Perception of linguistic and emotional prosody in Parkinson's disease - evidence from Slovene.

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ABSTRACT
The present study investigated the perception of emotional and linguistic prosodic functions in speakers of Slovene language affected by Parkinson's disease. Eight participants with a diagnosis of Idiopathic Parkinson's disease (PD group) and eight elderly healthy controls (HC), matched for age and years of education, were tested using an identification and a discrimination task for emotional and linguistic prosody. The stimuli for linguistic prosody consisted of sentences uttered as a question or as a statement. The stimuli for emotional prosody consisted of sentences uttered in six different emotional tones: anger, disgust, fear, happiness, sadness and pleasant surprise. Compared to healthy control the overall performance of the PD group was lower in three out of four tasks: linguistic identification, linguistic discrimination, and emotional discrimination. Moreover, the PD group identified less accurately negative emotions, more specifically anger and sadness.

Keywords
Parkinson's disease, receptive prosody, emotional prosody, linguistic prosody

1. INTRODUCTION
Prosody, the rhythm and melody of speech, plays many important functions in human communication. Through the variation of acoustic cues of pitch, loudness, and intensity speakers can convey linguistic (e.g. stress, sentence mode), as well as extra linguistic information (e.g. attitudes, emotions, irony and sarcasm) [1]. In neurolinguistics literature, two main functions of prosody are distinguished: linguistic and emotional [1]. Linguistic prosody encodes linguistic distinctions (e.g. phrase boundaries) [2]. Emotional prosody encodes information about the emotional state of the speaker or the emotional emphasis of the uttered content [3]. The processing of prosodic features of speech seems to rely on different neurocognitive mechanisms than the processing of other linguistic domains (e.g. syntax or semantics) [1]. A comprehensive model of the brain structures involved in emotional and linguistic prosodic processing is still missing [1]. Evidence from lesion [4] and neuroimaging [5] studies suggest that the basal ganglia, a subcortical structure with numerous connections to cortical areas, might play a role in how we process (express and perceive) linguistic and emotional prosody.

Parkinson's disease (PD) is a neurodegenerative disorder, characterized by the loss of dopaminergic cells in one of the nuclei of the basal ganglia. PD has been associated with expressive prosodic impairments and PD speech described as monotonous, lacking loudness and inappropriate in speech rate [6]. More recently, evidence for the receptive prosodic ability in PD has also been found [7-12]. Many studies investigating the perception of emotional prosody in PD reported a deficit in the recognition for specific emotions: sadness [11,12], anger [9], fear [9], and disgust [7,9,11]. Lower recognition rates in the perception of emotions in PD seem to converge on negative emotions [13]. Other studies [14-16] however, found no evidence for an impaired perception of emotional prosody in PD. Investigations of the recognition of linguistic prosody in PD report a preserved ability to recognize prosodic meanings of smaller units, such as words (e.g. PROject – noun, projECT – verb) and an impaired perception of prosodic meanings that require integration of prosodic information on longer units, such as for spoken sentences (e.g. the rising intonation indicating a question) [17]. The above described receptive prosodic difficulties in PD have been found independent of dementia or depression, but strongly correlated with executive functions and working memory capacity [8]. Among studies on prosodic disorders in patients with brain conditions, only few investigated the perception of both types of prosodies in the same group of patients. Moreover, contributions from Slavic languages are missing.

The aim of the current study was to investigate the perceptive ability of emotional and linguistic prosody on sentence level for speakers of Slovene language affected by PD, similarly to studies for Germanic (e.g. English; [10]) and Romance languages (e.g. Italian; [7]). For the investigation of linguistic prosody, we tested the identification and discrimination of questions and statements. For emotional prosody, we tested the identification and discrimination of utterances expressing six different emotional categories: anger, disgust, fear, happiness, sadness, and pleasant surprise. A prosody recognition paradigm consisting of a combination of an identification and a discrimination task was administered to the participants. Along the lines of Pell [10], we expected PD participants to perform less accurately in the linguistic and emotional identification tasks, but no impairment was expected in the discrimination task for linguistic and emotional prosody. Moreover, we expected the PD group to perform worse in the identification of negative emotions and the reduced recognition to be emotion specific.

2. MATERIALS AND METHODS

2.1 Participants

Eight individuals diagnosed with idiopathic PD (seven males and one female) and eight healthy controls (four males and four females), whose first language is Slovene, were included in the study. Participants of the PD group were recruited from the University Medical Center of Ljubljana, Department of Neurology. The participants for the HC group were recruited from the Retirement Home of Bežigrad, Ljubljana. Exclusion criteria for both groups included: dementia, hearing problems, language disorders, and depression. The neuropsychological assessment of participants included the administration of the Mini Mental State Examination (MMSE) [18]. The demographic data, together with the statistical comparison between groups using independent samples t-test, is presented in Table 1. The PD and HC groups did not differ significantly with respect to age $t(14) = -1.071$, $p = .370$ (PD = 77.38 ± 9.1; HC = 71.88 ± 11.3), years of education $t(14) = -1.007$, $p = .175$ (PD = 14.75 ± 4.6; HC = 12.75 ± 3.1), and MMSE scores $t(14) = 2.016$, $p = .063$ (PD = 28.13 ± 0.6; HC = 28.88 ± 0.8). Moreover, the comparison of the distribution of males and females between groups did not result as significant ($p = .282$, df = 1, Fischer's exact test).

Table 1: Demographic, neuropyschological, and neurological information for PD and HC (mean ± SD) together with the statistical comparison for age, years of education, and MMSE scores.

Variable	PD group Mean ± SD	HC group Mean ± SD	t-Test P value
Age (years)	77.38 ± 9.1	71.88 ± 11.3	> 0.05
Education (years)	14.75 ± 4.6	12.75 ± 3.1	> 0.05
MMSE (/30)	28.13 ± 0.6	28.88 ± 0.8	> 0.05

2.2 Materials

A new inventory of audio stimuli, uttered by an actress, was built for the purpose of this study. In order to ensure that the identification and discrimination would be based on prosodic cues and not on the content, pseudo-words (constructed from existing Slovenian syllables) were used in sentences (e.g. "*Prohast katoh groji zdrog")*. Ten raters first validated all stimuli. Included in the narrow selection were only those that scored high on the recognition test (at least 70%).

2.2.1 Stimuli-identification tasks

For the linguistic prosody identification task we used 20 utterances, 10 were statements and 10 questions. For the emotional prosody condition 42 utterances were used uttered in 6 distinct emotional tones: anger, sadness, disgust, fear, happiness and pleasant surprise (42 utterances: 7 utterances × 6 emotional categories).

2.2.2 Stimuli-discrimination tasks

The stimuli in the discrimination tasks consisted of pairs of prosodically same or different utterances. The content of two paired utterances was kept equal. For the linguistic prosody discrimination task 16 pairs of utterances were used, 8 uttered with the same and 8 with different intonation. For the emotional prosody discrimination task 20 pairs of utterances were used, 10 uttered with the same emotional tone and 10 with different.

2.3 Experimental tasks and procedure

For both experimental conditions (linguistic and emotional) we administered an off-line forced choice identification task followed by the corresponding off-line forced choice discrimination task. In the identification task single stimuli were presented in each trial (linguistic prosody condition: 20 trials; emotional prosody condition: 42 trials) and participants were asked to recognize and choose the correct label for stimuli belonging to distinct linguistic (question, statement) or emotional (anger, disgust, fear, happiness, sadness, pleasant surprise) categories. In the discrimination task, participants were presented with pairs of stimuli in each trial (linguistic prosody condition: 16 trials, emotional prosody condition: 20 trials) and were asked to judge whether they are the same or different in regard to prosody. To familiarize the participants with the tasks and speaker's voice, practice trials were presented before every task (not included in the analysis). Participants listened to the stimuli through headphones connected to a touch screen laptop on which they would give their responses.

2.4 Data analysis

Group differences between PD and HC in tasks were analyzed by comparing the proportions of correct responses (raw scores) to stimuli using the Chi-square test. Participant's responses (correct, incorrect) were in all comparisons treated as the dependent variable. The independent variables were: the two groups (PD and HC), the two different tasks (identification, discrimination), and the stimuli type in the identification tasks. The stimuli type for linguistic prosody were questions and statements. The stimuli type for emotional prosody were the six different emotional categories (anger, disgust, fear, happiness, sadness, and pleasant surprise), which were also grouped as positive (happiness and pleasant surprise) and negative emotions (anger, disgust, fear, and sadness).

3. RESULTS

Mean percentages of corrent answers of the PD and HC groups for linguistic and emotional identification and discrimination tasks are reported in Table 2.

Table 2: Mean percentages PD's and HC's correct responses in the identification and discrimination task for both conditions (linguistic and emotional prosody).

	Group	
Task	**HC**	**PD**
1. Identification		
Linguistic	94%	87%
Emotional	50%	43%
2. Discrimination		
Linguistic	93%	79%
Emotional	89%	80%

3.1 Linguistic prosody

Identification task: a significant difference between the participant's overall response to the stimuli was found $\chi 2(1, N = 320) = 5.297$, $p < .05$, with PD being less likely to respond

correctly (87%) compared to HC (94%) (see Table 2). No statistically significant differences in the response to questions $\chi2(1, N = 168) = 2.210$, $p = .137$ or statements $\chi2(1, N = 168) = 3.059$, $p = .080$ was found between groups. Discrimination task: a statistically significant difference $\chi2(1, N = 240) = 10.440$, $p < .01$ was observed between the groups in the overall proportion of correct responses, with PD performing worse (79%) compared to HC (93%) (see Table 2).

3.2 Emotional prosody

Identification task: no statistically significant difference between PD and HC was observed in their overall responses to the stimuli $\chi2(1, N = 672) = 3.449$, $p = .063$ (see Table 2). However, a comparison between PD's and HC's performance in response to negative emotions revealed a statistically significant difference $\chi2(1, N = 448) = 6.531$, $p < .05$, with PD (47%) scoring lower than HC (59%). No statistically significant difference was found between groups for positive emotions $\chi2(1, N = 224) = .183$, $p = .669$. Moreover, a comparison between PD's and HC's performance in response to specific emotions revealed a statistically significant difference for stimuli belonging to two emotional categories: anger $\chi2(1, N = 112) = 4.432$, $p < .05$ (PD 71%; HC; 87%), and sadness $\chi2(1, N = 112) = 10.351$, $p < .01$, (PD 37%; HC 68%). The mean percentage of PD and HC correct responses across different emotional categories is presented in Figure 1**.** Discrimination task: a statistically significant difference $\chi2(1, N = 320) = 4.073$, $p < .05$ was also observed in the overall correct responses between groups in the emotional prosody discrimination task, with PD performing worse (80%) compared to HC (89%) (see Table 2).

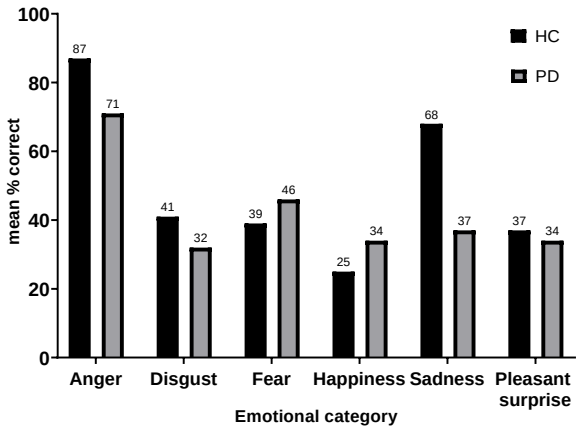

Figure 1: Mean percentage of PD and HC correct responses across the different emotional categories in the emotional identification task.

4. DISCUSSION

The present study sought to investigate the recognition of linguistic and emotional prosody in PD by providing evidence from Slovene language. Overall, compared to HC, the performance of the PD group was significantly lower in three out of four tasks: linguistic identification task, linguistic discrimination task, and emotional discrimination task. These findings did not confirm our first hypothesis, since we expected the PD group to perform significantly worse in the identification tasks only. Our findings are in contrast with Pell [10], where no low performance of PD in the emotional and linguistic discrimination task was found, but are in line with Ariatti, Benuzzi and Nichelli [7], who reported a low performance of PD in the discrimination tasks for both types of prosody. Moreover, Pell and Leonard [11] also reported a marginally significant worse performance of PD compared to HC in the discrimination of emotional prosody. Our PD group scored significantly lower than HC in the linguistic identification task, which tested the participants' ability to identify utterances as sentences or as questions based on intonation only, similarly to Ariatti et al. [7]. No statistically significant difference between PD and HC emerged in the overall scores in the emotional identification task. However, a further analysis comparing group performances in negative and positive emotions revealed a significant difference for negative emotions. The impoverished performance of PD was evident for the emotional categories of sadness and anger. These findings confirmed our predictions on PD's performance to be lower for negative emotions compared to positive ones and for it to be emotion specific. Our findings on low recognition rates for negative emotions (anger, disgust, fear, and sadness) and for the emotional categories of sadness and anger are in line with several other studies [9,11,12]. Overall, the results of our study supported the notion that PD affects receptive prosodic ability. Our study was the first attempt to investigate how Slovene speaking individuals diagnosed with PD perceive prosody conveying emotional and linguistic information on sentence level.

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