch the velar region. Figure 12 depicts the slope plot for velar sounds such as /kɑ/ and /ɡɑ/. /kɑ/ and /ɡɑ/ have near similar values as both of these phonemes belongs to velar place of articulation.

Minimum mean slope values were also analyzed. As /kɑ/, /ɡɑ/ and /ɑ/ phonemes does not have significant movement for the tip of the tongue, these phonemes have minimum deviation from the tongue rest position. This is true for the points A, B, C, and D. Also from the analysis of the plots, it is evident that the phonemes /jɑ/ and /ɑ/have minimum values at points E and F respectively.

3.2 Mean Angle of deviation

Figure 11 has been obtained by plotting the angle of deviation values for both the tongue in rest position and for the chosen twelve phonemes. It represents the degrees up to which tongue is bent or curled from the rest position to touch the mouth ridge for the production of each of the twelve phonemes. As in the slop plot, each point in the graph for angle of deviation [A, B, C, D, E, F] represents dental, alveolar, retroflex, palatal and velar zones respectively. Dotted line represents the angle of deviation in rest position of tongue and solid line represents the target contour of tongue during the production of different speech sounds. Table 4 represents the maximum angle of deviation from the tongue rest position for each point.

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Table 4

Maximum angle of deviation at each point with respect to the reference [tongue rest position].

A	B	C	D	E	F
/d̪ɑ/ 68.42	/lɑ/ 72.51	/ɭɑ/ 88.74	/rɑ/ 86.03	/lɑ/ 58.3	/lɑ/ 43.28

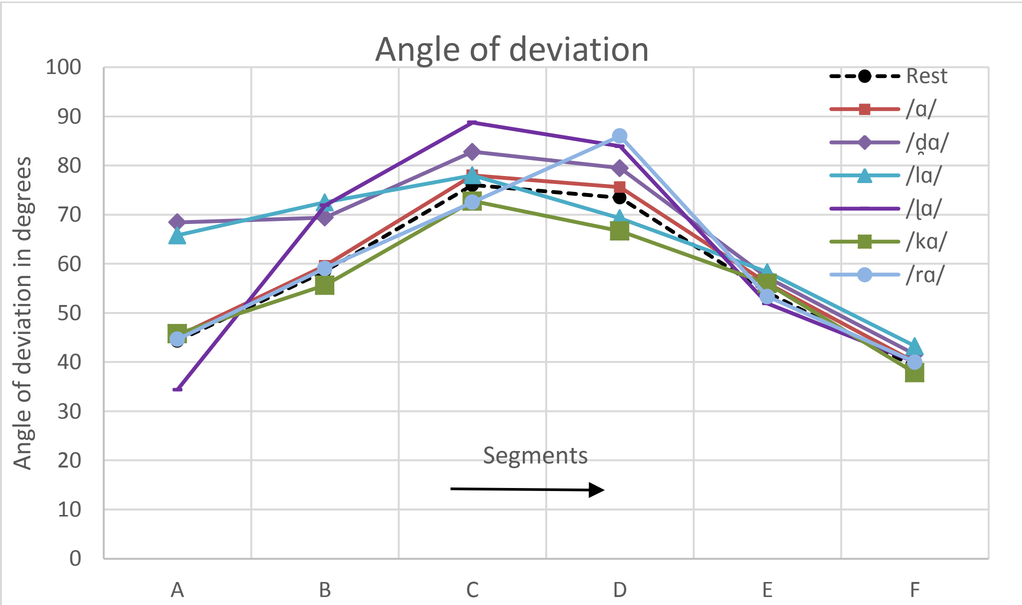

Figure 11. Angle of deviation of the selected sounds and tongue in rest position

The results obtained from the analysis of maximum angle of deviation correlates with the analysis of slope plot at the points A, B and C (dental, alveolar, retroflex zones respectively). The phonemes /d̪ɑ/, /lɑ/ and /ɭɑ/ show maximum angle of deviation at points A, B and C respectively. Among those points, when compared to all the twelve phonemes, point C is the point at which maximum value for angle of deviation is obtained. This is obtained for the phoneme /ɭɑ/ as the production of retroflex sounds involves the bending or curling of the tongue at the peak. At point D /rɑ/ has maximum angle of deviation. Adler-Bock at al. (2007) also showed that, for the adult speakers /rɑ/ is produced by both anterior and posterior constriction with the tip of the tongue touching a point near the palate. For rest of the phonemes such as /kɑ/, /ɡɑ/ and /ɑ/ even if there are significant changes in slope values, with respect to the tongue in rest position there is no significant deviation for angle. Therefore the tongue path (angle of deviation) follows the same path as obtained for the tongue in rest position.

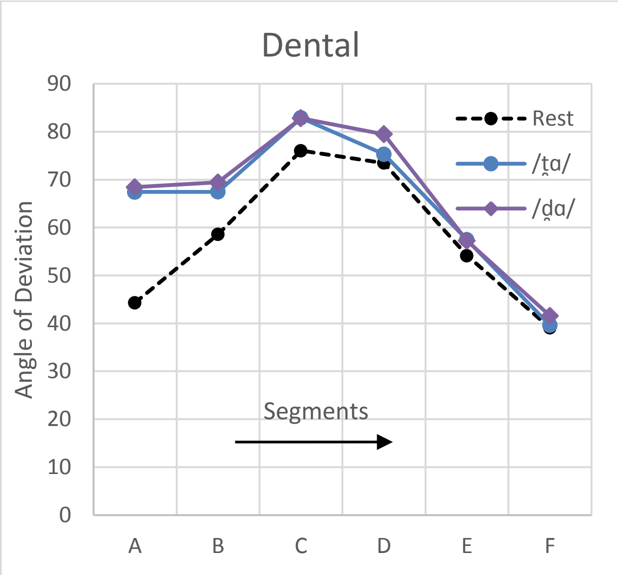

Figure 12. Plot of angle of deviation for dental sounds such as /tɑ/ and /dɑ/

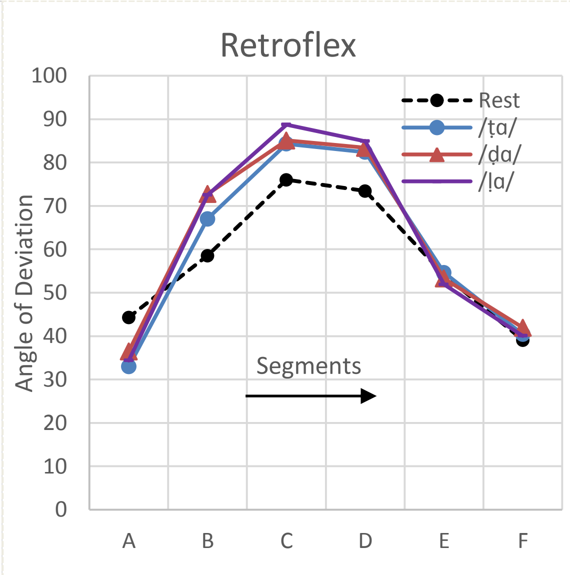

Figure 13. Plot of angle of deviation for retroflex sounds such as /ʈɑ/, /ɖɑ/and/ɭɑ/

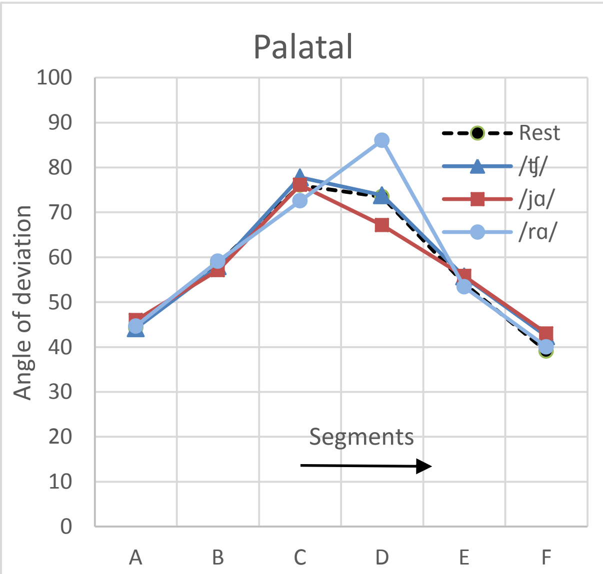

Figure 14. Plot of angle of deviation for palatal sounds such as /ʧ/, /jɑ/and /rɑ/

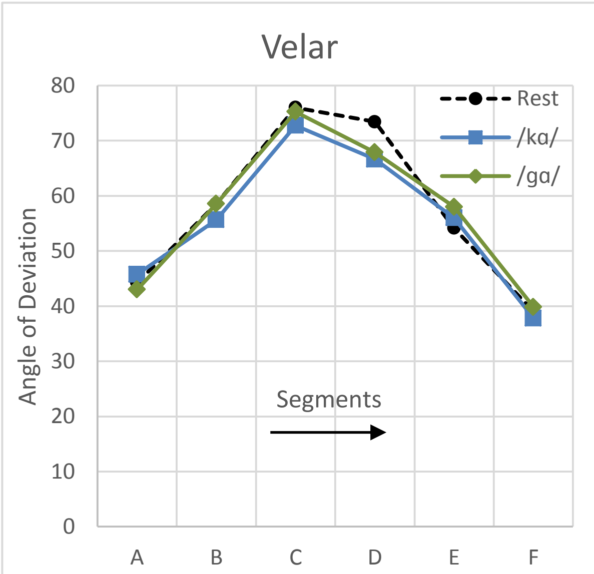

Figure 15: Plot of angle of deviation for velar sounds such as /ka/ and /gɑ/

Figure 12-15 represents the contour of tongue based on the angle of deviation for dental, retroflex, velar and palatal sounds respectively. This data will provide sufficient information in modelling 3D tongue, as this provides precise representation of each point in terms of its slope and angle.

4. Conclusions

The tongue profile obtained for the selected phonemes in the study is in agreement with the previous studies. In this study, we obtained end to end tongue profile of Kannada speakers with segmentation of ultrasound tongue images using an image processing and analysis tool. Analysis of the tongue contour for different phonemes was carried out with the acquired tongue profile of native Kannada speakers. The tongue contours for different places of articulation such as dental, alveolar, retroflex, palatal and velar, and the range of deviation in terms of coordinates and angles with respect to the tongue in rest position for native Kannada speakers were obtained. From the results, it is evident that there is a specific pattern which determines where the tongue should touch and how much should the tongue curl or bend for different phonemes with respect to the tongue rest position. We have also found the phonemes with maximum values of slope and angle of deviation at each of the five segments. It is observed that the retroflex sounds have comparatively greater deviation in angle from the tongue in rest position (88.74 degrees). Palatal sounds have maximum deviation in slope in comparison with the rest of the phonemes (52.18). Also velar sounds have minimum displacement from tongue rest position and minimum deviation in slope and angle compared to other phonemes considered in the study. It is expected that our present work will help in implementation of an automatic tongue in intelligent robotic systems for articulation training which would help in effective and faster rehabilitation of children with articulation disorders.

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Toward a typology of children's early verb forms

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Abstract

This paper explores the notion that not only adult languages, but child languages might also be classified according to typological criteria that may be similar to or different from those used to compare and contrast structures in their corresponding adult or target languages. A number of first language acquisition studies have pointed out the predictable variability of certain verbal structures in child speech that correspond to tensed forms of the corresponding adult language. These occurrences include: 1) exclusive use of "bare" forms, 2) root infinitives occurring alongside tensed forms; and 3) imperatives that occur alongside tensed forms. A most interesting characteristic of such configurations is that they appear to be in complementary distribution of each other, that is, only one of the three arrangements appears in a particular child language. In addition to asserting that the array of early verb systems as observed by such studies may support the idea of an overall typology of early verb forms, this study proposes three potential universals with regard to child verbal morphology. Not only the universals proposed in this paper, but several of Greenberg's "adult" universals also refer to language behavior that can be described in terms of what has been proposed as some binary parameter setting. Similar to Greenberg's universal regarding head-complement order, the child language universals proposed in this paper likewise correlate to the setting of a parameter, that being the specification of null- versus non-null subject languages. Establishing a typology for developing languages may be particularly useful in terms of implications it has for the timing and potential ordering of parameter settings by children. As regards this study, the early verb structures studied here were found to correlate to the null subject status of a language, suggesting that this parameter has already been set for the languages compared.

Keywords Linguistic typology, child language, early verb forms, root infinitives, bare verbs, imperatives

1. Introduction

The field of linguistic typology strives to classify the variety of forms across adult languages according to similarities and differences among them. Once classifications were made, such pioneers of the field as Greenberg (1963) have then tried to abstract from their observations a number of linguistic universals that could be said to apply to all languages. Greenberg states that an overwhelming majority of his universals have to do with word order or morphology, but he adds that this is only because he found there to be a "considerable measure of orderliness" in these categories. With a goal to restrict the total number of universals as much as possible, Greenberg's

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total number of universals reached 45. Examples (1) and (2) correspond to Greenberg's Universals 26 and 29[2], respectively, with regard to morphology:

(1) *Universal 26*. If a language has discontinuous affixes, it always has either prefixing or suffixing or both.

(2) *Universal 29*. If a language has inflection, it always has derivation.

To date, first language scholars have yet to apply the notion of typology to the differing manifestations of forms that systematically appear across child languages, and there are several reasons why this may be the case. The first may be that there has been relatively little systematic, cross-linguistic work done with regard to the wide array of possible early representative forms across languages. Another reason why this venture may not have been undertaken is the notion that Hoekstra and Hyams (1998) refer to as "early morphosyntactic convergence" whereby the developing morphology and syntax of a child learning a particular language can be recognized in its earliest stages as essentially that of the adult or target language, which begs the question why one would need to perform a separate classification of the child's manifestations of a given language.

Despite such limitations, the purpose of this paper is to suggest that not only adult languages, but child languages as well may, and perhaps should, be classified according to typological criteria that may be similar to or different from those used to compare and contrast structures in their corresponding adult or target languages. To further demonstrate this point, the author will focus on verb forms such as infinitives or the imperative mood which the literature suggests are overproduced in addition to tensed forms by children learning certain languages. These differing usages have been found to occur in systematic ways that differ from the target adult forms in these languages. Moreover, usage of these forms within language is not random, but rather, to use Greenberg's own words, they represent "a considerable measure of orderliness," and therefore, such combined usage with tensed forms is referred to as a "system," suggesting more of a typological classification than merely a haphazard occurrence of possibly alternating verb forms.

Having been attested by a number of first language acquisition researchers to occur in developing child languages in places where the corresponding adult languages opt only for tensed forms, this variety of verb "systems" is as follows: 1) the exclusive occurrence of "bare" verbs and no tensed forms, 2) root infinitives that occur alongside tensed forms; and 3) imperatives that occur alongside tensed forms. A most interesting characteristic of these configurations is that they appear to be in complementary distribution of each other, that is, only one of the three arrangements appears in a particular child language. There is no mixing within a language of these three possibilities. What's even more interesting is that the findings with regard to these different cross-linguistic manifestations come from the

[2] This paper could have showcased any of Greenberg's universals. However, choice of Greenberg's Universals 26 and 29 as illustrations here is based solely on the fact that these are morphologically- and not syntactically based. Since the focus of this paper is that of the evidence for varying, yet systematic morphology across child languages, it is the author's opinion that they are the most appropriate to include here.

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opposing generative camps cited earlier in this paper, both maturationalists and continuity theorists, none of whose findings seem to override those of the other.

It is for these reasons that I will argue that the array of early verb systems as has been cited by such studies as ensue here may contribute to an *overall typology of early verb forms*. For example: 1) English has been suggested by Radford (1990) to function with bare verb forms in small clauses initially with no co-existence of finite verb forms at all. I call such languages as English that manifest this behavior Bare Verb (BV) Languages; 2) Dutch, German, Swedish, Icelandic, and non-null subject Romance languages such as French, on the other hand, tend to opt for root infinitives alongside finite verb forms (Hoekstra and Hyams, 1998). These have been called Root Infinitive (RI) languages in the literature, and are represented here as such as well; and finally, 3) All null subject Romance languages and some other, non-Romance, Indo-European languages, such as Hungarian (Finno-Ugric) and Slovenian (Slavic), have all been attested to opt not for root infinitives, but rather for imperatives alongside finite indicative forms (Salustri & Hyams (2003). These are referred to here as Imperative Modal[3] (IM) languages.

Figure 1 illustrates these three different developing verb systems typologically.

Attested Developing Verb Systems

Bare Verb Languages	**Root Infinitive Languages**	**Imperative Modal Languages**
bare or uninflected forms	tensed forms + infintives	tensed forms + imperatives
↓	↓	↓
Attested for English, a **Non-pro drop language** (Radford, 1990)	Attested for one Romance (French) and some Germanic (Dutch, German, Swedish, Icelandic) languages all of which are **Non-pro drop languages** (Hoekstra & Hyams, 1998)	Attested for other Romance (Italian, Catalan, Spanish, etc.) and non-Romance (Hungarian, Slovenian, etc.) varieties. all of which are **Pro-drop languages** (Salustri & Hyams, 2006)

Figure 1. Proposed Typology of Early Verb Systems

[3] According to Salustri & Hyams (2003), the semantics behind the morphology of both root infinitives and imperative forms, is similar in that they both imply modal interpretations. They claim that this explains why in some languages the infinitive form is often used to express the imperative mood, as in the use of the infinitive in negative, second-person singular commands in Italian (*non ti preoccupare* 'don't worry') These authors suggest, however, that bare forms in English, unlike their root infinitive or imperative counterparts, exhibit a somewhat different behavior, and do not in fact imply this modal interpretation.

2. Data from first language studies

This section provides the data upon which the typological analysis of this paper is based:

2.1. *'Bare' Verb (BV) Languages*

Radford (1990) perhaps has done the most work which is representative of the maturationalist viewpoint of first language acquisition (Phinney, 1981; Aldridge, 1989; Borer & Wexler, 1987; Levin & Rappaport, 1995 & 1998; Clahsen, 1996; O'Grady, 1997; Bittner, Dressler & Kilani-Schoch, 2003; Borer, 2004; Potts & Roeper, 2006). Drawing on empirical evidence from early English, Radford suggests that the verb forms a child initially uses can be explained in terms of purely lexical-semantic categories (or rather, those that exist in the VP) and a lack of functional categories which include CP, TP, and DP. Radford proceeds to cite much evidence in the early speech of children learning English where they might at first lack both CP and TP layers, potentially functioning solely in the VP realm. He goes on to say that children at this first stage typically have highly reduced clauses that are similar to what have been referred to in adult grammar as small clauses or SCs. As compared to adult Ordinary Clauses (as Radford terms full clauses), adult Small Clauses simply consist of a determiner phrase and a predicate phrase. Following are examples of adult ordinary and small clauses:

(3) I consider [that this candidate would be unsuitable for the post.] Ordinary

(4) I consider [this candidate unsuitable for the post.] Small

According to Radford, children learning English at first produce clauses very much like the adult type in (4), only usually (but not always) without determiners. Some authentic examples of SCs from real children (Radford, 1990) are:

(5) 'Wayne in bedroom.'
(6) 'Teddy want bed.'
(7) 'Daddy go?'

Radford asserts that this reduced version of a clause in the form of an SC does not ever reach the level of TP or CP in either adult or child language. First of all, the verb is usually uninflected, and secondly, as in (7) there appears to be no movement in the case of questions. Other indicators that Radford cites for the lack of a TP in early child language are the following absent items: 1) infinitival to; 2) modals; 3) finite verb inflections; 4) do-support; 5) copula be; 6) progressive be; and 7) perfective have.

Moreover, according to Radford, along with the evidence for the lack of a TP layer in children's speech, there is also evidence for the lack of the CP layer as well, typically demonstrated by the following features of child language: 1) children are observed to first lack any complementizers whatsoever in their speech; 2) auxiliaries are usually never preposed in early children's speech, suggesting that without the head of a complementizer phrase, there is no landing site for a moving auxiliary; 3) children normally do not productively move wh-constituents from their place of origin to the specifier position of C, suggesting that without a complementizer phrase, there is no landing site in the form of the Spec of the CP for a moving wh-constituent; and 4) when children are presented with input containing preposed wh-constituents, they rarely parse them correctly.

Aldridge (1989) lends further support to Radford's less-than-full-syntax hypothesis, primarily by: 1) countering the continuity-based claim by Hyams (1986) that T exists in children early on but is pronominal; and 2) providing evidence for acquisition of T after two years. Another study which also focuses on the child's language system as limited and comparably underdeveloped is Phinney (1981) who demonstrates that the production of complementizers doesn't happen with children until as late as 5 years of age. More recent maturational work conducted by Potts and Roeper (2006) lends further empirical evidence to Radford's small clause hypothesis in what P & R refer to as the "non-sentential." According to the authors, adult use of expressive small clauses (ESCs), as in (6) or incredulity small clauses as in (7) are actually extensions and continuations of the child stage of small clauses that never developed into "larger" syntax.

(8) "You idiot!"
(9) "What, me worry?"

Potts & Roeper suggest that the adult small clauses such as those in (6) and (7), in fact, remained at the small clause level. They suggest a two-fold process corresponding to acquisition of English by children in two stages: 1) All two-word forms are small clauses. At first, mapping is not functional; each structure is associated with a large set of meanings. 2) As learners acquire more functional projections, they begin to also move toward a one-to-one syntax-semantics connection. At first, children use small clauses as all-purpose structures but as they acquire significantly more complex syntax, namely, the TP level, they specialize structures according to what they want to mean. As they start to assign meaning to the new structures, they likewise start disassociating the meanings now associated with the new structures from the old small clause structures. P & R suggest that expressive small clauses or incredulity small clauses of English-speaking adults, as in (6) and (7), respectively, never become disassociated with their small clause origins from child English.

2.2. Root Infinitive (RI) Languages

Other studies on early verb forms, namely by continuity theorists, who unlike their maturationalist opponents such as Radford, propose that some early verb structures indeed do suggest the early existence of an adult system. These studies have focused on a phenomenon in some languages called root infinitives (RIs) (Rizzi, 2000). Root infinitives are much like the bare verb forms in small clauses as proposed by Radford for English, in the sense that they too are uninflected forms. In fact, this led Wexler (1994) to classify bare verb forms as infinitives themselves. However, as Hoekstra and Hyams (1998) point out, a major difference between the two forms is that the

English bare form has no infinitival morphology and hence does not imply a modal meaning. RIs on the other hand, tend to have a modal interpretation, known as the Modal Reference Effect (MRE) and tend to happen with eventive (as opposed to stative) verbs, known as the Eventivity Constraint (EC). For ease of explanation, early languages that manifest root infinitives will be referred to in this Dissertation as RI languages.
Another important observation of root infinitives in languages that manifest them, and which also distinguishes them from the bare verbs of English small clauses, is that unlike early English bare verbs which according to Radford exist by themselves until modal verbs are the first finite forms to appear on the scene, RIs have been found to exist alongside finite forms, suggesting that these have a grammatical function to themselves that is separate from the use of finite forms.
The production of root infinitives by children has been attributed in the continuity research as some kind of underspecification. In other words, full syntax is believed to be there, but for one reason or another the child opts to underspecify some category or constituent, resulting in a surface form that is different from the adult target. Some examples of these forms (from Hoekstra & Hyams, 1998) are:

(10)	a.	Papa	schoenen	wassen.		
		Daddy	shoes	wash-INF		(Dutch gloss)
	b.	Auch	Teddy	fenster	gucken	
		also	Teddy	window	look-INF	(German gloss)

Another important observation of the root infinitive phenomenon which is of direct importance to this paper is that they do not appear to occur in null-subject languages, including Romance and other languages. Instead, recent research proposes that an analog in the form of the imperative mood is the form of choice for null-subject languages, more of which will be discussed in the following section.

2.3. Imperative Modal (IM) Languages

More recent studies on root infinitives by Salustri & Hyams (2003) suggest an early verb form analog to exist in the null-subject Romance, as well as other early null-subject languages that do not employ root infinitives. This form appears to be the imperative[4]. In presenting what they conceive as the *Imperative Analog Hypothesis* (IAH), Salustri & Hyams provide evidence from these non-RI early languages that the imperative is indeed used in analogous modal contexts where root infinitives have been attested to occur in RI languages. This overused imperative form, like its root infinitive counterpart in those languages that overuse them, appears alongside tensed forms.
For purposes of typology, these languages are referred to here as Imperative Modal Languages. Examples from of these languages follow:

[4] Salustri & Hyams (2003) address arguments that have been made by others that the form in question may in fact not be the imperative but rather a third person singular tensed form (which for some languages has been argued to be the same form as the imperative) or some neutral or 'bare' form. See Salustri & Hyams for an explanation as to why languages such as Italian or Spanish provide clear evidence for the imperative interpretation of this structure.

(10)	a.	Mangia	la	pasta!		
		Eat-imp	the	pasta!		Italian gloss
	b.	Non	mangiare	la	pasta!	
		Not	eat-INF	the	pasta!	Italian gloss

In a recent study in which he uses data from CHILDES (MacWhinney, 2000), Ryan (2017) makes two important updates to the IMH, based on an analysis of early verb use by two children, one learning Spanish and the other Italian. The study, which compared the emergent production of two different intransitives, namely, unaccusatives and unergatives, found that unaccusatives were produced earlier than unergatives, suggesting that verbs with theme arguments are perhaps acquired earlier than those with agents. This finding led Ryan to reassess the so-called Eventivity Constraint, proposed by Hoekstra and Hyams (1998) to be what determines the use of an infinitive or imperative by the child to mark events (as opposed to states that would be marked by a tensed verb). Instead, Ryan (2017) proposed that agentivity of the verb may be what in fact determines the non-finite verb form.

Describing and classifying the different forms across child languages that are used uniformly for corresponding structures in the target adult language is an important step in creating a typology of child language, however, this is only the first phase in the typological process. If we are to use as a model the trend that mainstream typology has followed for adult languages, it follows logically that once characteristic patterns have been identified cross-linguistically, the next, more challenging task for the language typologist is that of reviewing the sum of evidence from the many grammars and structures studied in order to propose a set of generalizations that might apply to the range of languages studied, and in turn, an even greater task would be that of implying a certain set of universals for languages generally. Accordingly, if an early child language typology were to be formulated, it would then follow that one might be able to suggest certain universals that are applicable to all developing languages[5].

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[5] Abstracting a series of linguistic universals for child language comes with its own complications. In the first place, this process requires much more first language acquisition data and analysis than are currently available for the wide variety of existent languages. This issue of inadequate data, coincidentally, has been raised for mainstream typology as well, due to the fact that there are many adult languages, both ancient and modern-day, for which adequate grammars are lacking to allow for such an analysis. If we take this notion a step further, the process for creating a linguistic typology for children would seem even more precarious than that for adults in that there exists a double complication: 1) some languages for which there are no corresponding adult grammars that might help us to understand their structures; and 2) as seen previously, there is just not enough data that would constitute an adequate sample size of the many developing child counterparts. This second problem may be addressed in theory with the advent and growth of such prominent first language data resources as the Child Language Data Exchange System (CHILDES) (MacWhinney, 2000). Although the intent of this paper is not to create a child language typology itself but to argue why such a typology should be created hypothetically, the line of

Based on the cross-linguistic studies of early verb forms that have been cited throughout this paper, one might suggest the following universals with regard to child verbal morphology as it relates to the particular null-subject parameter that has been set for a given language:

> *Child Language Universal 1.* Children who produce only one verb form early in development will do so in bare, or some other non-tensed, uninflected form. This language will most probably be a non-null subject language.
> *Child Language Universal 2.* Children learning non-null subject languages who produce two verb forms will most likely produce tensed forms and root infinitives as these forms.
> *Child Language Universal 3.* Children learning null subject languages will most likely produce two verb forms which will appear as tensed forms and the imperative.

What is perhaps the most noticeable observation about the first language "universals" as postulated here is the similarity to Greenberg's "adult" universals in the sense that both describe behavior in terms of some parameter setting. For example, Greenberg's universals for adult languages correlate primarily to the parameter setting of head-complement order, where implications are made for the order of certain constituents such as adjectives or prepositions based on the status of a particular language as either head-first or head final. Here too, as do Greenberg's universals, the child language universals proposed in this paper likewise correlate to a parameter, but rather than to that of head-complement order, the parameter in question appears to be the status of the language as being null subject or non-null subject.

The correlation between adult and child universals in terms of parameters makes for a strong argument for the usefulness of a typology of developing languages in that it makes some implications for the timing and potential ordering of parameter settings by children. In other words, the early structures studied here were found to correlate to the null subject status of a language, suggesting that this parameter has already been set for the languages compared. An implication for further research would be to look for other correlations that may exist between other early forms or structures and other parameters such as headedness or wh-movement. As mentioned in the section on bare verb forms as suggested for English, Radford (1990) attributes no apparent wh-movement to the lack of a CP. In terms of this paper, however, this might also imply a setting of the wh-movement parameter in children that is later than that of the null subject parameter.

inquiry here is intended solely as a starting point from which further investigation and discussion might blossom.

3. Summary and Conclusions: The Bridge between Linguistic Universals and UG

This brief paper opened with a discussion of the difference between continuity and maturationalist accounts of language acquisition and the controversy surrounding the extent to which the child's grammar resembles that of an adult. The paper then entertained the idea of constructing a typology of early child language that is to be distinguished from mainstream language typology that is typically constructed for adult languages. Examples from current first language acquisition research were then provided to illustrate how some systematic manifestations of early verb forms in certain languages have been found to correlate with the null-subject parameter settings of those languages. Using Greenberg's (1963) first language universals as a guide, three preliminary child language "universals" were then proposed for the early child verb forms that have been suggested by the research.

A compelling motivation for the creation of a typology of child language is that it might in fact reconcile two very basic linguistic notions that until now have not been directly addressed in the literature as being related, namely: 1) the concept of linguistic universals from the field of typology, and 2) that of Universal Grammar, the child's initial innate system, or S^0, before exposure to any language input (Chomsky, 1995). Both concepts, after all, refer to the idea of generality or communality across languages. The possible reason why acquisitionists have not attempted to draw a connection between these two abstractions is that until now they appeared to be representative of either adult (in the case of typology) or child (in the case of UG) grammars, but not both. Constructing a child language typology, however, now makes it possible to discuss one notion in terms of the other. In other words, the differing yet systematic early manifestations found in child languages might be said to correlate with some very specific first language issues. One such example, as pointed out above, is that of language parameters that are set by children who are all alleged to start out with the same UG or S^0.

This paper is intended solely to introduce the idea of child language typology as suggested by some recent acquisition work on early verb forms. Before anything more definitive can be said about such an attempt, much more work will have to be done in terms of structures other than early verb forms and parameters other than the null subject parameter. As suggested earlier, one such parameter showing promise in this area is that of wh-movement. This paper closes by adding a new question to the lively debate between continuity theorists and maturationalists. If children do indeed produce forms in predictable, systematic ways that are different from the adult target form and these forms are found to correlate directly with a particular language "type" in terms of some parameter setting, AND if there is additional evidence that other parameter settings are not made until later, would not this make child language typology not only a worthy, but necessary, pursuit, and even provide additional empirical evidence for a more maturational account of language acquisition?

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