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**Original Research**

# A Comparative Study on Emotional Prosody in Patients with Broca's and Wernicke's Aphasia

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**Abstract**
Prosody, the rhythm, stress and intonation of speech provides important information beyond literal meaning of a sentence. Belyk& Brown (2013) functionally distinguished two forms of prosody, namely linguistic prosody and emotional (affective) prosody.Prosody has three main physical parameters; fundamental frequency (F0), duration, and amplitude. As stated in different literatures, patients with both Broca's and Wernicke's aphasia exhibit dysprosodic features in their speech. The aim of the present study is to compare the production of emotional prosody in patients with Broca's aphasia and Wernicke's aphasia. A total of 10 Punjabi speaking aphasic participants between age group 50 to 65 years with mean age of 58.4 years were included in the present study. They were divided into two groups: Group I consisted of five patients with Broca's aphasia and Group II consisted of five patients with Wernicke's aphasia. Praat software version 5.2.01 was used for acoustic analysis of speech samples of all the participants. To analyse emotional prosody, two frequency related parameters (average F0, F0 slope), two intensity parameters (average intensity and maximum intensity) and duration of sentence parameters were considered. The results revealed that patients with Broca's aphasia exhibited higher mean values of F0, higher utterance duration and lower amplitude as compared to those with Wernicke's aphasia which is indicates that patients with Broca's aphasia exhibit more dysprosodic components than that of Wernicke's aphasics in their speech.

**Key words:** Aphasia, Emotional Prosody, Neurolinguistics, Acoustic Analyses



## Introduction:

Prosody, the melody of speech, is considered one among the major aspects of communication. According to American Psychological Association (2014), Prosody- the rhythm, stress and intonation of speech provides important information beyond literal meaning of a sentence. It is also used to provide semantic information. Several studies indicated that prosody serves as a facilitator for different aspects of information processing and communicative functions including emotional (affective), pragmatic, and linguistic aspects (Baum et. al., 2001).Belyk& Brown (2013)functionallydistinguished two forms ofprosody,namely linguistic prosody and emotional (affective) prosody. Linguistic prosody relates to the intonation of sentences, including the specification of focus within sentences, stress within polysyllabic words, segmentation of speech stream into sentences and broad pragmatic categories of utterances (Xu & Xu, 2005).On the other hand, emotional prosody is defined as the ability to express emotionsbybringingvariations to different parameters of human speech, such as pitch contour, intensity and duration (Besson, Magne, &Schon, 2002). The emotional prosody conveys emotional states such as happiness, sadness and anger. For example, in terms of variations in fundamental frequency (F0), it is known that expressions of happiness are generally characterized by higher and more variable F0 (Viscovich et al., 2003). In contrast, the linguistic prosody conveys linguistic functions such as interrogatives, statements, and imperatives. It has been found, for example, that statements in different languages are distinguished with low F0 peaks, whereas imperatives and interrogatives have higher F0 (Bauer, 1987). Prosody has three main physical parameters: fundamental frequency (F0), duration, and amplitude. These physical components are perceived by the listener as pitch, rate, and loudness. Many acoustic studies found that variations in fundamental frequency (F0), duration and intensity

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(amplitude) can be a predictor of emotional prosody (Gussenhoven& Carlos, 2004, Nesporet al. 1986).

There is a dearth of published literature addressing neuroanatomical and neurophysiological mechanisms involved in prosody production(Aziz-Zadeh et al., 2010). However, frontal and temporal networks are considered to be central in prosody production. Affective components of prosody production have been reportedly related to basal ganglia and limbic areas (Pichon&Kell, 2013). In general, prosody production yielded bilateral activation patterns but the contribution of posterio-superior temporal gyrus (pSTG) seemed to be stronger in the right hemisphere (Pichon&Kell, 2013).

Aphasia is a language disorder caused by lesion to different brain areas, traditionally either expressive or receptive type. The most common expressive type of aphasia is Broca's aphasia (caused due to lesion in Broca's area of the frontal lobe) and most common type of receptive aphasia is Wernicke's aphasia (caused due to lesion in Wernicke's area of the temporal lobe). It may affect different modalities of language function, such as speaking, writing and reading. It also affects different levels and components of the language system, including phonology, lexicon, syntax, and, semantics. These components are affected on the word, syllable, and, sound levels based upon the type of language disturbance. Speech of agrammatic speakers with Broca's aphasia is characterized by the omission and substitution of grammatical morphemes (Goodglass, 1976). Goodglass and Kaplan (1972) reported speech of these clinical populations to be labored, slowed and dysprosodic.Additionally, it has also been found that Broca's aphasics display impaired melodic modulation and temporal deficits. Ryalls (1982) evidenced that F0 variation in speech of Broca's aphasics is restricted in range for sentence-level stimuli. Although speech of patients with Wernicke's aphasia may be normal in rate and rhythm, some may exhibit dysprosody in their speech (Javed, Reddy, Das &Wroten, 2022).

Emotional prosody is one of the most important component of expressing own feelings and emotions. As stated in different literatures, patients with both Broca's and Wernicke's aphasia exhibit dysprosodic features in their speech. It requires keen attention towards emotional prosody of such patientsin order to assess expressionof their emotional states. There is no literature comparing the emotional prosody of patients with Broca's and Wernicke's aphasia. The current study is an attempt to fill up some of the gaps in understanding how prosodic features vary between Broca's and Wernicke's aphasia.

The aim of the present study is to compare the production of emotional prosody in patients with Broca's aphasia and Wernicke's aphasia.

## Methods:

### Study design & sampling methods

A comparative survey along with convenience sampling method was used to carry out the study.

### Participants

A total of 10 patients with aphasia aged between 50 to 65 years (mean age = 58.4 years, SD = 2.53) were included in the present study. All the participants had a good proficiency in Punjabi language. All the participants were referred from the department of neurology of Guru Gobind Singh Medical College & Hospital, Faridkot, Punjab and diagnosed by neurologists. They were divided into two groups: Group I consisted of five patients with Broca's aphasia and Group II consisted of five patients with Wernicke's aphasia.

### Inclusion & exclusion criteria for Group I

1. All the participants had bilateral hearing sensitivity within normal limits as assessed by an Audiologist.
2. None of the participants had memory loss and any other neurocognitive and neurolinguistic impairments other thanBroca's aphasia as diagnosed by Neurologists and Speech Language Pathologists.
3. Patients with other comorbid conditions were excluded from the study.
4. For Group I, Western Aphasia Battery (WAB) score revealed Spontaneous Speech (3-4), Auditory Comprehension (7-8), Repetition (5-6), and Naming (7-8).
5. The Broca's aphasics who had no spontaneous speech and repetition skill were excluded from the study.

### Inclusion & exclusion criteria for Group II

1. All the participants had bilateral hearing sensitivity within normal limits as assessed by an Audiologist.
2. None of the participants had memory loss and any other neurocognitive and neurolinguistic impairments other than Wernicke's aphasia as diagnosed by Neurologists and Speech Language Pathologists.
3. Patients with other comorbid conditions were excluded from the study.
4. For Group II, WAB score revealed Spontaneous Speech (8-9), Auditory Comprehension (4-5), Repetition (5-6), and Naming (7-8).
5. The patients with Wernicke's aphasia with no auditory comprehension and repetition skills were excluded from the study.

None of the participants (Group I and II) underwent speech and language rehabilitation of any kind.

### Instrumentation

Acoustic analyses were done using Praat software version 5.2.01 (Boersma&Weenik, 2010) using HP

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Pavilion laptop with Microsoft Windows 10. High fidelity microphone i.e., Sennheiser Electret condenser microphone (Sennheiser HD 201) was used for the purpose of recording. The recordings were done at mono recording mode in the Praat software. The sampling frequency was fixed at 44100 Hz.

**Stimulus**

Personal interview was conducted for all the participants where they were asked about their hobbies, profession, daily activities, job and family to elicit spontaneous speech samples.

**Procedure**

**Phase I (Demonstration of pre-recording trials)**

All the target questions were asked to all the participants for familiarization with the test procedure.

**Phase II (Presentation of test stimuli)**

Participants were informed about the nature of the study and their written consent was obtained. They were asked for different Wh-questions about their hobbies, profession, daily activities, job and family. Each patient was asked to answer each questions three times. Of the three samples, the best response was considered for further analysis.

**Phase III (Recording of stimulus)**

Participants were seated inside an acoustically treated room to eliminate any extraneous noise.Themicrophone was positioned at a distance of approximately 10 centimeters from participants' mouth. A wideband spectrograph was then obtainedusing PRAAT software. Each word of each sentence was truncated from the whole recording and were analysed separately. The distorted segments were eliminated from the sample. The selected signal was then analysed for fundamental frequency, intensity and duration.

**Data Analysis**

Data analysis was done for each target sentences. To analyse emotional prosody, two frequency related parameters (average F0, F0 slope), two intensity parameters (average intensity and maximum intensity) and duration of sentence parameters were considered. The spectrographic representations of target sentence occurrence wereanalysed for the features mentioned above.

**Statistical Analysis**

All the statistical analysis for the present study was performed using SPSS20 software. One way ANOVA was used with the significance level set at 95% to assess the significant differences in acoustic features of emotional prosody between two groups.

**Results:**

The mean score was calculated for each parameter of target word and the difference in their mean was obtained. One way ANOVA was applied to find out any significant difference in acoustic features of emotional prosody between the two groups.

Table-1 shows mean and standard deviation of F0 between patients with Broca's and Wernicke's aphasia. One way ANOVA was done to compare between two groups which revealed there was significant difference in F0between two groups, $p=0.000919$ ($p<0.05$, df =1) with F value of 26.10 (Table-2).

Table-3 shows mean and standard deviation of difference in rate of F0 change (F0 slope) in Hzbetween two groups. One way ANOVA was done to compare between two groups which revealed there was significant difference in F0slopebetween two groups, $p=0.017$ ($p<0.05$, df =1) with F value of 8.99 (Table-4).

Table-5 shows mean and standard deviation of average intensity in dBbetween patients with Broca's Aphasia and Wernicke's Aphasia. One way ANOVA was done to compare between two groups which revealed there was significant difference in average intensitybetween two groups, $p=0.000$ ($p<0.05$, df =1) with F value of 83.71034, (Table-6).

Table-7 shows mean and standard deviation of maximum intensity in dBbetween two groups. One way ANOVA was done to compare between two groups which revealed there was significant difference in maximum intensitybetween two groups, $p=0.00124$ ($p<0.05$, df =1) with F value of 135.414, (Table-8).

Table-9 shows mean and standard deviation of duration of each word in secondsbetween patients with Broca's Aphasia and Wernicke's Aphasia. One way ANOVA was done to compare between two groups which revealed there was significant difference in duration of each word between two groups, $p=0.0001$ ($p<0.05$, df =1) with F value of 13.24807, (Table-10).

**Table-1: Mean and standard deviation of F0 between patients with Broca's and Wernicke's Aphasia**

| Groups | Count | Mean | SD |
|---|---|---|---|
| Broca's Aphasics | 5 | 130.48 | 10.51 |
| Wernicke's Aphasics | 5 | 103.084 | 5.76 |

**Table-2: Comparison of F0 valuesbetween patients with Broca's and Wernicke's Aphasia**

| Source of Variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Between Groups | 1876.352 | 1 | 1876.352 | | |
| Within Groups | 574.9147 | 8 | 71.86434 | 26.10964 | 0.000919 |

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| | | | | | |
|---|---|---|---|---|---|
| Total | 2451.267 | 9 | | | |

**Table-3: Mean and standard deviation of F0slopebetween patients with Broca's and Wernicke's Aphasia**

| Groups | Count | Mean | SD |
|---|---|---|---|
| Broca's Aphasics | 5 | 14.132 | 4.13457 |
| Wernicke's Aphasics | 5 | 10.606 | 2.77808 |

**Table-4: Comparison of F0 slopebetween patients with Broca's and Wernicke's Aphasia**

| Source of Variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Between Groups | 31.08169 | 1 | 31.08169 | | |
| Within Groups | 27.6506 | 8 | 3.456325 | | |
| Total | 58.73229 | 9 | | 8.992699 | 0.017103 |

**Table-5: Mean and standard deviation of average intensitybetween patients with Broca's and Wernicke's Aphasia**

| Groups | Count | Mean | SD |
|---|---|---|---|
| Broca's Aphasics | 5 | 44.66 | 3.59035 |
| Wernicke's Aphasics | 5 | 60.402 | 11.21132 |

**Table-6: Comparison of average intensity between patients with Broca's and Wernicke's Aphasia**

| Source of Variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Between Groups | 619.5264 | 1 | 619.5264 | | |
| Within Groups | 59.20668 | 8 | 7.400835 | | |
| Total | 678.7331 | 9 | | 83.71034 | 0.000 |

**Table-7: Mean and standard deviation of maximum intensitybetween patients with Broca's and Wernicke's Aphasia**

| Groups | Count | Mean | SD |
|---|---|---|---|
| Broca's Aphasics | 5 | 48.272 | 2.56492 |
| Wernicke's Aphasics | 5 | 65.82 | 1.6798 |

**Table-8: Comparison of maximum intensity between patients with Broca's and Wernicke's Aphasia**

| Source of Variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Between Groups | 769.8308 | 1 | 769.8308 | | |
| Within Groups | 16.97888 | 8 | 5.685 | | |
| Total | 786.8096 | 9 | | 135.414 | 0.00124 |

**Table-9: Mean and standard deviation of durationbetween patients with Broca's and Wernicke's Aphasia**

| Groups | Count | Mean | SD |
|---|---|---|---|
| Broca's Aphasics | 5 | 0.398 | 0.00067 |
| Wernicke's Aphasics | 5 | 0.232 | 0.00037 |

**Table-10: Comparison of duration between patients with Broca's and Wernicke's Aphasia**

| Source of Variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Between Groups | 0.06889 | 1 | 0.06889 | | |
| Within Groups | 0.00416 | 8 | 0.0052 | | |
| Total | 0.07305 | 9 | | 13.24807 | 0.0001 |

**Discussion:**

The present study was conducted to compare the emotional prosody between patients with Broca's aphasia and Wernicke's aphasia. We had taken 5 patients with Broca's aphasia and 5 patients with Wernicke's aphasia to carry out the study. Acoustic analyses were done using PRAAT software. The parameters considered for assessing emotional prosody were two frequency related parameters (average F0, F0 slope), two intensity parameters (average intensity and maximum intensity) and duration of sentence.The results reveal patients with Broca's aphasia exhibited higher mean values of F0, higher utterance duration and lower amplitude as compared to Wernicke's aphasics. This in turn lead to patients with Broca's aphasia exhibiting more problems in emotional prosody production than Wernicke's aphasics. This suggests that there is a divergence in emotional prosody production of patients with Broca's aphasia when compared with Wernicke's aphasics. Patients with Broca's aphasia exhibit more dysprosodic components than that of

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Wernicke's aphasics.The speech characteristics of patients with Broca's aphasia can be typified by slow, labor and dysprosodic whereas the patients with Wernicke's aphasia exhibits less dysprosodic component in their speech as compared to those of Broca's aphasia (Goodglass& Kaplan, 1972).

**Conclusion:**

It is concluded from the current study that production of emotional prosody of Broca's aphasics is significantly more affected than Wernicke's aphasic patients. The parameters which are supposedly most prominent for conveying emotional prosody, which were F0, intensity and duration, were taken into account and analysed statistically. Results indicated that there were significant differences in acoustic parameters when both the groups were compared.It can be said that, firstly, these acoustic parameters can be good predictor of emotional prosody, secondly, Broca's Aphasics demonstrate poor emotional prosody skill than Wernicke's aphasics. This acoustic investigation will contribute to the neurolinguistic research in aphasia across languages. Furthermore, this study can be a guide to rehabilitate these populations keeping eyes on production of emotional prosody. This study can be further extended with large sample size to observe the reproducibility.

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