INTONATION CONTOURS IN THE SPEECH OF INDIVIDUALS WITH BROCA'S APHASIA

[1]Gouri Shanker Patil, & [2]Manjula R.

Abstract

The study acoustically examined the nuclear tones and terminal intonation contours in individuals with Broca's aphasia vis-à-vis the neurologically normal participants. Ten individuals with Broca's aphasia who spoke Kannada as mother tongue participated in the study along with 10 age and gender matched neurologically normal individuals. They narrated a picture card while their utterances were audio recorded using a digital tape recorder. The Computerized Speech Lab (CSL) 4400 software was used for generating intonation contours from the utterances of participants. The nuclear tones were analysed in terms of traditional classification of rise, fall, rise-fall, fall-rise, rise-fall-rise, fall-rise-fall, and level contour whereas the terminal contours analysis included rise, fall, and level contours. The results revealed presence of similar types of nuclear contours in both groups of participants. However, the terminal contours had occurred more frequently in within-sentence intonation units in individuals with Broca's aphasia suggesting that were using this as a device to indicate utterance continuity, owing to a limited output in terms of utterance length. The intonation contour analysis results suggest that individuals with Broca's aphasia are able to signal variations in F0 and they are able to utilise effectively the prosodic features of nuclear and terminal contours in discourse.

Key words: *nuclear tones, terminal contours, discourse.*

Intonation involves the occurrence of recurring pitch patterns, each of which is used with a set of relatively consistent meanings, either on single words or on groups of words of varying length (Cruttenden, 1986). Grammatical constituents of any level up to a sentence consist of separate intonation units having their own meaningful tune. The intonation unit encapsulates a functional, coherent segmental unit, be it syntactic, semantic, or informational (Cruttenden, 1997; Hirst & Di Cristo, 1998; Silber-Varod, 2005). The intonation contours consist of two types of tonal specification - tones which have a prominence-lending function, referred to as 'nuclear tones' and those which delimit intonational phrases, referred to as 'boundary tones' or 'terminal contours' (Pierrehumbert, 1980; Beckman & Ayers, 1994). The nuclear tones are associated with the nuclear stress syllables of intonation units while the boundary tones are found at the edges of intonation units. Palmer (1922), one of the pioneers to have done a systematic analysis of the nuclear tones and their configurations in English language described 4 types as falling, high rising, falling-rising, and low rising. Variations were later reported by other investigators. For example, Kingdon (1958), described 5 types of nuclear tones in English language as rising, falling, falling-rising, rising-falling, and rising-falling-rising, and Halliday (1967) also described 5 tones which included falling, high rising, low rising, rising-falling-rising, and falling-rising-falling. Three types of phrase-final contours which are commonly reported and they include level, falling, and rising tones (Ambrazaitis, 2005). An additional boundary tone was observed in German language as falling-slightly-rising contour (Ambrazaitis, 2005). The falling boundary contour may suggest utterance finality like in a declarative statement as in English (Hirschberg, 2002), or the conclusion of an argument, or categoricalness as in German (Peters, 1999; 2000; Ambrazaitis, 2005). The final rises are suggested to be used as an index of social relations between participants wherein the final rises indicate 'authoritativeness' (Horvath, 1985), index of turn-taking in narratives (Guy & Vonwiller, 1989), request for response (Ladd, 1996), marker to describe and express opinion (Horvath, 1985), or clue to speaker's attitude as being friendly or attentive (Guy & Vonwiller, 1989). Other reported pragmatic functions of the final rises include issuing warnings or threats and astonished utterances (Peters, 1999; Ambrazaitis, 2005) and polite offers (Grice & Baumann, 2002; Ambrazaitis, 2005).

Intonation contours in Indian Languages

There are few studies on the nature of intonation in Indian languages (Sethi, 1971; Nataraja, 1981; Ravisankar, 1987). In Kannada language, which is a non-tonal language spoken in southern state of India, very few studies have addressed the feature of intonation, although there are studies, which investigated the nature of intonation in emotive utterances (Manjula, 1979; Nataraja, 1981; Nandini, 1985). Other studies report the linguistic nature of intonation in various modes

[1]Lecturer in Speech & Hearing, Ali Yavar Jung National Institute of Hearing Handicapped (AYJNIHH), Southern Regional Centre (SRC), Secunderabad-09, Email: gourishanker07@rediffmail.com, & [2]Prof. in Speech Pathology, All India Institute of Speech & Hearing (AIISH), Mysore-06.

such as questions, statements, narration, and simulated dialogues, and its association with the segmental constituents of Kannada language (Rathna et al., 1976; Rathna et al., 1982; Patil, 1984; Manjula, 1997; Krishna, 2002). The features of intonation such as the initial and terminal contours, peak F0, excursions of F0, declination of F0, tonal groups, the relationship of all these features with the segmental correlates of the linguistic units and others have been addressed in these studies. Patil (1984) noted falling pitch at the terminal segments for non-polar questions while Manjula (1997) reported rising and falling terminal contours for Y-N and WH- interrogatives in Kannada language. In another study Nataraja (1981) found falling and rising contours at the end of sentences for different emotions in four Indian languages constituting Kannada, Tamil, Gujrati, and Hindi. In Telugu language, 7 types of nuclear pitch movements viz., low fall, high fall, low rise, high rise, fall-rise, rise-fall, level tones, and 3 types of terminal contours i.e., falling, rising, and level tones have been identified (Girija & Neeraja, 2003). In a study involving contrastive analysis of Hindi and Malayalam language, Geethakumary (2002) inferred that both these languages are characterized by 4 pitch levels and 3 terminal contours. The pitch levels found to occur were Extra high, High, Mid, and Low while the terminal contours included rising, falling, and level tones. Specific intonation patterns that express different attitudes were reported in Malayalam language (Asher, 1997; Girish, 2004). A less extended fall conveyed politeness, rise-fall tone expressed annoyance, fall-rise expressed dissatisfaction or doubt, low level tone suggested differences, high level tone issued a warning (Asher, 1997). A low falling tone on declaratives and a low rising tone on interrogatives are reported to be the characteristic boundary tones in Tamil language (Ravisankar, 1987). Sadanand and Vijayakrishnan (1993, 1998) outlined a three-way tonal contrast in Punjabi language - neutral, falling tone, and falling-rising tone.

Tonal deficits in individuals with aphasia

In tonal languages, the tones assume a phonemic function. A small variation in tonal contour brings about a change in meaning of the utterance. Thus, there is an increased probability that the LHD aphasics are prone to tone production deficits. T' sou (1978) in a case study of Cantonese-English bilingual conduction aphasic, reported that the client had difficulty in producing the low falling tone. Tonal productions were reportedly compromised in aphasic individuals in Mandarin (Naeser & Chan, 1980; Packard, 1986) and Norwegian languages (Moen & Sundet, 1996). In order to determine the nature and extent of tonal deficits in aphasia, Gandour, Petty, and Dardarananda (1988) carried out an acoustic perceptual study of lexical tone in Thai. In all types of aphasics, the tonal confusion was predominant between the mid and low tone, which was possibly due to similarities in height and shape of F0 contours. In a severe Broca's aphasic client, the low tone was virtually indistinguishable from mid tone. Overall, the results suggested a positive relationship between severity of aphasia and tone production. In a subsequent study, Gandour, Ponglorpisit, Khunadorn, Dechongkit, Boongird, Boonklam, and Potisuk (1992) recruited additional number of brain-damaged participants (11 right-brain-damaged nonaphasics, 9 fluent aphasics, 8 non-fluent aphasics, and 4 aphasics with subcortical lesions) to evaluate the tonal contrasts. The results were similar to the previous findings, in the sense that tonal productions of brain-damaged individuals demonstrated accuracy rate in excess of 93% except for the non-fluent aphasics whose scores recorded 85% accuracy. Contrasting findings by Gandour, Ponglorpisit, Potisuk, Khunadorn, Boongird, and Dechongkit (1997) implied that some aspects of intonation are preserved in brain-damaged individuals regardless of site of lesion. In their study, individuals with RHD and LHD aphasia could produce lexical tone contrasts at different positions in a sentence in Thai language. Besides, the brain-damaged individuals produced final lowering effect similar to the normal controls.

It may be noted that little research was carried out in non-tonal languages concerning intonation contours in individuals with Broca's aphasia. Thus the study aimed to evaluate nuclear and terminal contours in the speech of individuals with Broca's aphasia.

Method

Participants

Individuals with Broca's aphasia

The experimental group constituted 10 individuals with Broca's aphasia. The diagnosis was based on neurological evaluation including neuro-imaging reports and test results of Kannada version (Karanth, Ahuja, Nagaraja, Pandit, & Shivashankar, 1990) of Western Aphasia Battery (Kertesz, 1982). The participants had undergone speech therapy for a minimum of 4 months to a maximum of 2 years. The clinical and demographic profile of individuals with Broca's aphasia is given in table 1.

Table 1: *Clinical and demographic profile of individuals with Broca's aphasia*

subject	sex/age (in years)	no. of years of formal education (pre-morbid)	time post-onset at the time of recording (in years)	therapy duration (in years)	WAB aphasia quotient	Etiology (CT scan findings)
GP	M/45	12	2.0	2.0	39.20	Left MCA territory infarct
RK	M/47	15	1.0	0.6	44.30	Left MCA territory infarct
MH	M/51	17	0.8	0.8	43.84	Left frontal and parietal infarct
NJ	M/52	7	1.1	0.5	47.08	Left frontal and parietal infarct
RS	M/55	5	0.8	0.8	41.84	Left MCA territory infarct
MG	M/55	15	0.6	0.4	44.64	Left MCA territory infarct
TN	M/56	12	1.4	0.6	49.12	Left frontal and parietal infarct
SD	M/59	12	1.3	1.0	45.84	Left MCA territory infarct
TR	M/60	19	2.6	1.2	38.62	Left MCA territory infarct
VK	M/60	10	2.2	1.5	40.12	Left MCA territory infarct

Note. WAB - Western aphasia battery, CT - Computerized tomography, MCA - Middle cerebral artery.

The factors considered for selection of individuals with Broca's aphasia in the study were:

- Native speakers of Mysore-Bangalore dialect of Kannada language.
- Participants whose expressive speech consisted of at least phrases. The expressive speech ability was determined by results of 'Spontaneous Speech' sub-section of Kannada version of Western Aphasia Battery (Karanth, Ahuja, Nagaraja, Pandit, & Shivashankar, 1990; Kertesz, 1982).
- All the participants had right hemiparesis.
- All the participants were right-handed individuals in the pre-morbid period and mostly used left-hand during post-morbid period due to right hemiparesis.
- All the participants reportedly had normal visual acuity or had corrected vision.

Neurologically normal control group

It consisted of 15 normal male participants in the age range of 45 - 60 years. In order to determine age related variations in the selected acoustic measures, the control group was further divided into three subgroups: 45 - 50 years, 51 - 55 years, and 56 - 60 years. Five participants were included in each of these age groups. This was also done to establish the confidence intervals for the selected temporal and F0 measures in the normal control group against which the measures obtained by participants in the experimental group were compared. The participants did not present any previous history of neurological damage, which was ascertained by information provided by the participants and/or the caregivers. Participants included right-handed individuals who were native speakers of Mysore-Bangalore dialect of Kannada language.

Stimulus

The stimulus consisted of a picture which depicted a market scene. The selected picture stimulus is part of a standardized test called the Linguistic Profile Test in Kannada language (Karanth, 1980).

Procedure

The participants were tested individually either in home or clinic situations. Prior to actual recording of speech sample, the investigator demonstrated narration of picture using another stimulus to each subject. All participants were given sufficient time to formulate the utterances and get familiarised about the picture to be narrated. The picture stimulus was placed in front of participants. The participants were instructed to observe the activities depicted in the picture and verbally describe as many events, things, activities etc. as possible about the picture. The speech sample was recorded in a single trial for normal control participants but the recording had to be carried out in one or two

sittings for participants with Broca's aphasia, owing to difficulties in understanding instructions. Specifically, individuals with Broca's aphasia initially resorted to gross description of picture stimulus. They were asked to describe the picture giving finer details and the sample was rerecorded. The recording was carried out with minimal distraction in a quiet environment. The duration of recording extended from 3 - 5 minutes across participants. The participants' utterances were recorded using Sony MZ R-55 digital tape recorder with a uni-directional microphone placed at a distance of about 10 cm from the mouth.

Analysis

The recorded utterances were transcribed by the investigator using The International Phonetic Alphabet (revised to 1993, updated 1996). Later, the investigator and another speech pathologist independently identified the intonation units occurring in the utterances of individuals with Broca's aphasia and normal controls. The perceptual criteria adopted for demarcation of intonation units were: presence of at least one stressed syllable, significant pause between intonation units, phrase final lengthening, anacrusis, and pitch reset (Cruttenden, 1986). The item-by-item inter-judge reliability coefficient 'Alpha' for identification of intonation units in the speech of individuals with Broca's aphasia was found to be 0.9704 and in normal control participants it was 0.9506. The judgment task was repeated after 3 weeks time by the investigator and other judge to establish intra-judge reliability. The item-by-item intra-judge reliability coefficient 'Alpha' for the investigator was found to be 0.9902 in the speech of individuals with Broca's aphasia and 0.9807 in normal control participants. For the other judge it was found to be 0.9804 in the speech of individuals with Broca's aphasia and 0.9801 in normal control participants. The intonation units that were not agreed upon by the two judges were not considered for final analysis.

Later, the utterances of participants were transferred through line feeding to Computerized Speech Lab (CSL) Model 4400 (Kay Elemetrics) for the purpose of acoustic analysis. The speech signal was digitized at a sampling rate of 16000 Hz. For the purpose of pitch analysis, F0 range was set between 70-350 Hz and the window frame length of analysis was 25 ms. The intonation contours were extracted using pitch extraction algorithm of CSL software. The intonation contour analysis in terms of nuclear and terminal contours was based on visual inspection of the contours seen on nuclear stressed syllable and final syllable of each intonation unit, respectively. The widely used ToBI approach to intonation analysis in other languages of the world such as English (Beckman and Hirschberg 1994), German (Grice et al., 2005), Korean (Jun, 2000), and Japanese (Venditti, 1995) is language specific. It may not be generalised to Kannada language. Therefore, intonation analysis in this study adopted an approach which is based on the system of analysis in English language promulgated by Palmer (1922), Kingdon (1958), and Halliday (1967). The nuclear contours were analysed in terms of rise, fall, rise-fall, fall-rise, rise-fall-rise, fall-rise-fall, and level contour. The operational definitions of these types of nuclear contours are given below:

1) The rise type nuclear contour was defined as the rising contour occurring on nuclear stressed syllable (Kingdon, 1958).
2) The fall type nuclear contour was defined as the falling contour occurring on nuclear stressed syllable (Palmer, 1922; Kingdon, 1958).
3) The rise-fall nuclear contour was defined as a contour consisting of a compound contour in which there is an initial rise followed by a falling contour on nuclear stressed syllable (O'Connor & Arnold, 1961).
4) The fall-rise nuclear contour was defined as a contour consisting of a compound contour in which there is an initial fall succeeded by a rising contour on nuclear stressed syllable (O'Connor & Arnold, 1961).
5) The rise-fall-rise nuclear contour was defined as a complex contour consisting of a rising, falling, and then rising contour on nuclear stressed syllable (Halliday, 1967).
6) The fall-rise-fall contour was defined as a complex contour consisting of a falling, rising, and falling contour on nuclear stressed syllable (Halliday, 1967).
7) The nuclear level contour was defined as a contour occurring on nuclear stressed syllable whose contour was relatively flat.

The terminal contours were analysed in terms of rise, fall, and level contour. The operational definitions of terminal contours were as follows (Cruttenden, 1986):

1) The rise type of terminal contour was characterised by a rising tonal pattern.
2) The fall type of terminal contour was characterised by a falling tonal pattern.
3) The level type of terminal contour was characterised by a relatively flat tonal pattern.

The data was obtained and compared between groups of individuals with Broca's aphasia and normal controls.

Results

The study aimed to evaluate nuclear and terminal contours in spontaneous narrative discourse speech of individuals with Broca's aphasia and compare these features with those of normal controls.

Nuclear tones in intonation unit

The nuclear tones observed in either subject groups were rise, fall, rise-fall, fall-rise, and level contour (see table 2). The complex nuclear contours including rise-fall-rise and fall-rise-fall were not observed in any of the participants of either group. In individuals with Broca's aphasia, the rising nuclear contour occurred with mean percentage frequency of 38.26% while the mean percentage of falling nuclear contour was 20.92%. The mean percentage frequency occurrence of rise-fall contour was 27.50%. The fall-rise and level contour were less common, occurring with corresponding mean percentage of 8.27% and 5.01%. In normal controls too, the rising contour was more frequent than other type of contours. It occurred with mean percentage frequency of 43.96%. The falling contour followed rising contour in terms of percentage frequency of occurrence. It recorded mean percentage frequency of 30.10%. The combination contours rise-fall and fall-rise occurred less frequently with mean percentage frequency of 19.56% and 2.7% respectively. The level contours occurred with mean percentage frequency of 3.6%.

Table 2: *Mean percentage frequency occurrence of types of nuclear contour*

Groups	Rise	Fall	Rise-fall	Fall- rise	Rise-fall-rise	Fall-rise-fall	Level contour
Experimental	38.26	20.92	27.50	8.27	0.00	0.00	5.01
Control	43.96	30.10	19.56	2.70	0.00	0.00	3.60

Terminal contour in intonation unit

The terminal contours in intonation units were analysed in terms of rising, falling, and level type of contours. All 3 types of terminal contours were observed in individuals with Broca's aphasia and normal controls (see table 3). In participants with Broca's aphasia, the rising terminal contours were more common than falling contours. The rise type contours occurred with mean percentage frequency of 51.52% while the fall type contours occurred with mean percentage of 45.37%. Whereas in normal controls a reverse pattern was noticed. The rising contour occurred with a mean percentage frequency of 44.92% while the falling contour was 51.66%. The frequency of occurrence of level contour was low in either group of participants.

Table 3. *Mean percentage frequency occurrence of types of terminal contour*

Groups	Rise	Fall	Level contour
Experimental	51.52	45.37	3.00
Control	44.92	51.66	3.38

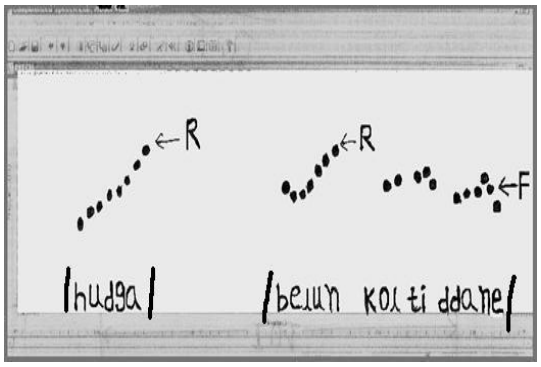
Discussion

It is observed that with regard to realisation of different types of nuclear tones, the individuals with Broca's aphasia displayed proficiency which was on par with those of normal controls. They could effect fluctuations in F0 and lend melody to speech. The lesser frequency of occurrence of level contours together with higher percentage occurrence of other types of contours in the speech of individuals with Broca's aphasia lends further evidence that their speech was not monotonous. Some of the nuclear tones configurations observed in normal controls of the present study were also reported in English language by Palmer (1922), Kingdon (1958), and Halliday (1967). It is reported to occur in Telugu (Girija & Neeraja, 2003) language which has a close relationship with Kannada, since the two languages belong to the Dravidian language family. However, the complex nuclear contours like rising-falling-rising and falling-rising-falling observed by Halliday (1967) in English language were not seen in the present study.

Individuals with Broca's aphasia could produce varied nuclear tones configurations similar to those of normal controls. Few researchers in tone languages indicated tone production deficits in individuals with aphasia. Packard (1986) found significant errors in tones produced by Chinese non-fluent aphasic speakers, while, Gandour et al. (1988) demonstrated absence of Thai low versus mid contour distinction in the tones produced by a client with Broca's aphasia. In another study, Gandour et al. (1992) recorded tonal accuracy of 85% in individuals with non-fluent aphasia. Similar deficits were reported in individuals with Broca's aphasia concerning phonological distinction of Norwegian Pitch Accent 1 versus Accent 2 (Moen & Sundet, 1996). In contrast, Gandour et al. (1997) found preserved distinctions in lexical contour at different positions in a sentence produced by participants with LHD aphasia. In contrast to the

tone production deficits reported in various tone languages, individuals with Broca's aphasia in this study presented intact ability to signal tonal modulations. However, direct comparison of results of this study with investigations in tone languages is not possible because the language under study is a non-tone language.

The results of terminal contour analysis suggest that individuals with Broca's aphasia presented increased number of rising contours relative to normal controls. It should be noted that rising contours are usually observed in yes/no interrogatives or in utterances suggesting continuity (Essen, 1964; Meinhold, 1967; Caspers, 1998, 2001; Gilles, 2000, 2003; Dombrowski & Niebuhr, 2005). In declarative sentences containing two or more intonation units, the final intonation unit is usually characterized by a falling contour to signal that the sentence is complete. The rising contours that were noticed in individuals with Broca's aphasia occurred in intonation units that were within sentences. They were not observed in final intonation units of sentences. Figure 1 gives an instance of such findings in individuals with Broca's aphasia. In a sample sentence spoken by MJ, a client with Broca's aphasia - /hudga belun koltiddane/ (boy is purchasing balloon), 3 intonation units are observed. The terminal contours of first two intonation units portray rising pattern, suggesting utterance continuity whereas the final intonation unit of a sentence is marked by a rising-falling contour indicating the statement has ended.



Note. R - rising contour; F – falling contour.

Figure 1. *Intonation contour of a sample sentence spoken by MJ - a client with Broca's aphasia.*

The findings suggest that individuals with Broca's aphasia used the rising contours to indicate that their utterance is incomplete (Gandour & Baum, 2001; Danly & Shapiro, 1982; Danly, Cooper, & Shapiro, 1983; Kent & Rosenbek, 1982). The continuation rise served to maintain sentence coherence (Gandour & Baum, 2001). It should be noted that individuals with Broca's aphasia presented specific difficulty in the expression of larger units of utterances. They could produce only short utterances. In order to compensate for this, they were probably using rising terminal contours to indicate to the listeners that the utterance is not complete and there is something more to come.

Some of the terminal contours such as rising and falling contours found in normal controls of the study were similar to those reported in English (Cruttenden, 1986), German (Gibbon, 1998; Ambrazaitis, 2005), Kannada (interrogatives) (Manjula, 1997; Patil, 1984), Tamil (Ravisankar, 1987), Telugu (Girija & Neeraja, 2003), Hindi (Geethakumary, 2002), and Malayalam (Geethakumary, 2002). In present study, the level terminal contour characterized by relatively flat contour was also observed. This was also reported in Telugu (Girija & Neeraja, 2003), Hindi (Geethakumary, 2002), and Malayalam (Geethakumary, 2002) languages. Even though there were differences some intrinsic variables such as age and extrinsic variables like formal education, therapy duration, and post-onset duration of aphasia, all participants were able to produce only phrase to simple sentence level utterances. The study did not find any correlation between the aforementioned variables versus occurrence of either nuclear tones or terminal contours.

Conclusions

The intonation contour analysis results suggest that individuals with Broca's aphasia are able to signal variations in F0 as evidenced by the types of nuclear tones and terminal contours exhibited by these individuals. Both groups of individuals exhibited rise, fall, rise-fall, fall-rise, and level nuclear tones. The combination nuclear tones such as rise-fall-rise and fall-rise-fall were not seen in either groups. Concerning the terminal contours, both groups of participants presented all types of terminal contours including rise, fall, and level contours. However, some differences were observed in individuals with Broca's aphasia as against normal control individuals. Most notably, the terminal contours in individuals with Broca's aphasia occurred with a greater frequency than in normal controls. The variations were also observed between the two groups in terms of relative frequency of occurrence of each type of nuclear tones. The rise and fall types of nuclear tones were higher in normal controls compared to individuals with Broca's aphasia. Overall, the results reveal that individuals with Broca's aphasia are able to utilise effectively the prosodic features of nuclear

and terminal contours in discourse especially the manner in which they used terminal contours to convey utterance continuity.

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