

Deficits in Emotion Perception and Cognition in Patients with Parkinson's Disease: A Systematic Review

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Abstract

Non-motor symptoms (NMS) are common among Parkinson's disease (PD) patients and have a significant impact on quality of life. NMS such as deficits in emotion perception are gaining due focus in the recent times. As emotion perception and cognitive functions share certain common neural substrates, it becomes pertinent to evaluate existing emotion perception deficits in view of underlying cognitive deficits. The current systematic review aimed at examining studies on emotion perception PD in the last decade. We carried out a systematic review of 44 studies from the PubMed database. We reviewed studies examining emotion perception and associated cognitive deficits, especially executive function and visuospatial function in PD. This review also examines how early and advanced PD differ in emotion perception deficits and how the presence of common neuropsychiatric conditions such as anxiety, apathy, and depression as well as neurosurgical procedure such as deep brain stimulation affect emotion perception. The need for future research employing a comprehensive evaluation of neurocognitive functions and emotion perception is underscored as it has a significant bearing on planning holistic intervention strategies.

Keywords: Cognitive deficits, emotion perception, non-motor symptoms, Parkinson's disease

INTRODUCTION

The cardinal motor symptoms of PD appear due to progressive degeneration of dopaminergic neurons in substantia nigra pars compacta^[1-4] and subsequently extend beyond mesencephalic region to neocortex.^[5] Along with motor symptoms, the NMS such as neuropsychiatric symptoms and cognitive deficits among many emerge and evolve as disease progress.^[6,7] One of these NMS, emotion perception deficit is gaining its due importance in the recent past.

Emotion and cognition are distinctive yet interdependent mental aspects.^[8] Emotion perception deficits in PD patients may occur secondary to the denervation of dopaminergic pathways of the ventral striatum, subthalamic nucleus, and other basal ganglia regions.^[9] These regions have connections with regions involved in emotional processing, including both subcortical areas like the amygdala, the nucleus accumbens, the hypothalamus, and other cortical regions.^[10] Many of these regions, especially territories of pre frontal cortex engage in various cognitive functions, especially executive functions.^[11] Executive dysfunction in PD patients is related to the dysfunction of the frontostriatal pathways.^[12] Other cognitive functions such as attention and working memory^[13] and visuospatial abilities^[14] are also affected in PD patients which play a crucial role in emotion perception.^[15] Emotion perception deficits might exist in cross-modality that is perceiving emotions through stimuli such as facial, prosody and musical. As many of neural structures involved in emotion perception overlap with each other.^[16,17] These subcortical regions are extensively connected and disruption of these networks might affect emotion perception in both prosodic and musical modalities.^[18,19]

OVERVIEW

The present systematic review aimed to examine research carried out on understanding nature of emotion perception deficits in PD. We further examined how emotion perception deficits are related to cognitive deficits in PD as well contribution of disease parameters like duration and severity of illness, mediating role of neuropsychiatric conditions such as depression, anxiety and apathy, role of dopamine replacement therapy (DRT) and common neurosurgical procedure such as subthalamic nucleus deep-brain stimulation (STN-DBS) in advanced PD.

LITERATURE REVIEW: SEARCH STRATEGY AND SELECTION CRITERIA

We carried out a detailed search of literature on PubMed and other sources [refer to Table 1 and Figure 1]. The articles were restricted to English language and published between January 2010 and

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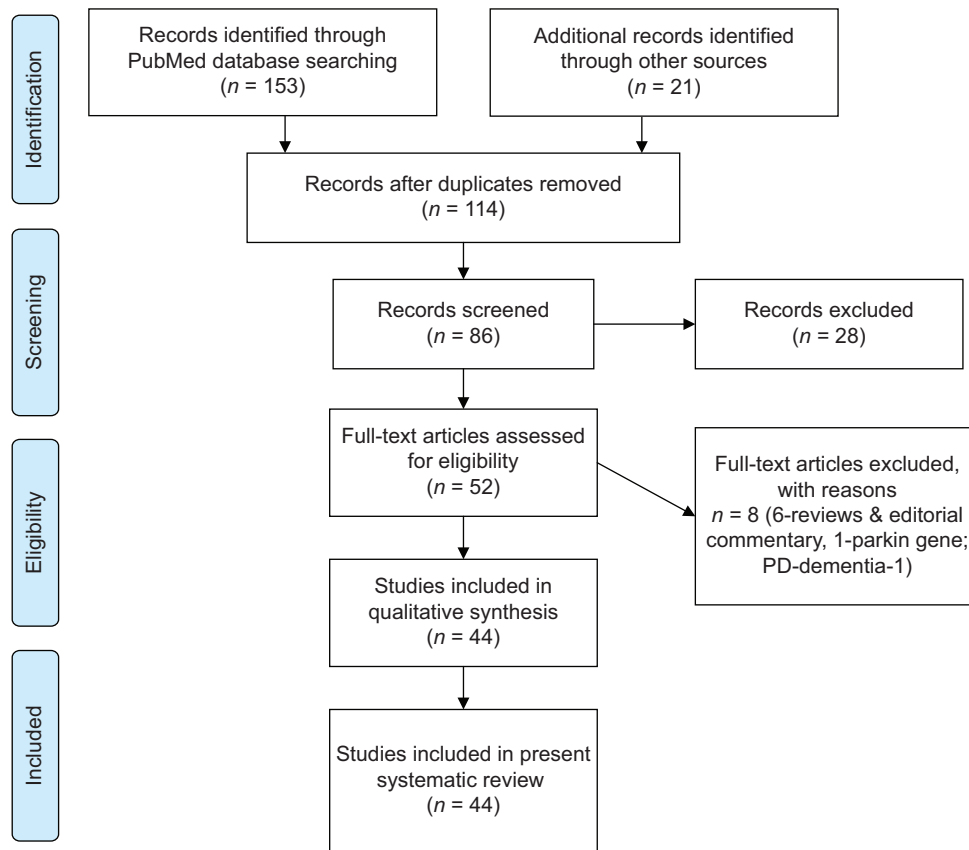


Figure 1: Flow diagram describing the steps for shortlisting the articles for review

Table 1: Results of PubMed and other additional research with various combinations

Key Words (Filter: Publication in past 10 years)	Articles found (reviewed)
Emotion Perception AND Parkinson's disease	174 (44)
Subdivision	Reviewed
Facial Emotion/Perception AND Parkinson's disease	32
Prosody Emotion Recognition/Perception AND Parkinson's disease	12
Music Emotion Recognition/Perception AND Parkinson's Disease	3

December 2019. The key terms were Parkinson's disease, emotion, facial expression, emotional prosody and music emotion perception. A total of 44 articles reporting emotion perception and cognitive assessment in PD were selected. Articles related to DBS were also reviewed as they highlight role of this neurosurgical process on emotion perception among PD patients. We collected the following data from the selected articles: Clinical parameters and control group, nature of cognitive assessments carried out, specific/general nature of deficits. [Table 2]

FACIAL EMOTION RECOGNITION (FER) IN PD

The facial emotion recognition is an essential ability to engage with our complex interpersonal world.^[20] The interpretation of emotional experiences from facial expression aids in understanding the intentions and goals of others. This ability to successfully interpret emotions through facial expressions require a complex interplay among brain regions such as amygdala,

hypothalamus, mesolimbic, dopaminergic signalling pathways, as well as cortical regions such as prefrontal cortex, and areas of temporal and parietal cortex. The pathophysiological changes in PD such as loss of grey matter in amygdala, orbitofrontal cortex, affected corticostriatal connections^[2] contribute to impaired emotion perception and might add to difficulty in pragmatic communication,^[21] refer to Figure 2.

It can be concluded that PD patients have impairment in correctly identifying emotions as represented by facial stimuli. Some of the reviewed studies provide evidence in support of specific emotion perception deficits such as decoding negative emotions. The accuracy to perform on emotion perception tasks is moderated by nature of emotion perception tasks (for example, performance varies on identification task compared to intensity rating task).

The performance on emotion perception was independent of clinical factors such as motor disability or mood disorder

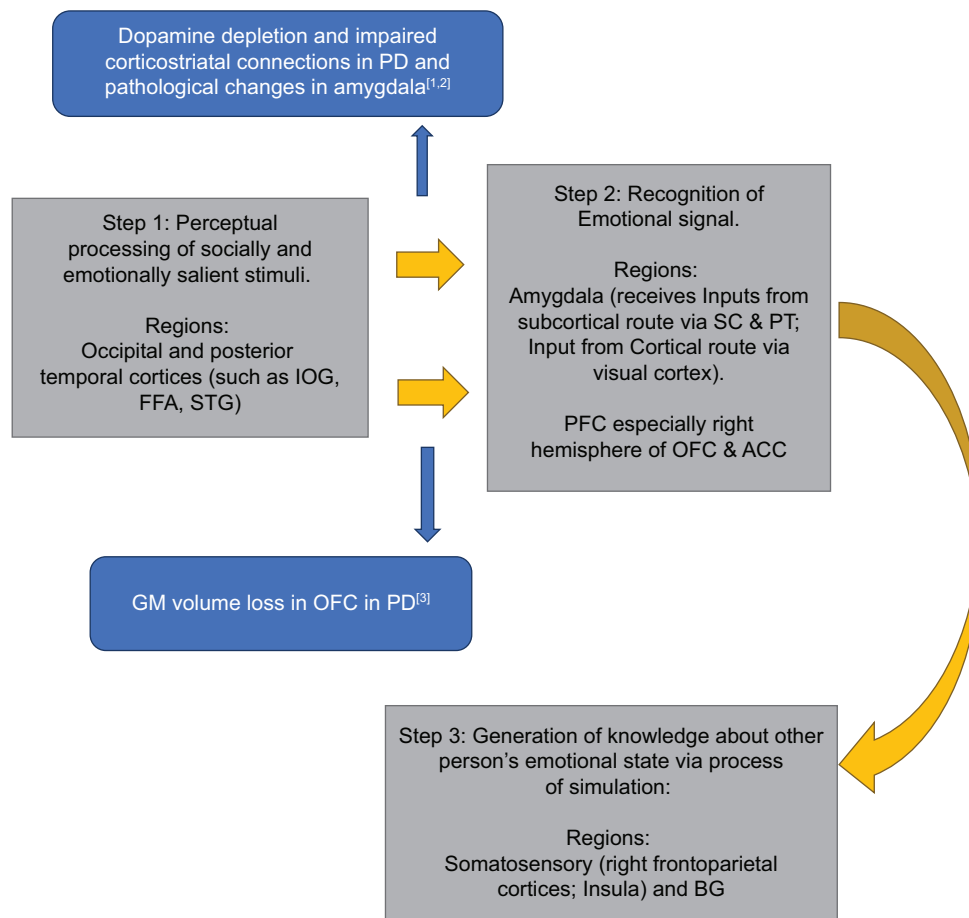


Figure 2: Neural systems associated with emotion perception and role of Parkinson's disease pathophysiology. The above figure mention processes and neural systems involved in emotional processing (in grey boxes) and pathophysiological changes (in blue boxes) associated with PD which affect process of emotion perception. Abbreviations: ACC-Anterior cingulate cortex; BG- Basal ganglia; FFA- Fusiform Face Area; GM- Grey matter; IOG- Inferior Occipital Gyrus; OFC-orbitofrontal cortex; PFC- Pre frontal cortex; PT-Pulvinar thalamus; STG- Superior Temporal gyrus.

such as depression. The cognitive performance on executive function and visuospatial tasks do tend to correlate with emotion perception performance.

One of the characteristic motor-symptoms of PD is hypomimia. This reduced emotional expressivity is linked to hypodopaminergic state results to hypokinesia and bradykinesia of facial muscles.^[22] As a result PD patients perceived to be “cold” or “unhappy”.^[23] It has been found that this reduced facial expression is related to impaired facial emotion perception in PD patients.^[24] It is proven in healthy controls where observing and imitating facial emotion expression lead to activation in premotor areas, as well as superior temporal cortex, insula and amygdala.^[25] Since facial mimicry aids in recognition of emotions.^[26] The embodied simulation theory brings these components together and argue that impairment in facial emotion perception could be related to deficits in emotion expressivity and hypomimia.^[27]

The other factor is status of DRT (ON vs OFF state) while performing the emotion perception task. For example, in early course of illness, dopaminergic treatment improves motor symptoms though at same time hyperdopaminergic state of mesolimbic regions can impair effective emotion recognition

however this effect becomes beneficial in later course of illness.^[28] Though only a few studies have conducted with cross-over design to assess PD patients under ON and OFF medication state^[29] accuracy improves after administration of DRT as it activates default mode network.^[30] Role of STN-DBS is not widely studied where few studies report STN-DBS does not affect emotion recognition performance^[31-33] while other reports a contrary finding.^[34]

In conclusion, facial emotion recognition studies found that mild to moderate PD individuals appear to have deficits in perception of negative emotions while advanced PD patients report of broad emotion perception deficits. These deficits were related to cognitive performance while mostly independent of disease severity.

EMOTION RECOGNITION THROUGH PROSODY (PER) IN PD

The effective processing of emotional prosody allows people to convey and understand varied range of emotions. However, question about how pwPD process emotional signals through

Table 2: Master Chart- overview of findings reported in scientific literature about Emotional processing in Parkinson's disease

Authors	Disease duration (Mean±SD) years	DRT when assessed (ON/OFF)	Emotion Perception Task	Cognitive Assessment (+/-)	Mood Assessment (+/-)	Findings Deficit emotion (+)
Assogna <i>et al.</i> , (2010) ^[43]	4.9±4.2	ON	ID	+	+	Disgust (+)
Cohen <i>et al.</i> , (2010) ^[44]	4.79 (2.85)	ON	ID	+	-	Nil
Martinez-Corral <i>et al.</i> , (2010) ^[45]	PD –apathy DOI=4.83±2.95 PD -non apathy DOI=7.26±4.26	ON	ID	+	+	Fear (+) Anger (+) Sadness. (+)
van Tricht <i>et al.</i> , (2010) ^[46]	11.9±4.6	ON	ID	+	+	Fear (+) Anger (+)
Delaveau <i>et al.</i> , (2010) ^[30]	11.4±4.4	ON and OFF	Matching	+	+	No impairment
Péron <i>et al.</i> , (2010) ^[37]	11±3.6	ON	ID	+	+	STN-DBS modifies Emotion perception
Vicente <i>et al.</i> , (2011) ^[47]	Early PD 2.48±1.41 Advanced PD 11.55±3.36	ON and OFF	ID	+	+	No impairment
Herrera <i>et al.</i> , (2011) ^[48]	7.22±5.47	ON	ID	+	+	General deficits
Narme <i>et al.</i> , (2011) ^[49]	9.8±3.7	ON	ID	+	+	Anger (+)
Brück <i>et al.</i> , (2011) ^[50]	15±6	STN-DBS -ON and OFF	ID	-	+	No effect of DBS ON/OFF General deficits
García-Rodríguez <i>et al.</i> , (2012) ^[51]	H&Y stage range I-II	LD naive	ID	-	+	No impairment
Garrido- Vásquez <i>et al.</i> , (2013) ^[52]	LPD H&Y stage=2.1(.51) RPD H&Y stage=2.33(.77)	ON	ID	+	+	No impairment
Ventura <i>et al.</i> , (2012) ^[53]	H&Y stage- II	ON	ID	+	-	Sadness (+)
Baggio <i>et al.</i> , (2012) ^[54]	5.67±3.8	ON	ID	+	+	Fear (+)
Dietz <i>et al.</i> , (2013) ^[55]	6.6±4.3	ON	ID	-	+	unpleasant processing (+)
Lima <i>et al.</i> , (2013) ^[56]	8.3±4.9,	ON	ID	+	+	Happiness (+)
Saenz <i>et al.</i> , (2013) ^[57]	8.58±5.27	ON	ID	+	+	Fear (+)
Buxton <i>et al.</i> , (2013) ^[58]	6.68±5.46	ON	ID	+	-	Sadness (+) Disgust (+)
Mermillod <i>et al.</i> , (2014) ^[31]	12.36±0.71	STN-DBS ON and OFF DRT ON and OFF	ID	+	+	Surprise (+) Sadness (+) DRT and STN-DBS has no impact.
Alonso-Recio <i>et al.</i> , (2014) ^[59]	6.57±4.01	ON	ID and Discr.	+	+	Overall Negative

Contd...

Table 2: Contd...

Authors	Disease duration (Mean±SD) years	DRT when assessed (ON/OFF)	Emotion Perception Task	Cognitive Assessment (+/-)	Mood Assessment (+/-)	Findings Deficit emotion (+)
Aiello <i>et al.</i> , (2014) ^[34]	10.9 (4.0)	DRT (On/Off) STN DBS stimulation (On/Off)	ID and Discri.	+	+	Emotions DBS reduces
Albuquerque <i>et al.</i> , (2014) ^[32]	15.85±7.02	ON	ID	+	-	Discrimination. Performance No significant
Péron <i>et al.</i> , (2014) ^[28]	Early PD-2.8±1.2 Advanced PD-11.1±3.4	ON and OFF	ID	+	-	Decline after STN-DBS. General deficits
Robert <i>et al.</i> , (2014) ^[60]	11.6±4.03;	ON	ID	+	+	General deficits
Wabnegger <i>et al.</i> , (2015) ^[61]	6.28±3.64	OFF	Intensity	-	+	No impairment
Schienze <i>et al.</i> , (2015) ^[62]	6.28±3.64	OFF	ID	-	+	No impairment
Ille <i>et al.</i> , (2015) ^[63]	6±3	OFF	ID	+	+	No impairment
McIntosh <i>et al.</i> , (2015) ^[64]	H&Y stage till 2.0	ON and OFF.	ID	-	-	No differential effects of DRT or STN-DBS on emotion recognition
Lin <i>et al.</i> , (2016) ^[65]	H&Y stage- 2.84	OFF	Discri.	-	+	General deficits
Albuquerque <i>et al.</i> , (2016) ^[66]	14.6±6.0	ON	Discri.	+	-	No impairment
Pietschnig <i>et al.</i> , (2016) ^[67]	range 0.25-19.00	ON	ID	+	+	General deficits
Bologna <i>et al.</i> , (2016) ^[68]	5.9 (2.3)	ON	ID	-	-	Disgust (+)
Jin <i>et al.</i> , (2017) ^[69]	7.93±2.3	ON	ID	+	+	Sadness (+) Fear (+) General deficits
Kalampokini <i>et al.</i> , (2017) ^[70]	9	ON	ID	+	+	Surprise (+)
de Risi <i>et al.</i> , (2017) ^[71]	6.7±2.6	ON	ID	+	+	Sadness (+)
Sedda <i>et al.</i> , (2017) ^[72]	9±6.7	ON	ID	-	+	Anger (+) Fear (+) Negative Emotion (+)
Ricciardi <i>et al.</i> , (2017) ^[24]	7.3±4.1	ON	ID	-	+	General deficits
Enrici <i>et al.</i> , (2017) ^[33]	12.56±3.03	ON	ID	+	+	No impairment
Moonen <i>et al.</i> , (2017) ^[73]	5.3±3.9	ON	ID	+	+	No impairment
Pohl <i>et al.</i> , (2017) ^[74]	5.94±4.39	ON	ID	+	-	General deficits
Bell <i>et al.</i> , (2017) ^[75]	7.3±2.2	ON	fMRI task	+	+	No Impairment
Stirnemann <i>et al.</i> , (2018) ^[76]	Left-side PD 12.85±6.13	ON	Discri.	+	-	General deficits

Contd...

Table 2: Contd...

Authors	Disease duration (Mean ± SD) years	DRT when assessed (ON/OFF)	Emotion Perception Task	Cognitive Assessment (+/-)	Mood Assessment (+/-)	Findings Deficit emotion (+)
	Right-side PD 11.79±4.19					
Palmeri <i>et al.</i> , (2019) ^[77]	4.63±2.66	ON	ID	+	+	All Negative
Saffarian <i>et al.</i> , (2019) ^[78]	4.67±1.24	ON	ID	-	+	Emotion (+) General Deficits

Abbreviations and description of emotion perception task: ID- Identification (Subject was asked to select appropriate emotional label for presented emotional expression), *Discri.-Discrimination* (Subject was asked to determine if facial/prosody (usually two) depict same/different emotion), *Intensity* (Subject was asked to rate emotion shown on visual analog scale from "not at all" to "intensively expressed"); *Matching* (Subject was asked to match target facial/prosody emotion expression with another facial/prosody expression depicting same emotion); *fMRI-Functional magnetic resonance imaging*

prosody has not been investigated in much detail. The evidence gathered from event-related potential (ERP) and neuroimaging studies suggest that not just cortical brain areas, but subcortical areas such as basal ganglia which engage in sequencing auditory affective information are crucial in emotion recognition through prosody^[35] and impairments of these areas provide a model to understand emotion recognition through prosody.

General (non-specific) recognition of prosody deficits has been reported in both mild to moderately PD and advanced PD others reported specific prosody deficits in fear, anger, disgust. In pwPD, deficits in recognizing emotions through prosody are related to executive function.

Effect of DRT is not studied extensively, report suggested that DRT tends to improve performance on prosody emotion perception in advanced PD.^[28] However, in early PD the administration of DRT negatively influence prosody emotion perception in comparison to OFF state^[28] possibly due to dopamine overdose in mesocorticolimbic pathway^[36] which is still intact in early PD.

Only a handful of studies have evaluated the effect of DBS on PER. Some reported alteration in PER for pwPD who underwent STN-DBS,^[37] while other studies found no alteration in identifying emotions.^[32] To summarise, most of reviewed studies report intact positive emotion perception thorough prosody while more studies reported deficits in negative emotion recognition through prosody.

Emotion Recognition through Music (MER) in PD

Musical emotion perception among PD patients is a relatively a new area of research. Music is capable of inducing strong emotions with both positive and negative emotional valence. Music activates brain region such as which overlap with processing linguistic stimuli.^[38] Music can induce wide range of emotions which mediated by brain structures such amygdala and insula that is implicated in encoding many other kinds of emotional stimuli.^[39] Some common neural regions between

music processing and the affected regions in PD, such as orbitofrontal cortex^[40] as well mesolimbic reward circuitry^[41] are worth studying.

To summarise, the findings remain inconclusive in terms of presence or absence of emotion perception deficits through musical stimuli and require further evaluation to conclude.

DISCUSSION

Emotion perception deficits as a crucial NMS has gained significant research interest. Emotion perception deficits have debilitating effect on overall functioning in PD patients. In this systematic review, we found three main approaches taken to study emotion perception in PD namely facial, prosody and musical emotions. These three modalities are mediated by overlapping and distinct neural pathways.^[15,41] The existing studies have predominantly assessed facial emotion and findings are suggestive of impaired facial emotion recognition in PD. This trend is not so strong in emotion recognition through prosody and inconclusive for emotion perception through musical stimuli. For facial emotion recognition, the overall identification of negative emotions is affected in PD which is partially related to cognitive functions such as executive functions though this trend is not significant in other studies. Neuroimaging studies do corroborate the claim of impairment in identifying negative emotion is probably due to dysfunction in frontostriatal pathways and mesolimbic regions as well as dysfunction of striatum, amygdala, basal ganglia and related dopaminergic pathways.

Findings in emotion recognition through prosody report general rather specific emotion perception deficits. However, the relation between emotion recognition and cognitive functions are not very clear.

Findings in emotion recognition thorough musical stimuli is a recent trend in PD research. There are only handful of studies that report contradictory results on emotion recognition. The

relation of emotion recognition through music and cognitive functions is also not clear.

Several confounding variables can explain the mixed results more so in prosody and music emotion recognition. For example, task used for the assessment, emotions displayed. The other factors such clinical parameters, cognitive deficits, medication status, presence of co-morbid mood conditions such as depression, apathy, anxiety may influence the findings. For example, only few studies have controlled for cognitive deficits or mood disturbances.

Future studies can probe further into emotion perception through multi-modal emotion stimuli, which provide crucial outlook on how subcortical and in advanced stage, neocortex has been affected in PD. Future work may examine the effect of DRT on emotion perception. Role of DBS which improves complications of motor symptoms also require extensive examination. Thus, a well-controlled study is desirable to study emotion perception in PD patients.

PD patients often report social interaction problem and being misunderstood by others as one of the important factors adversely affecting their quality of life.^[23,42] The relevance to understand psychological aspects of PD, providing indications on how to provide support to PD patients who have emotion perception deficits.

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Conflicts of interest

There are no conflicts of interest.

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