Effect of Parkinson Disease on Emotion Perception Using the Persian Affective Voices Test

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Summary: Background and Objectives: Emotion perception plays a major role in proper communication with people in different social interactions. Nonverbal affect bursts can be used to evaluate vocal emotion perception. The present study was a preliminary step to establishing the psychometric properties of the Persian version of the Montreal Affective Voices (MAV) test, as well as to investigate the effect of Parkinson disease (PD) on vocal emotion perception.

Methods: The short, emotional sound made by pronouncing the vowel "a" in Persian was recorded by 22 actors and actresses to develop the Persian version of the MAV, the Persian Affective Voices (PAV), for emotions of happiness, sadness, pleasure, pain, anger, disgust, fear, surprise, and neutrality. The results of the recordings of five of the actresses and five of the actors who obtained the highest score were used to generate the test. For convergent validity assessment, the correlation between the PAV and a speech prosody comprehension test was examined using a gender- and age-matched control group. To investigate the effect of the PD on emotion perception, the PAV test was performed on 28 patients with mild PD between ages 50 and 70 years.

Results: The PAV showed a high internal consistency (Cronbach's $\alpha = 0.80$). A significant positive correlation was observed between the PAV and the speech prosody comprehension test. The test-retest reliability also showed the high repeatability of the PAV (intraclass correlation coefficient = 0.815, $P \leq 0.001$). A significant difference was observed between the patients with PD and the controls in all subtests.

Conclusion: The PAV test is a useful psychometric tool for examining vocal emotion perception that can be used in both behavioral and neuroimaging studies.

Key Words: Nonverbal affect voices−Emotion perception−Validity−Reliability−Parkinson disease.

INTRODUCTION

Human beings express their emotions through different channels, including visual and auditory channels. Social interactions and the ability to respond to emotional signals are essential to purposeful interpersonal interactions.[1] Along with facial affective processing, vocal affective processing is fundamental to establishing an adequate and consistent relationship.[2] Considering the significant role of emotions in communication, exploring the mechanisms of perceiving emotions through visual and auditory channels is a topic of interest.[3−9]

Facial expressions are the universal language for expressing emotions.[10,11] Several studies have investigated emotional perception through facial expressions using nonverbal visual stimuli, such as the International Affective Picture System[12] or Ekman faces.[13−15] An advantage of the Ekman faces test is that it is nonverbal, making its application independent of language.[16,17] Another method of conveying emotions is auditorily. The majority of previous research on auditory affective processing has focused on speech prosody.[18−22] The study of emotions perceived from speech prosody, however, poses several challenges. The possible relationship between linguistic concepts and emotion perception is one of the main challenges. Different methods have been used to decrease the effect of this relationship. Using meaningless phrases such as Logatomes to control semantic processing,[18] application of a low-pass filter to verbal stimuli,[23] and using nonverbal affect bursts are some of the most well-known approaches.[24−31] Nonverbal affect bursts, expressed in facial or vocal forms, contain basic and universal features of communication.[11,27,32] Some classes of nonverbal affect bursts, such as laughing, crying, and screaming, are primitive (noncomplex) emotions, forming an interesting subject for research on the responses to emotion.[25,33,34]

The Montreal Affective Voices (MAV) is a set of 90 nonverbal affective bursts corresponding to emotions such as anger, happiness, disgust, fear, pain, pleasure, sadness, surprise, and neutrality, expressed by five actors and five actresses. In the MAV, the intensity, arousal, and valence of each of the eight emotions were evaluated in 30 subjects.[25] This test has several advantages: (1) The interjections do not include any semantic information and are therefore not affected by the interplay between the semantic and the emotional contents. (2) The stimuli are not limited by linguistic boundaries and can therefore be used to compare outcomes in different countries and to evaluate cross-cultural differences. (3) These interjections express basic emotions that are close to the basic emotions perceived by children and animals, making it possible to conduct comparative, cross-species studies, or to compare studies addressing human development. (4) The MAV stimuli are very similar to those used in emotional visual processing studies, such as the

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Ekman faces, enabling the comparison of different modalities and different studies on cross-modal emotional integration. The MAV has been used to study emotion perception in patients with Parkinson disease (PD) who have undergone deep brain stimulation (DBS) of subthalamic nucleus (STN),[35,36] and patients with progressive supranuclear palsy,[37] schizophrenia,[38] and major depressive disorder.[39]

The pathology of PD involves a progressive degeneration of the substantia nigra pars compacta, starting in the lateral tier of the substantia nigra and affecting the dorsal putamen or striatum.[40] Striatal processing in the ventral region of the striatum is eventually influenced either by disease progression or the use of dopaminergic medications. Additionally, primary symptomatology (of the motor symptoms) helps confirm that the dorsal striatum is affected. The PD is divided into four categories according to its clinical origin: (1) idiopathic PD (IPD), (2) secondary PD, (3) the Parkinson-plus syndrome, and (4) heredodegenerative diseases.[41] Anatomic evidence confirms the subthalamic nucleus comprises three distinct areas: the limbic, connective, and motor areas.[42] Basal ganglia circuits, especially the subthalamic nucleus, play an important role in emotion recognition.[8,26,43] Studies have determined the limbic role of the right ventral subthalamic nucleus and its interference in encoding emotional prosody.[35]

Damage to emotion perception in both facial and auditory expressions has been reported in patients with PD.[44] The factors affecting emotion perception in PD can be divided into two groups. First, factors related to emotion recognition tasks (stimulus modality, task type, and expressed emotion). Second, factors related to the patient (disability, depression status, performance on visual-spatial tasks, executive functioning, and medication regimen).[43] Patients with PD may encounter more problems in emotion perception via prosody than via facial expressions. Three hypotheses have been proposed with regard to this problem: (1) emotional prosody perception may be more sensitive to reduced working memory capacity, which is a common problem among patients with PD, (2) the basal ganglia might have a more active role in emotional prosody perception, typically impairing patients with basal ganglia degeneration due to the IPD,[45] and (3) it is typically more difficult to infer emotion from prosody than from faces.[43] Previous studies on emotion perception via prosody in patients with PD have used sentences,[46−48] meaningless words,[49] or filtered statements.[50] Nonverbal affective bursts can also be used in patients with PD to reduce the effect of meaningful concepts in the perception of emotion through vocal expressions. Because of the defects in working memory in PD,[43] using nonverbal affective bursts reduces the influence of working memory on emotion perception.

Cross-cultural studies seek to demonstrate similar perceptions of basic emotions such as happiness, sadness, fear, and anger among different cultures.[27,29,51−54] For example, in the International Affective Picture System (IAPS), the arousal and valence scores were different between Chinese and American participants. The scores of erotic images also differed significantly between Chinese and American women.[55] A cross-race effect was also observed, as the subject recognized the emotion in faces of their own race more quickly than the emotion in faces of other races.[55] The majority of cross-cultural studies conducted on auditory emotion perceptions have investigated the intensity and valence or perception of emotions through words as the stimuli,[11,56−58] and few studies have investigated emotion recognition from nonverbal vocalizations.[25,32,59−61] A cross-cultural study conducted on nonverbal emotional sounds showed that Swedish listeners frequently confuse the Indian and Kenyan vocalizations of distress with vocalizations of sadness; distress vocalizations by subjects from Singapore and United States were confused with fear instead.[29] The majority of positive emotions, that is, achievement or triumph, relief, and sensual pleasure are transmitted by particular cultural signals.[27]

Cross-cultural differences were also observed in a study using the MAV in Japan and Canada.[54] Although there were no differences in the intensity and valence of happiness and sadness ratings between the two groups, the Japanese subjects rated the intensity of anger, disgust, and fear significantly lower. Regarding the valence of emotions, the Japanese expressed less negative scores. Pleasant vocalizations were rated less positively in terms of both intensity and valence by the Japanese compared with the Canadian subjects. These findings reveal important cross-cultural differences in emotion perception by nonverbal vocalizations that express both basic negative and positive emotions.[54] A meta-analysis study also showed that the accuracy of emotion recognition was higher when emotions were both expressed and recognized by subjects from the same national, ethnic, or geographical background.[62] Owing to this evidence indicating cultural effects for identifying the same emotions, we aimed to determine the preliminary psychometric properties of the Persian version of the MAV test (the Persian Affective Voices [PAV] test), as well as to investigate the effect of PD on vocal emotion perception.

METHODS

Test development

To develop the PAV test, 22 actors and actresses participated in designing the test stimuli. Thirty healthy individuals then listened to the recorded stimuli for the preliminary psychometric evaluation. The sounds of 10 actors or actresses were selected based on their assessment. In addition, 16 individuals were retested 4 weeks later to determine the test-retest reliability. Afterward, to examine the effect of PD on the vocal emotion perception using the PAV test, 28 patients with PD and 28 control individuals were selected to rate the test stimuli. The convergent validity was also determined for the control group.

Participants

A total of 22 professional actors and actresses participated in the recording sessions. They had 5−10 years of work experience in acting, covering approximately 15−30 stage and film performances. The participants were asked to make short emotional sounds using the Persian vowel “a.” Before the recording sessions, each emotion was practiced several times. The participants had to show vocal expressions associated with happiness, sadness, anger, pain, pleasure, disgust, fear, surprise, and neutral emotions. For every emotion, the researcher made examples of emotional situations representing that specific emotion, and the actors and actresses improved their vocalizations to make them closer to the target emotion. Eventually, to check the accuracy of the emotional representation of the sounds, the researchers listened to all the records and confirmed those that were clearly recognizable as the target emotion. The recordings were made in a studio equipped with an acoustic room. A Neumann TLM 103 microphone (Georg Neumann GmbH, Berlin, Germany), with a large diaphragm condenser microphone, was used at an approximate distance of 10 cm to the mouth. The frequency range was between 20 Hz and 20 kHz. The sounds were preamplified with Behringer Sonic Ultramizer SU9920 (BEHRINGER International GmbH, Germany). The recordings were digitized at a 96-kHz sampling rate and 24-bit resolution using a Focusrite Saffire Pro 40 Sound Card (Focusrite Audio Engineering Ltd., UK). The sounds were edited in *Adobe Audition* version 3.0 (Adobe Systems Incorporated, San Jose, USA). In this software, the sounds were played at a 32-bit resolution and 44.1-kHz sampling rate in the stereo channel. As each actor and actress had the opportunity to produce several vocalizations, *Adobe Audition* software was used to extract the most accurate representation of the desired emotion, as determined by the research team in a process described later. Moreover, the sounds were normalized in the same software at 90% of the maximum amplitude with a 44.1-kHz sampling rate.[25] From the set of sounds recorded for each emotion by every participant, the sound closest to the target emotion was selected for validity and reliability testing. Two members of the research team evaluated the validity of the intended emotion. If the evaluators did not share the same assessment for any of the sounds, that sound was evaluated by another member of the research team to reach a consensus.

Internal consistency

To assess the internal consistency and reliability of the test, Cronbach's alpha and test-retest methods were used. The Cronbach's alpha was used to assess the accuracy of emotions perceived by listeners. Namely, if a listener correctly recognized the intended emotion, a score of 1, and if incorrectly, a score of 0 (zero) was considered. If a person identified all emotions correctly, he or she received a score of 9. Initially, 30 monolingual native Persian speakers (15 men and 15 women), aged 20−30 years, with normal hearing threshold levels (20 dB hearing level [HL] or better) in an octave frequency of 250−8000 Hz in both ears[63] were selected. The subjects' mean years of education was 16.50 years. They had no history of neurologic and etiologic disorders or neurologic medication use.

The 30 participants provided 10 total ratings for each of the 198 sounds (22 actors and actresses × 9 categories of emotion). The first rating was of the perceived valence of the actor's emotion (from "extremely negative" to "extremely positive," corresponding to anger, disgust, fear, happiness, pain, pleasure, sadness, and surprise), and the second rating was of the actor's perceived arousal (from "not at all aroused," to "extremely aroused"). The final eight ratings were of the perceived intensity of the actor's emotion (from "not at all angry" to "extremely angry," and the same for "fearful," "disgusted," "happy," "in pain," "pleasure," "sad," and "surprised"). Ten-point rating scales were presented one by one for each of the emotions and each part. The scales were in the form of the visual analog scale and were presented in the paper. In our study, the total scores of the PAV test were given based on the 10-point rating scale of intensity.[64] In this study, each participant graded the intensity of nine emotions that were produced by 10 actors or actresses. The total number of PAV's sounds was 90. Grading method ranged from 0 (not at all for example angry) to 10 (extremely angry). In statistical analysis, this range was rescaled to 0 to 1. To compute the average score, PAV test results of participants were summed up and averaged. Finally, the average PAV test result presented in percentage. Before the test, the participants received some information about the type of the sounds, the meaning of valence, arousal and intensity, the emotions in question, and how to fill out the paper. For example, the following instructions were given to each participant: "In this test, the sounds of 22 actors and actresses who have produced the nine emotions of anger, disgust, fear, happiness, neutrality, pain, pleasure, sadness, and surprise will be played for you. Listen carefully to each sound, and first, determine which of the emotions the sound conveys; second, establish the valence of the emotion based on the ten-point rating scale. The sound will be replayed as you request. Each actor or actress has produced each emotion only once. You can ask for a break whenever you need one." Each actor's sounds were presented individually for all the emotions, but the ordering of the emotions was random. The sounds were played at 80 dB HL for the participants using headphones. We used a sound level meter (SLM GM1357) to calibrate the earphones at this level by the conversational method. Regarding "valence," participants were asked to define to what extent a voice was positive or negative based on a 10-scale ranking (from 0 = extremely negative to 10 = extremely positive). For example, anger in general has negative valence and pleasure has positive valence. Regarding "perceived arousal," participants were asked to define how much a voice affected them based on a 10-scale ranking (from 0 = "not at all aroused" to 10 = "extremely aroused"). Regarding "intensity," participants were instructed to express to what extent the voice heard could transfer the intended emotion such as anger, 0 was "not at all angry" and 10 was "extremely angry."

The average scores of intensity obtained by each participant were measured. Based on the evaluations of the 30 participants, the recordings of 5 actors (scores: 90.5%, 88.9%, 86.5%, 84.1%, and 81.2%) and 5 actresses (scores: 89.8%, 89.0%, 88.8%, 88.4%, and 86.9%) who obtained the highest rating of emotional intensity were selected for further evaluation in the subsequent phases.

Test-retest reliability

A total of 20 new subjects (10 men and 10 women), aged 20−30 years, were included for the test-retest. Consent and demographic forms were filled out by these participants. The participants had normal hearing levels in both ears[63] and no history of neurologic disorders or neurologic medication use. They evaluated the sounds of the 10 actors and actresses with the highest rating of intensity on each of the emotions. Two participants did not complete the second test, so the test was repeated by the remaining 16 participants (8 women and 8 men) after 4 weeks[65] to determine the test-retest reliability.

The effect of PD on vocal emotion perception

The PAV test was implemented on 28 individuals with the PD (16 men and 12 women). The inclusion criteria consisted of age 50−70 years (mean age = 56.83 ± 4.23 years), the IPD,[66,67] diagnosed 1−8 years before[68] (mean duration since diagnosis = 4.67 ± 1.24 years), disease severity stages 1 and 2 according to the Hoehn and Yahr Staging of Parkinson's Disease,[45,66,67,69,70] monolingual native Persian speakers, at least a high school education, right-handedness, and having hearing and vision in the normal or modified range.[70] The exclusion criteria consisted of a history of stroke, head trauma or brain surgery,[45,66,67,69,70] and treatments other than antiparkinsonian medications such as L-dopa (including DBS surgery of the STN).[67] Because dementia is common among more than 75% of the patients in advanced stages of PD,[71] the patients' general cognitive ability was measured by the researcher using the Mini-Mental State Examination (MMSE).[11,72,73] Patients who obtained a score less than 26 (the maximum score of the MMSE test is 30)[67,70,73,74] were excluded. Moreover, the subjects' severity of depression was measured using the geriatric depression scale (GDS),[75] and patients who scored higher than 10 were also excluded. This exclusion was due to major depression being associated with a negative total bias in processing emotional stimuli, and because damage to emotional processing is not only limited to interpersonal stimuli (voice and face) in depression but also reduces the ability to properly perceive music.[39]

The PAV test was implemented on the patients during the medication phase (all the patients took their antiparkinsonian medications at least 1 hour before the evaluation and were in an on-medication state during the evaluation).[76] The evaluation was carried out in a quiet room. The procedure was identical for all the patients. The patients were requested to evaluate all the 90 voices (10 actors and actresses × 9 categories of emotion) based on a 10-point rating scale. The evaluation was performed as described in the "convergent validity" section. Each patient evaluated each voice separately. The evaluation condition complied exactly with the test conditions in the original test.

The control group consisted of 28 healthy subjects (16 men and 12 women), aged 50−70 years (mean age = 55.71 ± 3.34 years) and matching with the experimental group in terms of demographic characteristics such as age, gender, and education. The inclusion and exclusion criteria for the control group were the same as in the experimental group. The PAV test was performed with the same procedure as described for the PD group.

Convergent validity

To examine the convergent validity of the test, the relationship between the PAV and the speech prosody comprehension (SPC) test[77] was determined. The SPC test as a Persian test was implemented on the control group. This test is adapted from the Florida Affect Battery, which consists of three sections, including speech prosody, facial expressions, and the contrast between speech prosody and facial expression. The SPC test incorporated a speech prosody section, and 73 sentences were uttered by 22 actors and actresses with eight different tones in the speech prosody section of the test. To assess the content validity of the test, 200 individuals aged 18−30 years and one sound expert listened to the recorded sounds. A total of 169 sounds were ultimately selected. The test-retest reliability of the test was examined on 32 control subjects (aged 18−60 years). This test had a content validity of 100%, a reliability of 94%, and a correlation coefficient of 89%.[77] The SPC test developed consists of four subsets: (1) linguistic distinction, (2) emotional distinction, (3) labeling, and (4) conflict labeling. For linguistic distinction, the subject listens to two spoken statements and then identifies whether the two sentences are linguistically (indicative and interrogative) the same or not. This section consists of 16 items. For emotional distinction, the subject is asked to identify whether the two statements are emotionally the same or different. This section consists of 36 items. For labeling, the subject is asked to express the emotion perceived from the tone of the statements, including neutral and interrogative emotions or anger, fear, disgust, surprise, happiness, and sadness. This section consists of 32 items. The final section, that is, conflict labeling, asks the subject to pay close attention to both meaning and tone of the spoken statement and identify whether the tone contradicts the meaning of the sentence or not. This section consists of 36 items. The total score of the speech prosody test is 120 and is reported in percentage. Before administering the test, instructions on the test format and method of responding to each section were given to each subject. The sounds were replayed as per participants' request, so that they could exercise good judgment in the completion of the form.

Statistical analysis

All the statistical analyses were performed in SPSS version 22 (IBM Corp, Armonk, NY) with $\alpha \leq 0.05$. To determine the reliability of the test, two internal consistency methods were used, including Cronbach's alpha and the intraclass correlation coefficient (ICC). First, Cronbach's alpha was calculated to study the internal consistency of the test; then, the ICC was used for the test-retest. As the distribution of the data was not normal according to the Kolmogorov-Smirnov test, the Spearman correlation coefficient and the Mann-Whitney U test were also used to determine the convergent of the test and to compare the two groups. To interpret the data, Cronbach's alpha values[78] and ICC values above 0.75 were considered excellent, values of 0.60−0.74 were considered good, and values less than 0.40 were considered weak.[79]

RESULTS

Demographic and clinical characteristics

This section presents the descriptive statistics, demographic, and clinical characteristics of the experimental and control groups. The mean age of the subjects in the experimental group was 56.83 (±4.23) years and was 55.71 (±3.34) years in the control group. The mean years of education in the experimental group was 15.16 (±3.55) years and 15.64 (±1.82) years in the control group. The mean MMSE score in the experimental group was 28.1 and 29.85 in the control group. These statistics indicate a significant intergroup difference ($P < 0.001$). The mean severity of disease in the experimental group was 1.30 (mild severity) and the mean depression score was 3.42 in this group, whereas in the control group, it was 1.57, suggesting the lack of significant intergroup differences ($P = 0.080$).

Reliability

The developed test was found to have a high internal consistency (Cronbach's $\alpha = 0.80$) when implemented in 30 subjects. The test-retest reliability showed excellent reproducibility between the first and the second administrations (ICC = 0.815, lower boundary = 0.549, higher boundary = 0.931, $P \le 0.001$). The mean scores were 98.28% and 97.87% for the test and retest, respectively. The difference between the two groups was not significant ($P = 0.596$). Figure 1A presents the test-retest correlation for the PAV in the control group. Table 1 presents the intensity ratings (%) averaged across 5 actors and 5 actresses, and their judgments of each portrayed emotion and its intensity on the rating scale (in 30 subjects). As shown in Table 1, the maximum mean score in the scale was obtained for each emotion. In the control group, the anger and disgust revealed the most error (confusion) with pain, and fear and pleasure had the most error (confusion) with surprise.

Comparison of the PD and the control groups

A significant difference was observed in the test scores between the experimental and the control groups ($t = -6.434$; $P < 0.001$). This significant difference suggests that people with PD score significantly lower on the PAV compared with subjects without PD. The range of the intensity score in the PAV was 91.10%−97.70% in the control group and 51.10%−6.60% in the experimental group. Figure 1B shows significant differences in the scores of the PAV between the experimental and the control groups.

Convergent validity

The Pearson correlation coefficient between the scores of the PAV and the SPC test was calculated for the control group so as to determine the convergent validity of the test. A positive correlation was observed between the scores of the two tests ($r = 0.570$, $P = 0.002$). Figure 1C shows the relationship between the PAV scores and the SPC test scores in the control group.

DISCUSSION

The perception of emotions through the auditory channels can be tested by prosody expression or nonverbal affect bursts.[11] Nonverbal affect bursts are different from prosody in various aspects. One of the most important differences is that nonverbal affect bursts are emotion transmitters that are not limited to linguistic codes, whereas prosody expression uses verbal contents to transmit emotions.[29,32] Emotion perception has been studied in several diseases, including PD.

From a histopathological point of view, PD is a chronic and selective progressive nigrostriatal degeneration of the mesocorticolimbic dopamine system, enabling the study of the potential effects of dopaminergic pathways on emotional processes.[44] Studies have shown defects in the components of emotional processing in patients with PD. These defects include changes in the emotional experiences associated with an emotion, damaged production, and an impaired perception of emotions transmitted through the voice and face.[44]

In our study, the PD group revealed a significantly lower score in the PAV compared with the controls. The MAV has been assessed in the two studies on patients with PD who had undergone STN.[35,36] In one of the studies, emotion perception through the MAV test was less damaged in the early stage of PD.[36] In the other study, patients with PD revealed various difficulties in the perception of emotions during the medication stage and before STN.[35] Our PD group also displayed the most difficulty in perceiving anger,

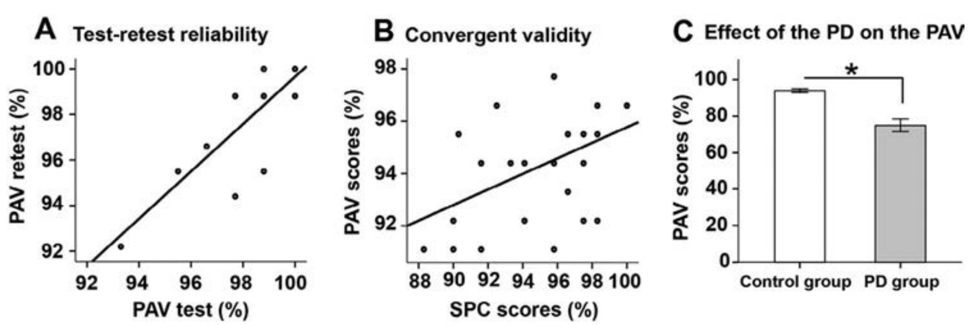

FIGURE 1. Psychometric properties of the Persian Affective Voices (PAV) test. **A**. Reliability: a high relationship was observed between the test and the retest scores in the control group. **B.** Convergent validity: a positive relationship was observed between the PAV scores and the speech prosody comprehension (SPC) scores in the control group. **C**. Effect of the Parkinson's disease (PD) on the PAV: a significant difference was shown between test scores of patients with PD and the control group.

TABLE 1.
The Relationship Between Intensity Ratings Made by the Control Group (n = 30) for Each Emotion (Results Reported as Mean ± Standard Error of the Mean)

	Angry	Disgust	Fear	Happiness	Neutral	Pain	Pleasure	Sadness	Surprise
Angry	**91.67 (2.28)**	2.88 (1.83)	0.76 (2.23)			4.39 (2.21)			0.30 (1.41)
Disgust	1.67 (2.25)	**89.55 (2.31)**	0.76 (2.64)			3.94 (2.53)	2.58 (1.62)		1.52 (2.31)
Fear	1.06 (1.41)	1.21 (2.44)	**84.16 (2.40)**			3.33 (2.64)	0.76 (1.87)		9.48 (2.42)
Happiness				**99.55 (2.08)**				0.45 (2.08)	
Neutral					**99.55 (0.76)**	0.45 (0.76)			
Pain	3.94 (2.25)	2.27 (2.64)	1.82 (1.91)			**89.24 (2.37)**	1.06 (2.53)		1.67 (2.31)
Pleasure		1.97 (2.10)	2.27 (1.74)			2.42 (2.65)	**87.94 (2.25)**		5.39 (2.56)
Sadness				0.30 (2.82)				**99.70 (2.15)**	
Surprise	0.45 (2.08)	1.06 (2.69)	8.21 (2.19)			1.82 (2.69)	0.30 (1.40)		**88.16 (2.42)**

pleasure, disgust, and fear, respectively. This finding was in line with other studies that indicated a reduced ability in identifying negative emotions (anger, disgust, fear, and sadness) compared with positive emotions (happiness and pleasure) in PD.[43,49,80,81] In the McIntosh et al[36] study, patients showed the defect in processing the anger and surprise stimuli in the early stages of PD. In our study, not only the negative emotions were more involved, but also recognition of "pleasure" was impaired, which could be due to cultural differences regarding this particular emotion. In another study on "valence," patients with PD demonstrated more difficulty in identifying voices associated with positive and neutral emotions compared with the control group.[35] In conclusion, although most evidence support that negative emotions are more involved than positive emotions in PD, further studies in this area are required taking into consideration age, disease stage, and cultural differences.

In the control group, a significant positive correlation was observed between the scores of the PAV and the SPC test.[77] As nonverbal affect bursts are components of basic emotional communication,[27] people with difficulty perceiving nonverbal affect bursts may show weaknesses in emotion perception through sentences. Sentences include linguistic information such as meaning and syntax. The perception of emotions through sentences requires the engagement of both cerebral areas responsible for linguistic processing and cerebral areas responsible for auditory emotion processing. The role of the left hemisphere has previously been demonstrated in syntactic-semantic processing.[82,83] Emotional prosody activates the anterior superior temporal gyrus and the anterior inferior frontal gyrus in the right hemisphere.[24] Bilateral dorsal and ventral temporal-frontal pathway connections are also compromised in affective prosody. The temporal-frontal connections in the left hemisphere, particularly the dorsal connections between the anterior STG and the inferior frontal cortex, are involved in processing emotion.[26] The perception of vocal prosody has three stages:[84] first, the extraction of acoustic suprasegmental cues, which is mainly performed by right-sided primary and higher order acoustic regions; second, representing the acoustic sequence of meaningful suprasegmental elements within the posterior of the right superior temporal sulcus; third, the explicit evaluation of emotional prosody at the level of the bilateral inferior frontal cortex.[84] It appears that similar areas in the right hemisphere cooperate in processing the lower levels of the basic suprasegmental vocal cues, linguistics, and emotional prosody. The precise judgment of the linguistic components of intonation, however, is associated with language areas in the left hemisphere, although the orbitofrontal cortex of both sides is involved in the perception of intonation. In addition, it seems that the implicit processing of affective intonation is limited to the subcortical areas that mediate the automatic generation of emotional reactions, such as the amygdala activity in response to fearful stimuli.[84] Common areas of the brain can therefore perceive the emotions created by nonverbal affect bursts (which contain nonlinguistic information) and perceive the emotion conveyed through the statements.

The reliability of the PAV was also assessed with two methods in the control group. First, the Cronbach's alpha correlation was measured for the test, which yielded a high internal consistency. Second, the test-retest was performed, which showed no significant difference between the scores in the first and second administrations of the PAV (within a 1-month interval), suggesting the excellent reliability and reproducibility of the test.[79] In the control group, anger and disgust showed the highest confusion with pain, and fear had the highest confusion with surprise, consistent with the results of Belin et al.[25] Pleasure also revealed the most confusion with surprise. In the Belin et al[25] study, the pleasure showed the highest confusion with happy, and then neutral and surprise respectively with a slight difference.

In our study, the scores of the PAV in the control group were higher than in the past studies,[35,54,81] which might be due to some methodological issues. In this study, each actor or actress produced each emotion (anger, disgust, fear, happiness, neutrality, pain, pleasure, sadness, and surprise) only once. The sounds of each actor or actress were presented separately (the arrangement of the emotions were random), and no time constraint was imposed for stimuli presentation, as the sounds could be repeated more than once at participants' request. In the two past studies,[35,54] the methodology of the study was not quite explained and varied slightly with our study. In the study by Eitan et al,[35] the mean age of the participants was 66.7 years, and their mean level of education was not clarified. In the Koeda et al[54] study, the mean age of the participants was 22.3 years and their mean years of education was reported as 14.1 years. The present study was different from these studies for both mean age (55.71 years) and mean years of education (15.16 years). Although age has been found to affect emotional perception,[85] few studies had individually addressed the effect of education on emotional perception. Hofer et al,[86] however, argued that emotional perception has a positive relationship with the level of education in schizophrenia. Moreover, the emphasis of the Eitan et al[35] study was on "valence," whereas the present study sought to report the intensity scores similar to the Dondaine et al[64] study.

Defects in the perception of emotional prosody in patients with PD may partially be due to the limitations of working memory; however, this limitation seems not to affect the scores of the developed test because it uses nonverbal affect bursts that they have a short duration and represent only basic stimuli.[32] One of the limitations of the present study pertained to the test used for the cognitive evaluation. The MMSE is not a sufficient assessment for identifying cognitive impairments, particularly at the mild level,[47] and further cognitive assessments are required to investigate that the lower emotional perception shown in patients with PD was not influenced by cognitive impairments. Moreover, our study was conducted on a particular age group with a certain level of education. As the age and the level of education can affect emotional perception, their influence on the results of the MAV is recommended to be further examined. We also entered only patients with mild disease severity who had received medical treatments, and those with higher disease severity or those who had undergone different treatments, that is, DBS surgery of the STN, were excluded. As a result, the findings cannot be generalized to other disease intensities and treatments. Finally, further studies are also recommended to determine the convergent validity of the PAV compared with the original MAV, to examine the effects of treatments other than medication, to realize the effect of the onset of involvement in the left or right hemisphere, and to investigate the specificity and sensitivity of the PAV.

CONCLUSION

Our study was a preliminary step to establishing the psychometric properties of the Persian version of the MAV test, and to investigate the effect of PD on vocal emotion perception. The PAV was found to have an acceptable level of reliability and convergent validity for the assessment of auditory emotion perception. As the test developed does not have any verbal content, it is expected to be less dependent on cerebral areas involved in language processing. The PAV provides information about the processing of emotions from nonprosodic auditory stimuli and can be used in behavioral studies and image capturing to address auditory emotion perception.

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