INTRODUCTION

Prosody encompasses aspects of speech that are superimposed on segmental units. The prosodic properties include intonation, stress, pause, and rhythm. These features are described acoustically by F0, duration, and intensity (Laver, 1994). Intonation relates to variations in pitch or F0 and is represented by pitch contour (Botinis, Granstrom, & Mobius, 2001). The pitch contour is described by two distinct tones - nuclear tone and boundary tone. The nuclear tone is associated with nuclear stressed syllable and performs a prominence-lending function whereas the boundary tone serves to delimit pitch contour by occurring at terminal edge of pitch contour (Pierrehumbert, 1980; Beckman & Ayers, 1994). The pattern of occurrence of nuclear and boundary tones may vary across languages (Palmer, 1922; Kingdon, 1958; Halliday, 1967; Ravisankar, 1987; Venditti, 1995; D’Imperio & House, 1997; Manjula, 1997; Chahal, 1999; van Heuven, Hann, & Kirsner, 1999; Jun, 2000; Geethakumary, 2002; Girija & Neeraja, 2003; Ambrazaitis, 2005; Dombrowski & Niebuhr, 2005; Grice, Baumann, & Benzmüller, 2005).

Stress indicates the most prominent syllable/word in an utterance. Acoustically, the nuclear stressed syllable is characterized by increased F0, duration, and intensity relative to the surrounding syllables (Liberman & Pierrehumbert, 1984; Ohala, 1977; Sluijter, van Heuven, & Pacilly, 1997; Balusu, 2001; Collins & Mees, 2003; Krishna & Manjula, 2004; Suomi & Ylitalo, 2004; Ortega-Llebaria & Prieto, 2005; Keane, 2006). Usually, the content words are stressed more often than functional words (Kenworthy, 1987; Wahba, 1998). The stress in an utterance is also reported to occur in certain
position in an utterance in some languages. For example, the default phrasal stress in English is reported to occur on the last major word (Russell, 1997), whereas in Kannada language, it reportedly occurs on the first few syllables (Manjula, 1997).

The research concerning prosody of speech in individuals with brain damage has often been carried out with 3 main objectives:

a) To establish the neural substrates for processing of prosody, that is, to identify the neurological structures that govern processing of prosody.

b) To describe aspects of prosody in individuals with specific brain damage.

c) To identify the cause of dysprosody in individuals with brain damage.

With regard to the first objective, several hypotheses were proposed to explain the neurological basis of processing of prosody.

a) The right hemisphere hypothesis contends that all aspects of prosody are independently processed by the right hemisphere and integrated with the linguistic information (which is processed by the left hemisphere) via interhemispheric callosal connections (Klouda, Robin, Graff-Radford, & Cooper, 1988).

b) The functional lateralization hypothesis assumes that there is a continuum from linguistic to affective functions of prosody and the processing shifts from the left hemisphere (for linguistic based tasks) to the right hemisphere (for affect based tasks) (Van Lancker, 1980).

c) The acoustic cues hypothesis contends that duration and pitch may be independently lateralized (Van Lancker & Sidtis, 1992).
d) The subcortical processing hypothesis claims that prosodic functions are highly dependent on processing of these functions in subcortical structures and are not lateralized to one or another hemisphere (Cancelliere & Kertesz, 1990).

In respect to the second hypothesis, distinction was made with respect to prosodic deficits resulting due to Right Hemisphere Damage (RHD) versus Left Hemisphere Damage (LHD). The earlier assumptions held that both linguistic and affect based prosody are compromised following right hemisphere damage (Blumstein & Cooper, 1974; Weintraub, Mesulam, & Kramer, 1981; Ley & Bryden, 1982; Grant & Dingwall, 1984; Shapiro & Danly, 1985; Shipley-Brown, Dingwall, Berlin, Yeni-Komshian, & Gordon-Salant, 1988). The other presumption was that only affective prosody is impaired due to RHD (Zurif & Sait, 1970; Zurif & Mendelsohn, 1972; Zurif, 1974; Van Lancker, 1980; Van Lancker, 1987; Heilman, Bowers, Speedie, & Coslett, 1983; Gandour, Larsen, Dechongkit, Ponglorpisit, & Khunadorn, 1995; Perkins, Baran, & Gandour, 1996; Geigenberger & Ziegler, 1998; Pihan, Altenmuller, Hertrich, & Ackermann, 1998). Still others argued that it is the F0 feature that is impaired in RHD individuals (Robin, Tranel, & Damasio, 1990; Van Lancker & Sidtis, 1992) and duration is impaired in those with LHD (Cooper, Soares, Nicol, Michelow, & Goloskie, 1984; Gandour, Dechongkit, Ponglopirst, & Khunadorn, 1994; Schirmer, Alter, Kotz, & Freiderici, 2001). Robin et al. (1990) found that right temporo-parietal lesions disrupted the discrimination of tones, but not perception of time patterns, while lesions in homologous regions of left hemisphere had opposite effects.
Among LHD individuals, the clients with non-fluent aphasia tended to be less proficient in signaling stress contrasts compared to fluent aphasics (Vijayan & Gandour, 1997). They erred more frequently on words with irregular stress than those with regular stress (Cappa, Nespor, Ielasi, & Miozzo, 1997; Laganaro, Vacheresse, & Frauenfelder, 2002). The clients with LHD non-fluent aphasia also had difficulty in shifting stress in stress-clash situations relative to clients with LHD fluent aphasia. Specific F0 deficits such as restricted F0 range (Ryalls, 1982; Cooper et al., 1984; Ryalls & Reinvang, 1986) and impaired declination in longer sentences were found in individuals with Broca's aphasia (Danly & Shapiro, 1982). In clients with Wernicke's aphasia, F0 variability and frequent F0 resets were observed (Danly, Cooper, & Shapiro, 1983).

The timing deficits were also reported to be common in clients with non-fluent aphasics, specifically those with Broca's aphasia (Gandour, Petty, & Dardarananda, 1989; Baum, 1992; Gandour, Dechongkit, Ponglorpisit, Khunadorn, & Boongird, 1993; Gandour et al., 1994; Ouellette & Baum, 1994). The timing control was preserved in clients with fluent aphasia in shorter utterances but impaired in longer stretch of sentences (Cooper et al., 1984; McNeil, Liss, Tseng, & Kent, 1990; Gandour, Ponglorpisit, Khunadorn, Dechongkit, Boongird, & Boonklam, 1992a, 1992b; Gandour et al., 1994).

The third objective set out to establish the cause of prosodic deficits in brain-damaged individuals, more specifically those due to left hemisphere damage. Gandour, Ponglorpisit, Khunadorn, Dechongkit, Boongird, Boonklam, and Potisuk (1992)
suggested that F0 deficits in LHD individuals resulted due to inadequate timing control. However, intact F0 production in the presence of abnormal timing in LHD individuals suggested that there may be dissociation in production of F0 and speech timing in individuals with aphasia (Seddoh, 1999, 2000, & 2004).

The temporal deficits observed in clients with non-fluent aphasia suggest that these individuals exhibit impaired timing at all levels of linguistic structure. Whereas, the clients with fluent aphasia retain timing control in shorter units of speech while displaying sentence level temporal processing abnormalities (Cooper et al., 1984; McNeil, Liss, Tseng, & Kent, 1990; Gandour et al., 1992a, 1992b; Gandour et al., 1994). Such different pattern of temporal deficits in clients with fluent and non-fluent LHD aphasia suggests different underlying mechanisms. In clients with non-fluent aphasia it is thought to be due to impaired phonetic implementation (Gandour et al., 1994). While in clients with fluent aphasia, Gandour et al. (1993) suggested that it may be due to limitations in speech planning, leading to breakdown in temporal control of longer utterances.

**Need for the study**

Few studies have reported the features of stress and intonation in some Indian languages (Sethi, 1971; Rathna, Nataraja, & Samuel, 1976; Manjula, 1979; Nataraja, 1981; Rathna, Nataraja, & Subramanyaiah, 1982; Patil, 1984; Nandini, 1985; Ravisankar, 1987; Savithri, 1995; Asher, 1997; Manjula, 1997; Sadanand & Vijayakrishnan, 1998; Geethakumary, 2002; Girija & Neeraja, 2003; Girish, 2004; Krishna & Manjula, 2004).
However, little attempt was made in any of the Indian languages including Kannada language to understand these features in the speech of individuals with aphasia, specifically those with Broca's aphasia. In comparison, extensive research was carried out to investigate in processing of prosody in clients with aphasia in other languages of the world like English (Baum, Daniloff, Daniloff, & Lewis, 1982; Danly & Shapiro, 1982; Danly et al., 1983; Cooper et al., 1984; Baum & Pell, 1997; Seddoh, 1999, 2000, & 2004), Norwegian (Ryalls & Reinvang, 1986; Moen & Sundet, 1996), Italian (Cappa et al., 1997; Lagnaro et al., 2002), Spanish (Pietrosemoli & Mora, 2002), Thai (Gandour et al., 1988; Gandour et al., 1989; Gandour et al., 1992; Vijayan & Gandour, 1997; Gandour, Ponglopirisit, Potisuk, Khunadorn, Boongird, & Dechongkit, 1997; Balan & Gandour, 1999; Gandour & Baum, 2001), and Chinese (T'sou, 1978; Naeser & Chan, 1980; Packard, 1986). Despite these extensive studies, questions regarding the nature of dysprosody in the speech of individuals with Broca's aphasia and its cause have not been answered equivocally. In addition, the influence of length and complexity of linguistic unit and speech mode on the speech prosody in clients with Broca's aphasia is not clearly understood. These factors prompted the present study.

**Objectives of the study**

The study aimed to address 2 broad objectives:

1) To study some aspects of stress and intonation in the speech of individuals with Broca's aphasia in spontaneous narrative discourse mode in Mysore-Bangalore dialect of Kannada language.
2) To compare the results obtained in individuals with Broca’s aphasia against those of normal control group.

**Method**

The experimental group included 10 male subjects with Broca's aphasia whose expressive speech consisted of at least phrases. The individuals with Broca's aphasia had left hemisphere damage resulting due to stroke. The age range of clients with Broca's aphasia was from 45 - 60 years ($M = 54.00, SD = 5.23$). Fifteen normal male subjects in similar age range of 45 - 60 years ($M = 52.67, SD = 5.05$) served as control group. In order to determine age related variations in the selected acoustic measures, the experimental and control groups were further divided into three subgroups: 45 - 50 years, 51 - 55 years, and 56 - 60 years. 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 subjects in the experimental group were compared. All the experimental and control group subjects were native speakers of Mysore-Bangalore dialect of Kannada language. The subjects narrated a picture stimulus of a standardized test called the Linguistic Profile Test in Kannada language (Karanth, 1980). The subjects' utterances were recorded on a digital tape recorder and later subjected to analysis.

**Analysis**

The various aspects of stress and intonation in the uttered speech samples of experimental and control subjects were analyzed in two sections: (a) perceptual analysis and (b) acoustic analysis.
a) Perceptual analysis

The perceptual analysis was carried out for the identification of two key elements of prosody - intonation unit and nuclear stressed syllable. Together, they formed the basis for evaluation of acoustic correlates of stress and intonation. The reliability of identification of intonation units and nuclear stressed syllable by 2 judges was checked using reliability coefficient ‘Alpha’. 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 subjects it was 0.9506. The item-by-item inter-judge reliability coefficient ‘Alpha’ for identification of nuclear stressed syllable in clients with Broca’s aphasia was found to be 0.9405 while for normal control subjects it was 0.9203.

b) Acoustic analysis

The acoustic analysis was carried out using Computerized Speech Lab (CSL) Model 4400 of Kay Elemetrics Corp. The acoustic analysis included measurement of fundamental frequency (F0) and temporal features that represented various aspects of stress and intonation. To determine the reliability of acoustic measurements, 20% of the speech sample was measured independently by another Speech pathologist with experience in instrumental analysis of F0 and duration parameters associated with stress and intonation. The data obtained was subjected to 4-way comparison between

1) subgroups of clients with Broca's aphasia
2) subgroups of normal controls
3) corresponding subgroups of clients with Broca's aphasia and normal controls
4) combined experimental and control group

**Statistical analysis**

The statistical analysis was carried out using the SPSS 12.0 software. The following statistical measurements were applied:

- Reliability coefficient – ‘alpha’ was applied to determine
  1) inter-judge and intra-judge reliability for identification of intonation units
  2) inter-judge and intra-judge reliability for identification of nuclear stressed syllables
  3) inter-judge reliability for measurement of various acoustic features using CSL 4400 software.

- Oneway ANOVA: This measure was employed to check significance of difference in mean of the various acoustic measures between the
  1) three subgroups of clients with Broca’s aphasia
  2) three subgroups of normal controls

- Independent samples t - test: This measure was employed to check significance of difference in mean of the
  1) number of intonation units between experimental and control group
  2) length of intonation units (number of syllables in intonation unit) between experimental and control group
  3) various acoustic measures between corresponding subgroups of clients with Broca’s aphasia and normal controls
4) various acoustic measures between combined experimental and control group

Implications of the study

The results obtained will be useful to

• understand the nature and processing of prosodic features involving stress and intonation in clients with Broca's aphasia.
• devise tests to evaluate prosody in clients with Broca's aphasia speaking Kannada language.

Limitations of the study

1) The focus of present study was to carry out acoustic-phonetic analysis of prosody in spontaneous narrative discourse. It did not include phonological aspects of prosody in discourse. The discourse task was chosen to capture prosody in the most natural mode.

2) The study included only clients with Broca's aphasia. It thus imposes restrictions on generalizing and inferring about neural correlates of processing of prosody.

3) In order to maintain homogeneity with respect to variables such as language, dialect, etiology, level of speech expression, and handedness, subjects in the experimental group were limited.

4) Further, the experimental group consisted of only male subjects. However, this was purely coincidental. The female subjects conforming to the homogeneity criteria adopted for the study were not available.
5) The study considered evaluation of prosody in individuals speaking Mysore-Bangalore dialect of Kannada language. Individuals belonging to other dialects of Kannada like Gulbarga Kannada, Dharwad Kannada, Chitradurga Kannada, among others were not studied.